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PEANUT CONFECTIONS AND SNACKS

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PEANUT CONFECTIONS AND SNACKS

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CHAPTER 1

STANDARDIZATION OF THE ROASTING PROCESS FOR PEANUTS

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ABSTRACT

The current practice of roasting peanuts in the Philippines is a hit and miss method. The endpoint of roasting is based mainly on the color of the peanuts. The roasting process thus need to be standardized and this can be based on more objectively defined parameters such as the determination of the roasted peanuts' moisture content, water activity, and moisture sorption isotherm. Values obtained for the roasted peanuts' moisture content and water activity were 1.97% and 0.52 respectively. Constructed moisture sorption isotherms taken at 28°C for raw and roasted peanuts were of a typical sigmoid shape. The critical moisture content of roasted peanuts as determined by sensory analysis was 2.70 %.

INTRODUCTION

Roasted peanuts are used as a pre-processed ingredient for a number of snack products such as coated peanuts like cracker nuts, peanut butter, choco nut, chocolate coated peanut, for ice cream mix, peanut brittle, and garlic roasted peanuts.

The acceptability of roasted peanuts as an ingredient for these products depends to a large extent on color, crunchiness, and nutty flavor. Consumers prefer roasted peanuts with a golden brown color, crunchy texture, with a developed nutty flavor. Roasted peanuts at its flavorful best, contain 1-2 % to 50.7 % fat. As a product that is low in moisture and high in fat. Subsequent adsorption of moisture would bring about a series of progressive deteriorative reactions such as loss of crunchiness, development of rancidity, mold growth, and discoloration.

The average relative humidity and temperature in the Philippines are 81% and 28°C, respectively. Such climatic conditions predispose products to absorb moisture. Roasted peanut has a moisture content of 1.97 % and a water activity of 0.52 and will therefore readily absorb moisture from the atmosphere. Because of this, roasted peanuts has to be adequately protected from the atmosphere through the use of a suitable packaging material and better, if possible, a storage room with a controlled relative humidity and temperature.

A systematic approach to the proper selection of packaging material requires an exact knowledge of specific sensitivities of the product such as its moisture sorption isotherm. The sorption isotherm of a food material is best described as a plot of its moisture content as a function of relative humidity or activity of the vapor space surrounding the material with which it is in equilibrium at a given temperature (Labuza, 1968).

OBJECTIVES

The general objectives of this study are to improve the quality of roasted peanuts for institutional food service use and to gain further information on its roasting process. The specific objectives would be to: (1) standardize the roasting operation of peanut intended for institutional service use, (2) determine the equilibrium moisture content (EMC) at different A_w values using Proximity Equilibrium Cell (PEC) method, and (3) construct the sorption isotherm curve of the sample.

METHODS

Raw Materials and Equipment

The peanut sample was purchased from a retail store in Cubao, Quezon City. The peanuts were roasted at a temperature of 250°F using an electric oven with an amount of 500 grams sample per batch. No salt or other flavorings were added to the roasted samples.

Sampling and Preparation

From the bulk sample, 250 grams was comminuted and then three 1.0000 g portions were weighed out as samples. This was done for statistical validity and to ensure that representative samples were taken. The samples were wrapped separately in filter paper and set aside.

The jars used as the cell were 4 oz. glass jars with tin cover. The jars were washed and dried before 25 mL of the saturated salt solution was poured. A fine mesh plastic net was used as sample holder having been secured above the saturated salt solution using rubber bands. The set-up was equilibrated overnight before use.

Water Activity and Moisture Content Determination

The initial water activity of the sample was obtained using the water activity meter at the Quality Control Laboratory and the moisture content using the vacuum oven from Alonso Hall, Rm. 106, both at the College of Home Economics, University of the Philippines, Diliman, Quezon City.

Determination of Moisture Sorption Data of Roasted Peanuts

To determine the moisture sorption of the sample, the Proximity Equilibrium Cell (PEC) method was used. It is based on the use of saturated salt solutions to maintain a fixed relative humidity, and small closed containers which permit equilibrium of the moisture content of the sample with that of the test temperature.

Moisture sorption data were obtained for the raw and roasted peanuts. The samples were tested as ground samples to facilitate rapid equilibration. A pre-weighed and wrapped sample with known moisture content was placed on the net sample holder. The sample adsorbed/desorbed moisture depending on its original moisture content and the relative humidity of the atmosphere in the PEC.

Construction of Sorption Isotherm Curve of Roasted Peanuts (Brunauer *et al*., 1938)

The equilibrium moisture content (EMC) value was calculated using the formula:

$$m = \frac{(Wf-Wi) + (Mi/100 \times Wi)}{\frac{(100-Mi)}{Wi \times 100}}$$

where:
m = % moisture content (dry basis)
Mi = initial moisture content (wet basis)
Wf = final weight of sample after equilibrium at a specific relative humidity
Wi = initial weight of sample in the PEC

When Wf became constant, it was taken as the EMC.

The Equilibrium Moisture Content (EMC) data was fitted into the BET equation:

$$\frac{RH}{EMC\ (100 - RH)} = I + S \times RH$$

where: RH = relative humidity of the environment

EMC = equilibrium moisture content of the sample
I = y-axis intercept
S = slope

A plot of EMC (% dry basis) against A_w was then constructed using the Microsoft Excel. The monolayer value was calculated using the equation:

$$Wm = 1/ I + 100 S$$

where: Wm = monolayer value
I = y-axis intercept
S = slope

Determination of the Moisture Sensitivity of Roasted Peanuts

To determine the moisture sensitivity of the roasted peanuts, a sensory evaluation was conducted. The roasted peanuts were placed in laminated nylon/polyethylene bags, each with an amount of 500 grams. The bags were then placed inside a desiccator with a relative humidity maintained at 100%. Evaluation was performed at weekly intervals by a panel of 24 untrained panelists. Since texture is the characteristic that is greatly affected by moisture gain, texture acceptability ratings by the panelists was plotted against its moisture content at the time of testing. A rating of 5 corresponding to neither like nor dislike in the 9-point hedonic scale was used as endpoint of the moisture sensitivity determination and its moisture content was taken as the critical moisture content for roasted peanuts.

Consumer Acceptability of Roasted Peanuts

Panel

Twenty-four (24) panelists were asked to judge the acceptability and evaluate the individual attributes of the sample. The panel was composed of students from various degree programs in the College of Home Economics, University of the Philippines, Diliman, Quezon, City.

Sample Preparation and Presentation

The roasted peanuts were placed in white cups. Samples were presented to panelists on a long rectangular table.

After the initial evaluation, the samples were packed in a laminated nylon polyethylene bags. Each bag containing 250 grams of the sample, was sealed using a hand sealer and was placed in a desiccator with a relative humidity maintained at 100%. The desiccator was kept at room temperature.

Sensory evaluation was continued in the following weeks. The samples were evaluated using the same ballot and their moisture contents were determined.

Test Location

The evaluation sessions were conducted at Rm. 106 at the College of Home Economics, University of the Philippines, Diliman, Quezon City. Fluorescent light bulbs were used for lighting.

Ballots

The ballots were patterned in a 9-point Hedonic scale. A non-continuous 9 horizontal bars with corresponding numbers and descriptions (for numbers 1, 3, 5, 7 and 9 only) underneath were placed after each question. For the acceptability tests, the number 1 represents dislike extremely while the number 9 denotes like extremely. Panel ratings were indicated by placing a check at the horizontal bars which the panelists deemed appropriate.

Statistical Analysis

The raw data was obtained for the acceptability tests by listing the number where the panelists place the check for the sample. The same method was used for getting the raw data for the individual attributes of the sample. The mean for each acceptability test and individual attributes of each of the sample were calculated and was described according to the description in the 9-point Hedonic scale.

Descriptive Analysis of Roasted Peanuts

A new batch of roasted peanuts prepared as above was used for each session of the descriptive analysis of the sample.

Panel

Ten (10) panelists were asked to evaluate the sample’s sensory properties. The panel was composed of students from various degree programs in the College of Home Economics, University of the Philippines, Diliman, Quezon City. The sample preparation and presentation, and test location were as mentioned above.

Ballots

The ballots used were composed of two parts. The first part was for the flavor description of the roasted peanuts. The panelists were asked to place a check on the space provided for the listed flavor descriptors that they deemed to aptly described the sample, and to rate its corresponding intensity with a numerical scale from 0, which stands for not present, to 4 which stands for strong. They were also given the option to write other flavor descriptors for the product. The second part was devoted to texture evaluation. The panelists evaluated the samples’ texture by placing a number on the space provided based on the given intensity scale ranging from 0 (not brittle) to 4 (very brittle).

Data Analysis

The mean for the raw ratings was calculated. Its resulting value corresponding to the given scale was the sample’s overall rating.

RESULTS

Water Activity and Moisture Content

Water activity of the roasted peanuts was 0.52. Initial moisture content was 1.97%..

Moisture Sorption Isotherm of Raw and Roasted Peanuts

Table 1.1 below shows the data gathered for the determination of the isotherms of the raw and roasted peanut samples and the calculated monolayer value for each.

Table 1.1 Percentage (%) relative humidity and %moisture content of raw and roasted peanuts

% Relative Humidity	% Moisture Content	
	Raw Peanuts	Roasted Peanuts
	Initial moisture content: 3.31%	Initial moisture content : 1.97%
10	1.40	0.6
21.4	1.80	0.8
27	2.00	0.8
30	2.60	1.0
40	3.00	1.5
50	3.50	2.0
60	5.00	2.8
70	7.80	7.0
80	11.00	17.0
90	16.20	24.9
100	21.00	27.7
Monolayer value (Wm)	1.90 %	1.1 %

The sorption curves represent the integrated hygroscopic properties of diverse chemical compounds such as carbohydrates, proteins, fats, etc. (Rockland and Beuchat, 1987). Chemical composition and physical structures will directly influence the shape of the moisture sorption isotherm. Thus, different materials exhibit different isotherms because of its nature. The size of the samples i.e., ground versus whole, on the other hand, will exhibit different isotherms. The ground samples had more surface area exposed to the environment so they absorb more moisture.

The moisture sorption isotherm (Figs. 1.1 and 1.2) can be divided into three parts called the localized isotherms and were designated as Region I, Region II, and Region III. The inflection points of the constructed curve serve as the boundaries between the regions (Rockland and Beuchat, 1987). Generally, Region I has a relative humidity range from 0-35%, Region II from 35-75%, and Region III from 75-100%. However, the range of the relative humidities for each region may vary depending on the type of material being evaluated.

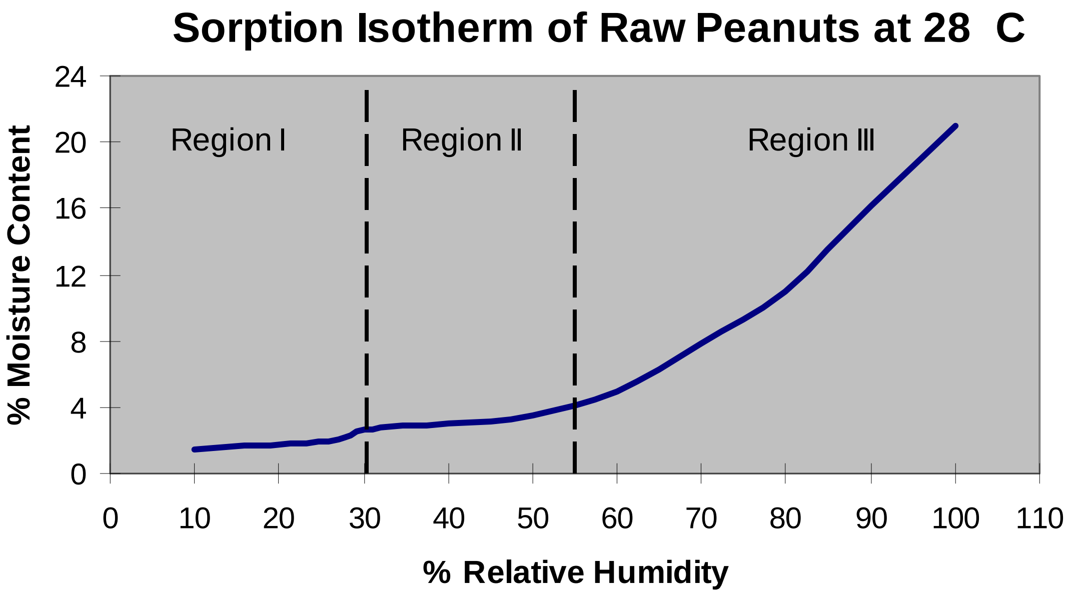

Fig. 1.1 Sorption isotherm of raw peanuts at 28°C.

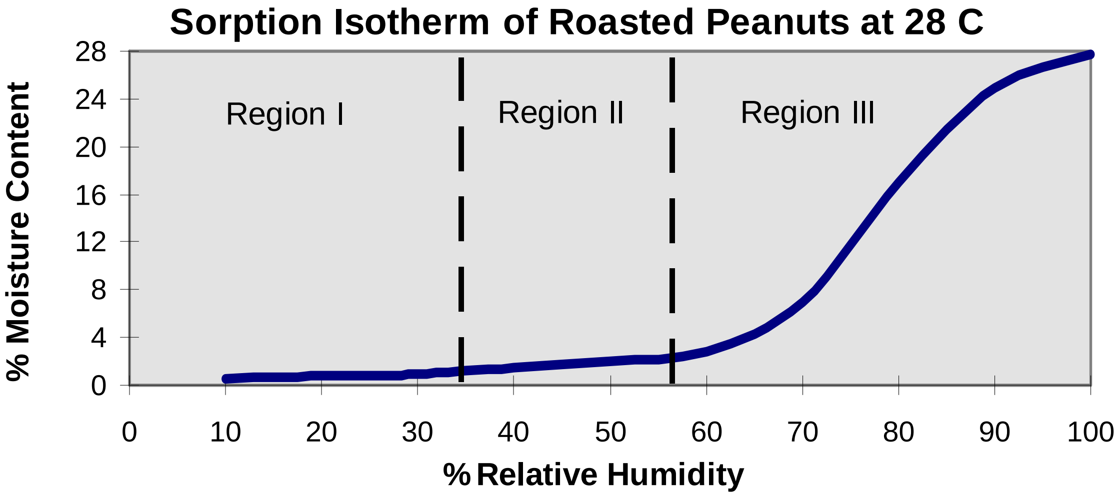

Fig. 1.2 Sorption isotherm of roasted peanuts at 28°C.

As seen from the isotherm graphs, Region I of raw peanut has a steeper slope than that of the Region I of the roasted peanut. Absorption of moisture occurred readily in the raw peanut at the range of 0-27% relative humidity. The almost linear graph or seemingly constant absorption of moisture at the first region of the roasted peanut is due to the migration of oil on the surface of the exposed material. The oil acts as a protective layer against water absorption because of its hydrophobic groups, however, in this region, oxidation greatly occurs. A study by Labuza (1975) shows the general effect of water activity on lipid oxidation on food. At a water activity above the monolayer value, oxidation rate decreases with increasing water activity. The rate reaches a minimum around the monolayer value and increases with a further increase in water activity. The “antioxidant effect” of water at low water activity has been attributed to bonding of hydroperoxides and hydration of metal catalysts, whereas the “pro-oxidant effect” of water at high water activity is due to the increased mobility of reactants (Heidelbaugh and Karel, 1970). At Region III, however, the condition was reversed, the roasted peanut exhibited a steeper slope than that of the raw sample. Because of the increase in water activity in this region, the peanuts are now prone to mold growth as well as the proliferation of other microorganisms.

Hygroscopicity

A comparison of the initial moisture content with the equilibrium moisture content (EMC) gives the hygroscopicity of the material, i.e., a measure of the capacity of the material to absorb or lose moisture at the different relative humidity conditions. Sorption plots differ depending on the hygroscopic property of foods.

Regions of an isotherm can be defined based on the relative humidities where the food material lose or absorb moisture. Based on the constructed sorption curve for the raw peanuts, Region I has relative humidity range approximately from 0-27%, Region II from 27-50%, and region III from 50-100% while for the roasted peanuts Region I has a range from 0-35% for Region I, 35-58% for Region II, and 58-100% for Region III. Table 1.2 below summarizes the relative humidity ranges for each region of the constructed sorption isotherm curve for the raw and roasted peanuts.

Table 1.2 Localized isotherm range for raw and roasted peanuts

	Raw Peanuts Initial moisture content : 3.31%		Roasted Peanuts Initial moisture content : 1.97%	
	% RH	% MC	% RH	% MC
Region I	0 -27	1.4 - 2	0 - 35	0.6 - 1-1.5
Region II	27 – 50	2 - 3.5	35 - 58	1-1.5 - 2-2.8
Region III	50 – 100	3.5 - 21	58 - 100	2-2.8 - 27.7

In Region I, values of EMC of raw and roasted peanuts were all lower than initial moisture content signifying that both the raw and roasted peanuts lost moisture. Initially, the samples had higher moisture content than the atmosphere and this supplied water vapor to the surrounding atmosphere until the partial pressure of water vapor within the area was equal to the vapor pressure existing in the sample. Focusing on Region I, it can be inferred that raw peanut is more hygroscopic than the roasted peanut.

Parts of Region II and the whole Region III have EMC values higher than the initial moisture of the samples indicating that the samples absorbed moisture. In Region III, more water is available. The magnitude of absorption depended largely on chemical composition.

Raw peanut had an initial moisture content of 3.31% which is within the safe moisture level of 2-5% for sealed storage. Peanuts having moisture level above 10% will be conducive to mold growth notably *Aspergillus flavus* which produces a carcinogenic substance called aflatoxin. The sorption isotherm for raw peanut indicates that at relative humidities higher than 50%, the peanut will absorb moisture and equilibrate at levels higher than 6%. At 80%, which is close to ambient conditions, raw peanut equilibrates at 11%. These data suggest that storage conditions for raw peanut should be strictly controlled.

Roasted peanut had an initial moisture content of 1.97%. At relative humidities above 50%, roasted nut will equilibrate at 2% moisture level. Therefore, the roasted peanut should not be stored at relative humidities of 50% and above.

Moisture Sensitivity of Roasted Peanuts

At the start of the study, the roasted peanuts were characterized as very light brown in color and moderately brittle. The texture of the roasted peanuts packed in a laminated nylon/polyethylene bags after exposure to 100% RH at weekly intervals are shown in Table 1.3.

Table 1.3 Moisture sensitivity of roasted peanuts

% Moisture content	Texture rating and description	Presence of off-flavor
1.97%	7-moderately brittle	None
2.18%	6-slightly brittle	None
2.31%	6-slightly brittle	None
2.45%	6-slightly brittle	not perceptible (24% of panelists detected off-flavor
2.70%	5-neither chewy nor brittle	not perceptible (24% of the panelists detected off-flavor)

Data indicated that roasted peanuts progressively lost their brittleness with increase in moisture. This relationship is shown in Fig. 1.3. Roasted peanuts can be considered a moisture sensitive product since a change of 0.5% moisture caused considerable decrease in brittleness - a key feature in its acceptability. At 2.45% moisture level, 24% of the panelists detected an off-flavor although mean of their ratings fall under not perceptible based on the 9-point hedonic scale used in the evaluation.

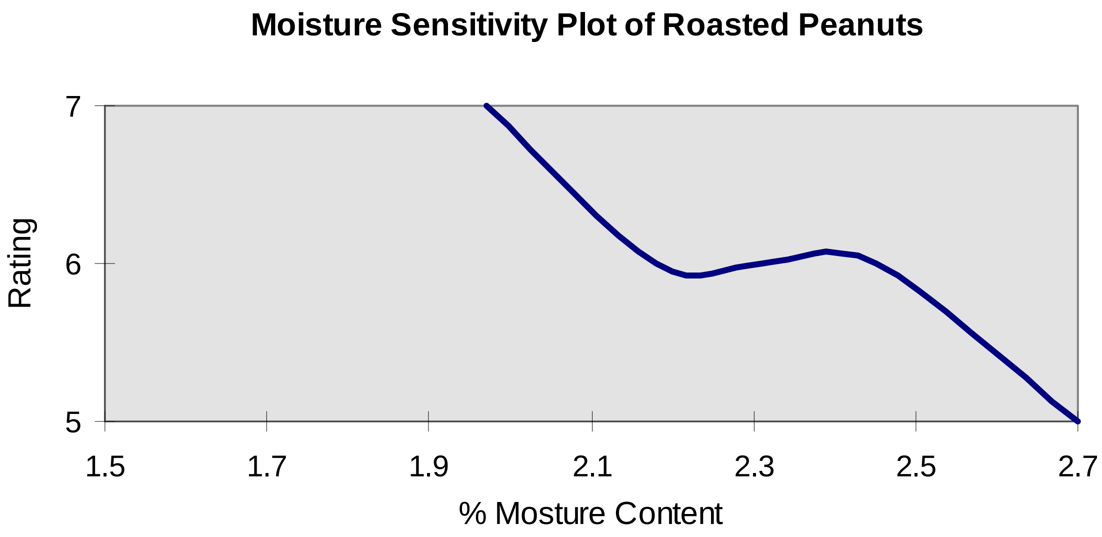

Fig. 1.3 Moisture sensitivity plot of roasted peanuts.

Defining Safe Moisture Limits

The transformation of moisture sorption curves into corresponding BET plot is shown in Figs. 1.4 and 1.5. A simple linear regression was done to derive the values needed to calculate the monolayer value of the raw and roasted peanuts.

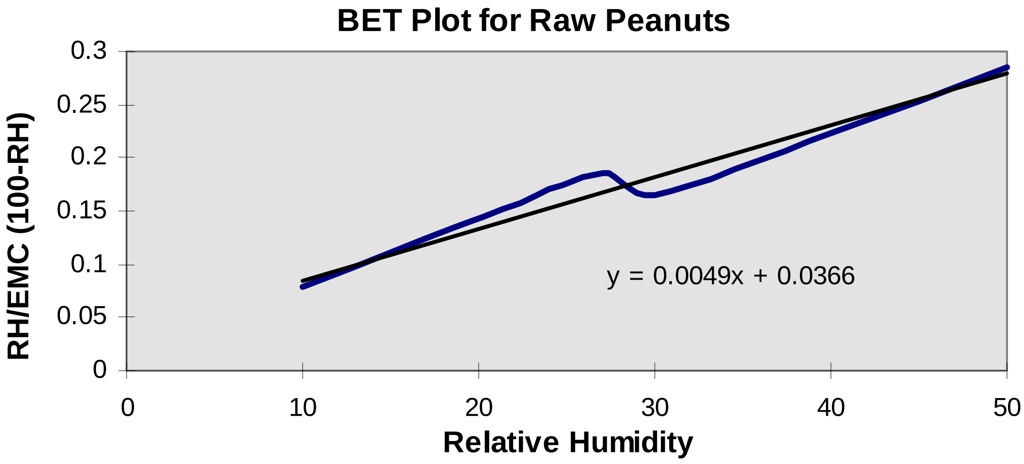

Fig. 1.4 BET plot for raw peanuts.

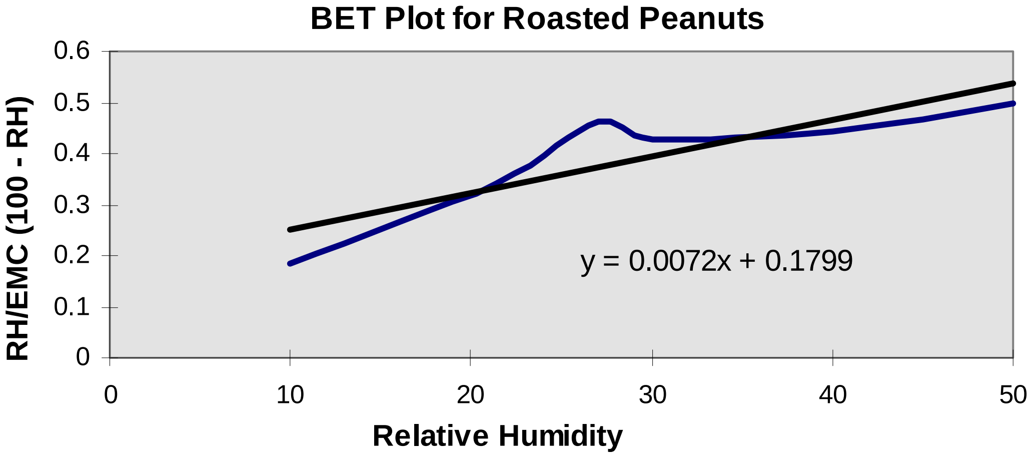

Fig. 1.5 BET plot for roasted peanuts.

The monolayer value of the product was used in defining the safe minimum moisture content of snack foods. The values for the critical moisture level, monolayer value, and danger point for the roasted peanut were 2.7%, 1.1%, and 2.2% respectively. Determination of the critical moisture level was based on the results of texture ratings, whereas a rate of 5 corresponding to neither like nor dislike on the 9-point hedonic scale used, would indicate that the peanuts are no longer acceptable. The obtained critical moisture level was 2.70%. Danger point of the EMC was set 5% lower than the ERH of the critical moisture level. This is the moisture level wherein there is perceived decrease in brittleness. The safe range for roasted peanut was taken as the monolayer value for the lower limit and the danger point for the higher limit. Thus, the safe range for the roasted peanut was from 1.1 - 2.2% moisture content.

For the raw peanuts, the monolayer value calculated was 1.9%. At relative humidities higher than 50%, the peanut started absorbing moisture and thus its critical moisture content is placed at 5% at a relative humidity of 60%. The danger point for raw peanuts is at 4.25% and its safe range is from 1.9-4.25% moisture. These values are significant since these would determine the shelf life of the stored raw peanuts, its main function not only to preserve the peanut's characteristics but as much as to prevent microbial contamination.

Table 1.4 shows the monolayer value, critical moisture level, danger point, and the safe range for the raw and roasted peanuts.

The presence of substantial amount of fat makes peanuts prone to rancidity. Peanut oil contains both saturated and unsaturated fatty acids. The hydrolytic type of rancidity is more prominent than autoxidation though both may happen simultaneously. Because of this, it may be advantageous to keep moisture content low but not lower than the monolayer value to prolong its shelf life. Further removal of water beyond the monolayer value would be equivalent to removing the protective film on reactive groups which may trigger the onset of this deteriorative reaction.

Table 1.4 Monolayer value, critical moisture level, danger point and safe moisture range of raw and roasted peanuts

	% Moisture Content	
	Raw Peanut	**Roasted Peanut**
Monolayer value	1.9	1.1
Critical moisture level	5	2.7
Danger point	4.25	2.2
Safe moisture range	1.9 - 4.25	1.1 - 2.2

Consumer Acceptability of Roasted Peanuts

The results of a consumer test conducted to evaluate the acceptability of the roasted peanut samples using a 9-point hedonic scale are presented in Table 1.5.

Table 1.5 Consumer acceptance ratings of roasted peanuts

Characteristic	Hedonic Rating	Description
Overall acceptability	7	like moderately
Color	1	very light brown
Color rating	6	like slightly
Aroma	5	moderately perceptible
Aroma rating	6	like slightly
Flavor	5	moderately perceptible
Flavor rating	6	like slightly
Texture	7	moderately brittle
Texture rating	7	like moderately
Off-flavor	0	no off-flavor
Off-flavor rating	0	-

After the initial evaluation, the samples were packed in a laminated nylon polyethylene bags. Each bag containing 250 grams of the sample, was sealed using a hand sealer and was placed in a desiccator with a relative humidity maintained at 100%. The desiccator was kept at room temperature. Sensory evaluation was continued in the following weeks. The samples were evaluated using the same ballot and their moisture content were determined. Results were tabulated in Table 1.6.

Table 1.6 Acceptability of roasted peanuts during storage

Characteristic	**Number of days in storage**			
	13 days		**21 days**	
	moisture content: 2.18%		**moisture content: 2.31%**	
	Hedonic Rating	***Description***	***Hedonic Rating***	***Description***
overall acceptability	7	like moderately	6	like slightly
Color	2	slightly light brown	2	slightly light brown
color rating	6	like slightly	6	like slightly
Aroma	5	moderately perceptible	5	moderately perceptible
aroma rating	6	like slightly	6	like slightly
flavor	5	moderately perceptible	5	moderately perceptible
flavor rating	6	like slightly	6	like slightly
texture	6	slightly brittle	6	slightly brittle
texture rating	7	like moderately	6	like slightly
off-flavor	0	no off-flavor	8% of the panelists detected an off-flavor	raw taste, fish cracker-like taste
off-flavor rating	0	-	0.4	not perceptible

Table 1.6 *continued* . . . .

Characteristic	**Number of days in storage**			
	27 days (moisture content = 2.45%)		**40 days (moisture content: 2.70%)**	
	Rating	Description	Rating	Description
overall acceptability	6	like slightly	5	neither like or dislike
color	2	slightly light brown	2	slightly light brown
color rating	6	like slightly	5	neither like or dislike
aroma	5	moderately perceptible	4	very moderately perceptible
aroma rating	7	like moderately	5	neither like or dislike
flavor	5	moderately perceptible	4	very moderately perceptible
flavor rating	6	like slightly	5	neither like or dislike
texture	6	slightly brittle	5	neither chewy nor brittle
texture rating	7	like moderately	5	neither like or dislike
off-flavor	24% of the panelists detected an off-flavor	raw taste, bitter, rancid, smoky	24% of the panelists detected an off-flavor	raw taste, old taste, bitter
off-flavor rating	1	not perceptible	1	not perceptible

Based on the above data the following observations were made: (1) overall acceptability dropped from like moderately to like slightly on its third week of storage and continued to drop still to neither like nor dislike on its last evaluation; (2) the color of the sample darkened after second week of storage while its rating declined by 1 unit, from like slightly to neither like or dislike on the last evaluation; (3) aroma of the sample described as moderately perceptible lessened on the last evaluation while its rating fluctuated from like slightly to like moderately to neither like nor dislike during its storage; (4) flavor of the sample maintained its description as moderately perceptible and rating as like slightly except for the last where it was described to be very moderately perceptible and a rating of neither like nor dislike; (5) texture of the sample was deemed to be slightly brittle until its fourth week of storage while its rating fluctuated from like moderately to like slightly and on its final evaluation, the texture was described as neither chewy nor brittle and its rating neither like nor dislike, prominent comments of the panelists was that of the texture being "makunat" or chewy; and (6) until its last evaluation, only 24% of the panelists detected an off-flavor, raw taste being the permanent description. On the whole, it can be said that the sample did not exhibit rancidity on its near six weeks in storage at 100% relative humidity as the typical off-flavor descriptor for roasted peanuts. However, the most affected characteristic of the sample was its texture, initially evaluated as moderately brittle to chewy/ "makunat" on its last evaluation which in turn greatly affected its overall acceptability.

Sensory Characteristics of Roasted Peanuts

Table 1.7 shows the summary of the results of the descriptive analysis of the roasted peanut sample. Roasted and raw peanutty were typical flavor descriptors used for peanuts. The roasted peanutty descriptor was rated to be moderate in the first trial and only slightly for the second trial. Raw peanutty descriptor, on the other hand, was rated to be slight for both trials. The sample was also said to be slightly lacking in nutty flavor and bitter for the two trials. The soapy and salty descriptors were not perceived by the panelists of the first trial while both were deemed to be just recognizable by the second batch of panelists. Also at the first trial, a flavor descriptor, bland, was added by some of the panelists and was given the intensity of moderate. The descriptor stale was not perceived by the second set of evaluators while it was rated to be slight by the first. The texture for both trials was pegged to brittle. Variation in the response of the panelists may be attributed to their partialness to eating unflavored peanuts.

Table 1.7 Flavor and texture of roasted peanut samples

Sensory attributes	**Hedonic Rating**		**Description**	
	First Trial	Second Trial	First Trial	Second Trial
1. Flavor Descriptor				
Roasted peanutty	3	2	moderate	slight
Raw peanutty	2	2	slight	slight
Lacks nutty flavor	2	2	slight	slight
Soapy	0	1	not present	just recognizable
Salty	0	1	not present	just recognizable
Bitter	1	1	just recognizable	just recognizable
Stale	2	0	slight	not present
Other descriptor:bland	3	-	moderate	-
2. Texture	3	3	brittle	brittle

CONCLUSIONS

The roasting procedure for the peanut was established. For small scale roasting, an electric oven was used, a roasting temperature of 250°F and 30 minutes as roasting time. Endpoint of the roasting process was based on the endpoint of roasting time.

The roasted peanuts were evaluated for acceptability testing. The samples were presented to a panel of 24 students at the College of Home Economics, University of the Philippines, Diliman, Quezon City. Initial sensory results obtained were like moderately for overall acceptability, a light brown color for the kernels, a moderately perceptible aroma and flavor, and a texture of moderately brittle. Subsequent results showed a decline for most of the characteristics, where unacceptability of the samples' texture marking the endpoint of the evaluation.

A sorption analysis was made on the raw and roasted samples. Both exhibited a sigmoid shaped moisture sorption isotherm. From the sorption data gathered, the monolayer values calculated were 1.90% and 1.1% for raw and roasted peanuts, respectively. The critical moisture level for the roasted peanut was at 2.70% based on the sensory evaluation for its texture and its danger point at 2.2%. A range from 1.1 - 2.2% was established as the roasted peanut's safe moisture range. For raw peanuts the values for monolayer, critical moisture level, danger point, and safe moisture range are 1.9%, 5%, 4.25%, and 1.9-4.25%, respectively.

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APPENDIX A

PROCEDURE FOR ROASTING PEANUTS USING AN ELECTRIC OVEN

PROCEDURE FOR ROASTING PEANUTS USING AN ELECTRIC OVEN

1. Weigh 500 grams of peanuts.

2. Spread the peanuts evenly on a metal tray.

3. Place inside the oven preheated at 250°F. Make sure that the tray is at the center.

4. Roast peanuts for 15 minutes. Remove the tray out of the oven and mix the contents thoroughly. Return the tray inside the oven and allow to roast for 15 more minutes.

5. Remove the tray from the oven and let the contents cool before placing them in a clean, dry keeping containers.

APPENDIX B

DETERMINATION OF MOISTURE SORPTION DATA USING PROXIMITY EQUILIBRIUM CELL

DETERMINATION OF MOISTURE SORPTION DATA USING PROXIMITY EQUILIBRIUM CELL

1. Prepare 25 mL of solution following closely the calculated amount (% by weight) of sulfuric acid in each solution.

H_2SO_4 (% by weight)	Water Activity (A_w)
5	0.9808
10	0.9562
15	0.9245
20	0.8814
25	0.8252
30	0.7549
35	0.6693
40	0.5711
45	0.4653
50	0.3574
55	0.2563
60	0.1677
65	0.0972
70	0.0470
75	0.0190
80	0.0059

All determinations must be done in triplicates.

2. Position the sample holder and unweighed filter paper in the PEC. Close tightly then place in an incubator of known temperature, preferably 30°C, for at least 24 hr. to condition the sample holder and the filter paper.

3. Take the PECs out of the incubator then weigh the filter paper on an analytical balance.

4. Reduce the food sample into to very small pieces to speed up equilibration. Weigh 2.0000g sample into each filter paper. If the sample is too bulky, weigh 1.0000 g only.

5. Position the filter paper with the sample in the sample holder. Cover tightly, then keep the PEC in the same incubator.

6. See to it that the temperature is maintained properly since water activity (and therefore RH) is temperature dependent.

7. Monitor the weight of the samples every 24 hr. over a period of around 2 weeks or until constant values are obtained.

APPENDIX C

DETERMINATION OF MOISTURE CONTENT (VACUUM DRYING METHOD)

DETERMINATION OF MOISTURE CONTENT
(Vacuum Drying Method)

1. Accurately weigh out 2.0000g of the sample into tared pan. Spread the material over the bottom of the dish to cover the greatest surface.

2. Dry in a vacuum oven at 60-70°C, 15 mm Hg.

3. Remove the dish after 5 hours. Cool in a desiccator and weigh.

4. Repeat the drying procedure for 15 minutes. Weigh. Continue to dry to constant weight.

5. Calculate the moisture content from the weight loss of the sample.

$$\text{Moisture content (\%)} = \frac{\text{weight of sample before drying - weight of sample after drying}}{\text{weight of sample before}}$$

APPENDIX D

DETERMINATION OF WATER ACTIVITY USING THE A_W VALUE ANALYZER

DETERMINATION OF WATER ACTIVITY USING THE A_W VALUE ANALYZER

A. Calibration of the sensor head

1. Place 4 sheets of the enclosed special paper in the sample container and moisten with saturated $BaCl_2$ solution which was previously shaken well.

2. Secure the sensor head and sample container to each other.

3. Calibrate for at least 1 1/2 hours.

4. Adjust the reading to the water activity corresponding to the registered temperature of the set up. Use the enclosed wrench to manipulate the adjustment screw.

B. Water activity determination

1. Place the ground sample material (enough to cover the bottom), whose temperature should be between 15 and 25°C, into the second container up to the bottom of the gasket ring.

2. Before using the calibrated sensor head, leave it upside down in the other compartment until the water activity reading is less then 0.8.

3. Secure the sensor head tightly to the filled sample container.

4. Leave the set up in the polystyrene case for 2 1/2 hours.

5. Reading is done by viewing the a_w meter through the see-through window.

6. Carefully clean the sample containers after the measurement has been completed.

APPENDIX E

BALLOT FOR THE SENSORY EVALUATION OF ROASTED PEANUTS

BALLOT FOR THE CONSUMER TEST OF ROASTED PEANUTS

Panelist Name :_________________________________ Date: ________________

Instructions: Please evaluate the roasted peanut sample. Indicate your rating for each specified attribute and how much you like or dislike the sample by placing a check above the corresponding numbers.

1. OVERALL, how do you like the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
dislike extremely		dislike moderately		neither like nor dislike		like moderately		like extremely

2. How do you describe the color of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
very light brown		light brown		brown		dark brown		very dark brown

How do you like the color of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
dislike extremely		dislike moderately		neither like nor dislike		like moderately		like extremely

3. How do you describe the aroma of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
not perceptible		slightly perceptible		moderately perceptible		highly perceptible		very highly perceptible

How do you like the aroma of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
dislike extremely		dislike moderately		neither like nor dislike		like moderately		like extremely

4. How do you describe the roasted flavor of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
not perceptible		slightly perceptible		moderately perceptible		highly perceptible		very highly perceptible

How do you like the roasted flavor of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
dislike extremely		dislike moderately		neither like nor dislike		like moderately		like extremely

5. How do you describe the texture of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
chewy		moderately chewy		neither chewy nor britttle		moderately brittle		very brittle

How do you like the texture of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
dislike extremely		dislike moderately		neither like nor dislike		like moderately		like extremely

6. Do you detect any off-flavor on the sample? _____ Yes _____ No

If yes, please describe the off-flavor you perceived. ______________________________
____

How would you rate the intensity of the off- flavor of the sample?

______	______	______	______	______	______	______	______	______
1	2	3	4	5	6	7	8	9
not perceptible		slightly perceptible		moderately perceptible		highly perceptible		very highly perceptible

Comments: ____
____
____
____

Thank you very much.

APPENDIX F

BALLOT FOR THE DESCRIPTIVE ANALYSIS OF ROASTED PEANUTS

BALLOT FOR THE DESCRIPTIVE ANALYSIS OF ROASTED PEANUTS

Panelist Name: ____ Date: ____________

Instructions: You are presented with roasted peanut kernels. Please evaluate the flavor and texture of the sample.

A. **Flavor Evaluation**: Pick a kernel and chew it slowly. Evaluate its flavor by placing a check on the blank beside the chosen descriptor and indicate its intensity (based on the **Intensity Scale A**) by writing a number on the second blank. You may choose more than one flavor descriptor as you perceive the sample has.

Flavor Descriptor		**Flavor Intensity**
Roasted peanutty	_____	_____
Raw peanutty	_____	_____
Lacks nutty flavor	_____	_____
Soapy	_____	_____
Salty	_____	_____
Bitter	_____	_____
"Lasang luma" (stale)	_____	_____
Others*:		
____________	_____	_____
____________	_____	_____

Intensity Scale A

0 = not present
1 = just recognizable or threshold
2 = slight
3 = moderate
4 = strong

* You may answer in Filipino

B. **Texture Evaluation**: Place a piece of kernel between your molars ("panga") and chew. Evaluate the sample's texture by placing a number on the blank (based on the **Intensity Scale B**).

Texture _____

Intensity Scale B

0 = not brittle
1 = slightly brittle
2 = moderately brittle
3 = brittle
4 = very brittle
Note: brittle = "malutong"

Thank you very much.

CHAPTER 2

CONSUMER-BASED OPTIMIZATION AND SENSORY PROFILING OF A PEANUT-CHOCOLATE BAR

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ABSTRACT

The formulation and degree of roast was optimized for a peanut-chocolate bar with high consumer acceptance ratings, using response surface methodology. The factors studied included sugar, peanuts, cocoa powder and a process variable, degree of roast. Twenty-seven peanut-chocolate bar formulations with two replications were evaluated for consumer acceptance (n = 168) for overall liking, and acceptance of color, appearance, flavor, sweetness and texture using 9-point hedonic scales. In terms of overall liking, the use of dark roasted peanuts had the most number of acceptable formulations than the medium and light roasted peanuts. Sensory evaluation indicated that sweetness acceptance was the limiting factor for acceptability. An acceptable peanut-chocolate bar can be obtained using formulations containing 44-54% peanuts, 1-4% cocoa powder and 41-55% sugar, that has a moderate cocoa aroma, roasted peanutty aroma, and peanut butter aroma, and with medium to dark brown color. The technology was transferred to a collaborating company, adopted, and used in commercial production of their peanut-chocolate bar.

INTRODUCTION

Peanut (*Arachis hypogaea*) is a highly acceptable food item in the Philippines (Muego-Gnanasekharan *et al*., 1990) and other countries throughout the world (McWatters, 1983). It is a highly nutritive crop. Dried peanut seeds contains approximately 18% carbohydrates, 22-32% protein and about 40-54% high quality oil that makes an excellent source of vegetable oil which is used for food shortening and other industrial products (DA, 1998). Peanut products manufactured in the Philippines are the peanut butter, candy bars, brittles, and confections (Muego-Gnanasekharan and Resurreccion, 1993).

Peanut-chocolate bar is a popular peanut confectionery prepared from a mixture of roasted peanuts, sugar, milk powder and cocoa powder, and then formed into a variety of shapes such a s round, rectangular or bar-shapes. The product is packed in foil as the primary packaging material and polypropylene or in boxes as the secondary packaging material. The bar-shaped Chocnut™ is the most common brand, Hany™ and Ricoa Curly Tops™ are the other brands. Most peanuts used in the manufacture of peanut-chocolate bar are obtained from small peanuts that fail the size specifications for roasted peanuts. The utilization of these peanuts will provide an additional product line and profit to the peanut manufacturer. Peanut-chocolate bar in the Philippines has a sweet taste and with lesser peanut aroma. Peanut-chocolate bar in the Philippines has a sweet taste and with lesser peanut aroma. An optimization study on peanut-chocolate bar could be conducted as a mixture experiment to optimize consumer acceptance of the product.

In mixture experiments, as in peanut-chocolate bar blends, the combinations of the ingredients used should total to 100% of the peanut-chocolate bar formulations (Cornell, 1983). Response surface designs are used to find combinations of a number of experimental variables that will lead to an optimum (Gacula and Singh, 1984), by using various combinations of the components in the formulation. Response surface methodology (RSM) is a system for optimizing variables by testing several variables at a time, uses special experimental designs to cut costs, and measures several effects by objective tests (Henika, 1982). It uses quantitative data from appropriate experimental designs to determine and simultaneously solve multivariate equations (Giovanni, 1983). The predictive equations generated from the data of consumer and descriptive tests can be used to describe how the test variables affect the response, to determine the relationships among the test variables, and to describe the combined effect of all test variables on the response.

Mixture response surface methodology is used to systematically evaluate multiple variables while minimizing the number of evaluations that must be conducted. In mixture experiments, the components in the mixture are expressed as a fraction of the total mixture, and the response is a function of the proportions of the components and not the total amount of the mixture (Snee, 1974). In mixture design studies, the components or ingredients are the independent variables and the responses for the sensory attributes are the dependent variables.

The study was conducted to determine acceptable formulations of a peanut-chocolate bar which the collaborator could choose from or use as a basic formulation in improving their product similar to the flavor characteristics of a popular brand milk chocolate that is less sweet but with a more intense peanut flavor, and with a texture similar to their existing product. The findings could be transferred and adopted by the collaborator to obtain an improved product.

OBJECTIVES

The study was conducted to: (1) identify the levels of sugar, peanuts and cocoa powder as well as the degree of roast that will result in an acceptable peanut-chocolate bar, (2) determine the effects of components on the intensity of sensory attributes, and (3) transfer the peanut-chocolate bar process to the collaborator for adoption.

METHODS

Establishment of Industry Collaboration

The collaborator for the study was identified based on an existing peanut-chocolate bar product manufacturer in the market. Collaboration started after the General Manager of a peanut-chocolate bar manufacturer, an FDC client, was informed through a telephone call that there was a project on peanut-chocolate bar with the objective of improving the product through the use of a state-of-the-art method, the response surface methodology. A meeting with the General Manager was arranged and held at FDC on April 2000 to discuss the objectives, expected outputs and the terms of collaboration. The General Manager agreed and preliminary activities for collaboration were undertaken. The collaborator was informed through a letter, dated June 13, 2001 (Appendix B), that the optimum formulations for peanut-chocolate bar were ready for technology transfer. The letter indicated the best formulation obtained from the study that could be used by the collaborator in the preparation of the product. The impact of the technology transfer is discussed in PCRSP Monograph Series #9 entitled Impact Assessment of PCRSP Projects in the Philippines – Part 2. The model used in this activity was in collaboration with a medium-scale peanut processor. The collaborator was chosen because they were identified to have an existing peanut-chocolate bar product in the market. The collaborator expressed interest to collaborate in order to improve the flavor characteristics of their existing product similar to the flavor characteristics of a popular brand Milk Chocolate that is less sweet but with intense peanut flavor without changing the texture of the product.

Location of where research was conducted

The samples used in this study were prepared at the Pilot Plant of the Department of Food Science and Technology, University of Georgia, Athens, Georgia, U. S. A. The consumer and descriptive tests were conducted in Athens, Atlanta, and Barnesville, Georgia; and statistical analyses were conducted at the Food Development Center.

Experimental Design

A mixture design consisting of three components, sugar, peanuts and cocoa powder was designed as described by Cornell (1983) and was used to optimize the formulation and degree of roasting of peanuts for the preparation of an acceptable peanut-chocolate bar. Preliminary experiments were conducted to determine the levels at which the components of peanut-chocolate bar could be optimized, such as identification of the components and levels that are important for acceptance of the product (Schutz, 1983). These components were found to be sugar, peanuts and cocoa powder. The formulation of the collaborator was initially used as basis for varying the levels of ingredients. Samples of peanut-chocolate bar with highest and lowest levels of the ingredients that would result in a product were prepared. These proportions were used as constraints in the mixture experiment where the highest and lowest levels were identified as the extreme vertices in the constrained region. Based on the components to be studied, 9 formulations were obtained.

The three mixture components were sugar (x_1), peanuts (x_2) and cocoa powder (x_3) consisting of a total of 94.5% of the peanut-chocolate bar formulation. The remaining percentage of the peanut-chocolate bar is 5.5% milk powder which was a fixed amount in the formulation. The range of the components were 45 to 64% sugar, 35 to 54% peanuts and 1 to 4% cocoa powder equivalent to a total of 100% of the mixture based on the preliminary experiments. Three degrees of roast of peanut: light roast (*L* value=51), medium roast (*L* value=48) and dark roast (*L* value=45) were also studied. Based on the number of components and degrees of roast to be studied, 27 formulations were obtained.

In this design, the number of points (n) necessary to run a mixture experiment is

$$n = 2^q - 1$$

where q is the number of components being studied. Therefore, the minimum number of points to be studied is $\{2^3 - 1\}$ or 7 points (Scheffe', 1958) as shown in Figs. 2.1a and 2.1b. The seven points are located in four extreme vertices (mixtures 1, 2, 3, and 4), two edge centroids (mixtures 5 and 6) and a center point or overall centroid (mixture 7) (Snee, 1974). Two additional peanut-chocolate bar blends (mixtures 8 and 9) were included to provide extra points within the mixture triangle to support a second-order polynomial. The total number of formulations is 9 points. A process variable, degree of roast, at three *L* values (*L* value = 45, 48 and 51) were used. The 27 different blends or formulations of peanut-chocolate bar are shown in Table 2.1. Two replications of the study were conducted.

Preparation of Raw Materials

Twelve (12) Kg of raw shelled medium Florunner type peanuts (*Arachis hypogaea L.*) (2000 crop, Tara Foods, Albany, GA) were manually sorted for damaged kernels and foreign materials. The sorted peanuts were divided into two 6-Kg batches and dry blanched using a rotary gas roaster (Model L5, Probat Inc., Memphis, TN), pre-heated at 204°C (400°F) and maintained at 101°C (214°F) for 2.5 minutes (Plemmons, 1997) or until the skin can be easily removed by fingers. The peanuts were immediately air cooled for 10 minutes (Hinds *et al.*, 1994) in a perforated cooling tray with an inside diameter of 65 cm and a depth of 12 cm. The peanuts were de-skinned using a dry peanut blancher (Model EX, Ashton Food Machinery Co., Inc., Newark, NJ). The peanuts were manually sorted to remove remaining testae and damaged nuts. Kernels with any remaining testae were passed through the blancher a second time. The sorted blanched peanuts were roasted based on the methods of Muego-Gnanasekharan *et al.* (1990) as adapted from Woodroof (1983). Four and a half (4.5) Kg of blanched peanuts were roasted using a rotary gas roaster (with 4.5 Kg capacity) preheated at 177°C (350°F) and maintained at 138°C (280°F) for approximately 8, 9 and 10 minutes for light, medium and dark roasted peanuts equivalent to L values of 51, 48 and 45, respectively.

The exact time of roasting was based on the number of minutes to reach a Hunter Color Lightness (*L*) value equivalent to 45 (dark roast), 48 (medium roast) and 51 (light roast). To monitor the color of peanuts during the roasting process, samples were obtained every 60 seconds and measured for color using Gardner Laboratory XL-800 series tri-stimulus colorimeter with a XL-845 circumferential sensor (Pacific Scientific, Bathesda, MD) until the kernels reached the desired degree of roast. The final *L* value of the product was measured by calculating the average of four readings.

Table 2.1 Composition of peanut-chocolate bar formulations with three roasts used in a three-component constrained simplex lattice mixture design (San Juan *et al.*, 2005)

Formulation No.	Degree of Roast (*L* value)[a]	Component proportion (%)[b]		
		Sugar (X_1)	Peanuts (X_2)	Cocoa powder (X_3)
1	45	45.00	54.00	1.0
2	45	45.00	51.00	4.0
3	45	64.00	35.00	1.0
4	45	61.00	35.00	4.0
5	45	55.00	44.00	1.0
6	45	53.00	43.00	4.0
7	45	54.00	43.50	2.5
8	45	49.00	48.50	2.5
9	45	58.00	39.50	2.5
10	48	45.00	54.00	1.0
11	48	45.00	51.00	4.0
12	48	64.00	35.00	1.0
13	48	61.00	35.00	4.0
14	48	55.00	44.00	1.0
15	48	53.00	43.00	4.0
16	48	54.00	43.50	2.5
17	48	49.00	48.50	2.5
18	48	58.00	39.50	2.5
19	51	45.00	54.00	1.0
20	51	45.00	51.00	4.0
21	51	64.00	35.00	1.0
22	51	61.00	35.00	4.0
23	51	55.00	44.00	1.0
24	51	53.00	43.00	4.0
25	51	54.00	43.50	2.5
26	51	49.00	48.50	2.5
27	51	58.00	39.50	2.5

[a] L value is the lightness of a color measured by the Hunter Color Lightness, *L* (Anonymous, 1979).

[b] The three components total to 94.5% of the peanut-chocolate bar formulation. Milk powder is the ingredient added in a fixed amount in the different formulations.

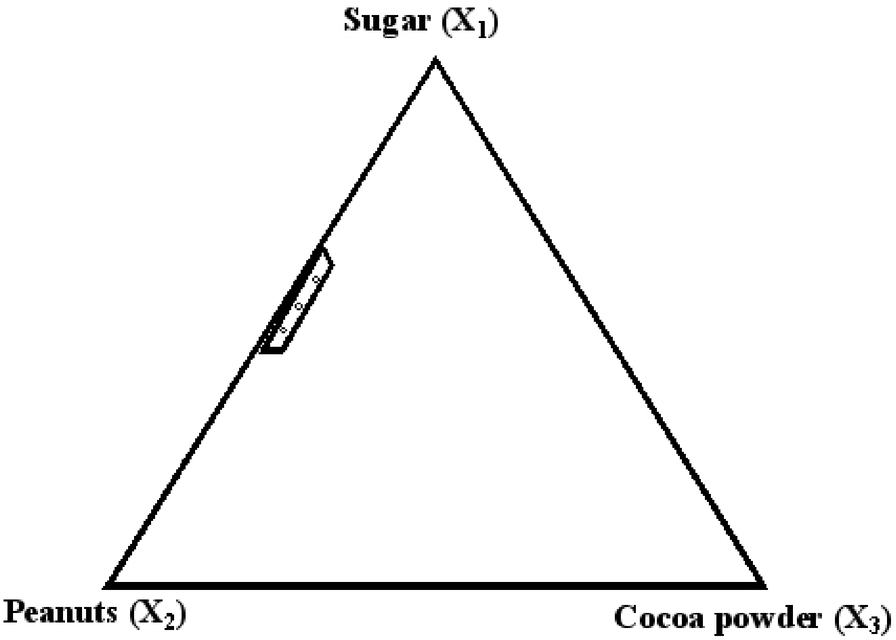


Fig. 2.1a

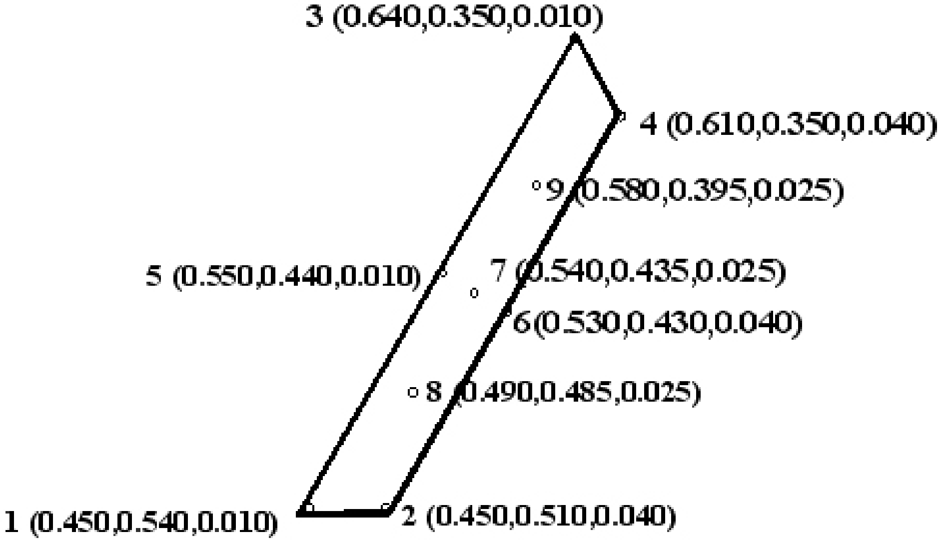


Fig. 2.1b

Fig. 2.1 (a) Constrained region in the simplex coordinate system for sugar, peanuts and cocoa powder; and (b) formulations in the constrained region used in the optimization of peanut-chocolate bar.

Roasted peanuts were ground once through a Morehouse mill (Morehouse Industries, Fullerton, CA) set at a stone clearance of 0.25 mm (10 notches) and maintained at 171°F (77°C) using a mixture of steam and water (Muego-Gnanasekharan and Resurreccion, 1993). Extra fine granulated sugar (Dixie Crystals, Savannah Foods Inc., Savannah, GA) was milled into powder form by passing through two disc mills. The first pass was through a Hammer mill (Horvick Mfg., Fargo, ND) with a 3 mm screen size and the second pass was through a Retsch Mill (Type ZM1, Retsch GmBH, Haan, West Germany) with 0.25 mm screen size. The milled sugar was stored at -17°C in a walk-in freezer until time of use. Two brands of cocoa powder, Brand A made in the Philippines and Brand B imported from Singapore, were thoroughly mixed in a 50:50 w/w ratio. The mixed cocoa powder was stored at –17°C in a walk-in freezer until time of use. Whey milk powder, obtained from Westfarm Foods, Chicago, IL., was stored at -17°C in a walk-in freezer until time of use.

Processing of Peanut-Chocolate Bars

Peanut-chocolate bar mixtures were prepared by blending 27 combinations of the ingredients (ground peanut, sugar, and cocoa powder) based on the experimental design in Table 2.1. The ingredients were mixed in a Hobart mixer (Model A-200, Troy, Ohio) for at least 15 minutes until a uniform blend was obtained. The mixture was formed into discs, 3 cm x 8 cm height (8-10 grams) using a hydraulic press (Carver Laboratory Press, Model M, Menemonee Falls, Wis.) at a pressure of 0 psi. The peanut-chocolate bars were wrapped in pre-cut aluminum foil, 10 x 8 cm in size. The samples were stored at –19°C in a walk-in freezer until a consumer test was conducted. Prior to the consumer test, the samples were placed in plastic cups with covers (4 oz capacity) and coded using 3-digit random numbers.

Sensory Analyses

Consumer Tests

Three central location tests were conducted in Athens, Atlanta, and Barnesville, Georgia. Panelists were recruited based on the following criteria: (1) were born in the Philippines, (2) had no food allergies, (3) were between the ages of 18 and 70, (4) had satisfied gender balance requirement consisting of 50% male and 50% female (only one of each gender per immediate family) and (5) had eaten peanut-chocolate bar or other related products at least 10 times in their entire lifetime. Each panelist for consumer testing was paid an honorarium of $10 per session.

A total of 168 panelists evaluated the samples. Each panelist evaluated 8 of the 54 samples and 1 control sample. Twenty-five responses per sample were required in the study. A 9-point hedonic scale was used to evaluate overall liking, and acceptability of color, appearance, flavor, sweetness and texture where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely. The control sample, a popular commercial peanut-chocolate bar, was crumbled then formed into discs to obtain a shape similar to the formulated samples to prevent bias due to appearance.

An open room was set up in one part with tables lined with white paper, and the other part of the room was set up with tables used by panelists to fill-out their demographic questionnaires prior to the test. The ballots were given to the panelists in the order of evaluation, the order of which was randomized for each panelist. Panelists were instructed to evaluate 5 samples, take a 1 minute break, then evaluate 4 more samples. Panelists were asked to place at least ¼ of the sample in their mouths while evaluating. The panelists were also instructed to drink water after every sample and not to make comments during evaluation to prevent influencing other panelists.

Descriptive Tests

Panel selection. Previously trained and untrained consumers who had participated in sensory tests at the Department of Food Science and Technology, University of Georgia, Griffin, Georgia, USA in 2000 were recruited to participate in the tests. The criteria for selection of panelists were as follows: (1) willingness to participate and ability to discriminate differences in sensory properties of peanut-chocolate bar, (2) had natural dentition, (3) no food allergies, and (4) did not smoke. Potential panelists with no experience on descriptive analysis were recruited over the telephone and scheduled for a screening test. The screening test consisted of an aroma and taste test to determine the panelist's ability to differentiate tastes and aroma. The taste test consisted of identifying the four basic tastes (solutions of sweet, salty, bitter, and sour) in small plastic cups with cover, while the aroma test consisted of identifying or describing the aroma perceived from the coded amber glass jars containing commonly found flavors such as licorice, pineapple, orange, peppermint, vanilla, orange, banana, and lemon. Prospective panelists who passed the test were asked to become members of the panel for peanut-chocolate bar.

Training. Ten panelists who passed the selection process underwent training for descriptive tests. Panelists were trained to use computerized ballots using 150-mm unstructured line scale with anchors at 12.5 mm from each end (Meilgaard *et al*., 1993). Ballots were developed by the panelists using reference samples and descriptors that represented attributes likely to be encountered in the product. Attributes, definitions, and evaluation techniques were developed by the panelists who agreed on references (Table 2.2) to be used. The attribute's definitions were obtained from published references (Meilgaard *et al.*, 1993; ASTM, 1992). All sensory properties of the product and their intensities such as appearance (maintains its form/shape, brown color, smooth surface, speckledness, homogenous, oiliness), aroma (cocoa, roasted peanutty, peanut butter, burnt, oxidized, milky, woody/hulls/skins), taste (sweet, salty, bitter), and texture (crumbliness, hardness, smoothness, oiliness, tooth pack, astringent, oiliness after swallow) were evaluated. Each trained panelist was paid an honorarium of $10 to $12 per session.

A warm-up sample (Formulation 25) was presented to the panelists as the initial sample during training and testing sessions (Plemmons and Resurreccion, 1998). Formulation 25 consisted of 54% sugar, 43.5% peanut and 2.5% cocoa powder and the lowest degree of roast (*L*-value=51). Intensity ratings for the warm-up samples, shown in Table 2.2, were obtained by taking the average of individual panelist ratings for each attribute during the training sessions and evaluation of test samples.

Sample evaluation. The 10 panelists evaluated 54 formulations (27 formulations x 2 replicates) of peanut-chocolate bar for 6 non-consecutive sessions, with 8-10 samples per session using a hybrid of the Spectrum and Quantitative Descriptive Analysis methods (Resurreccion, 1998). The samples, coded with three-digit random numbers, were served using a complete random block design. All references (Table 2.2), soda crackers, water, and cups for expectoration were provided. Each panelist evaluated the samples in environmentally controlled partition booths under white incandescent lights. The results were collected using a computerized interactive program, Compusense Version 2.4 (Compusense five, Compusense Inc., Guelph, Ontario, Canada).

Table 2.2 Descriptors and definitions of attributes developed in the descriptive analysis of peanut-chocolate bar with references and intensity ratings (San Juan *et al.*, 2007, unpublished)

Attribute	**Definition**	**Standard Reference**	**Intensity of Standard Reference**[a]	**Intensity of Warm-up Sample**[b]
1. Appearance				
Maintains its form/shape	Degree to which form/shape is maintained by product	Unformed chocolate-peanut mixture	0	87
Brown color	Intensity of color associated with cocoa powder	Cardboard [d]	34	70
		Chocolate fudge[g]	140	
Smooth surface[c]	The absence of particles on surface	Cheddar cheese (Kroger)	95	103
Speckledness	Presence of visible black particles on surface	10 specks/cm^2	10	10
		60 specks/cm^2	60	
		150 specks/cm^2	150	
Homogenous	The evenness of surface color			90
Oiliness[c]	The amount of oil perceived on surface of product	Cheddar cheese (Kroger)	45	0
		Peanut butter (Peter Pan)	76	
2. Aromatics				
Cocoa	The aromatic associated with cocoa powder	Cocoa powder (Hershey's)	60	44
		Chocolate fudge [e]	65	
Roasted peanutty[e]	The aromatic associated with medium roasted peanuts (L value = 49.3)	Roasted peanuts	70	54
Peanut butter	The aromatic associated with peanut butter	Peanut butter (Peter Pan)	78	65
Burnt	The aromatic associated with dark roasted peanuts and having very brown or toasted character (L value = 39.6)	Dark roasted peanuts	97	0
Oxidized	The aromatic associated with rancid/stale peanuts	Oxidized peanuts	36	0
Milky	The aromatic associated with skim milk or milk derived	Milk powder (Kroger)	33	10
Woody/hulls/ skins	The aromatic associated with base peanut character and related to dry wood, peanut hulls and skins	Peanut skins	74	0

Table 2.2 *continued…*

Attribute	**Definition**	**Standard Reference**	**Intensity of Standard Reference**[a]	**Intensity of Warm-up Sample**[b]
3. Tastes				
Sweet[c]	The taste on the tongue associated with sugars	2% sucrose	20	110
		5% sucrose	50	
		100% sucrose	100	
		150% sucrose	150	
Salty[c]	The taste on the tongue associated with sodium chloride	0.2% NaCl solution	25	15
		0.35% NaCl solution	50	
		0.5% NaCl solution	85	
Bitter[c]	The taste on the tongue associated with caffeine	0.05% caffeine solution	20	10
		0.08% caffeine solution	50	
		0.15% caffeine solution	100	
4. Texture				
First bite				
Crumbliness[c]	The force with which the sample breaks	Graham crackers (Kroger)	102	125
Hardness[c]	The force required to bite through	Cheddar cheese (Kroger)	90	30
First chew				
Smoothness[c]	The absence of particles after chew	Corn grits (Kroger)	45	90
Chew down				
Oiliness[c]	The feeling of oil in the mouth during mastication	Peanut butter (Peter Pan)	77	30
Residual				
Tooth pack[c]	The amount of product left on the mouth/teeth	Graham crackers (Kroger)	56	0
Feeling factor				
Astringentc	The puckering or drying sensation of the mouth or tongue surface	Grape juice (Welch's)	77	10
Oiliness after swallow	The feeling of oil in the mouth after swallow	Peanut butter (Peter Pan)	55	22

[a] A 150 mm unstructured line scale was used. Intensity scores were agreed upon by consensus by the descriptive panel

[b] Chocolate-peanut bar sample with peanuts roasted to L value = 51 (light roasted) at 138°C with sugar, peanut, and cocoa content of 54.00%, 43.50%, and 2.5%, respectively.

[c] Meilgaard, 1993

[d] Cardboard box packaging

[e] Hershey's cocoa powder and cornstarch

Physical Measurement (Color)

The color of roasted peanuts or the degree of roast, expressed as color lightness, L, was measured using a Gardner Laboratory XL-800 series tristimulus colorimeter with a XL-845 circumferential sensor (Pacific Scientific, Bathesda, MD). The degree of roast was measured during roasting from 4 sets of L readings after calibration with a standard yellow tile (L =79.56, a = - 2.17, b = 22.98).

The color of peanut-chocolate bar or the lightness, L, value was measured using SZ-80 II Color Measuring System (Nippon Denshoku Kogyo Co., Ltd., Tokyo, Japan). The L value of peanut-chocolate bar was determined four times for each sample after calibration with a standard plate with coordinates Y = 95.70, X = 93.86, and Z =113.56.

Statistical and Data Analyses

All data were analyzed using Statistical Analysis System (SAS Institute, Inc., 1985). Development of prediction models and model fitting were as described by Cornell (1982). Parameter estimates were determined by performing regression analysis (PROC REG) on raw data using the NOINT option. In this experiment, a mixture design has the limitation of $x_1 + x_2 + x_3 = 1.0$. Regression analysis was performed on each dependent variable used in the consumer test (overall acceptability and acceptance of color, appearance, flavor, sweetness and texture) and descriptive test (appearance i.e. maintains its shape, brown color, smooth surface, speckledness, homogeneous, and oiliness; aromatics i.e. cocoa, roasted peanutty, peanut butter, burnt, oxidized, milky, and woody/hulls/skins; tastes i.e. sweet, salty and bitter; and texture i.e. crumbliness in first bite, hardness in first bite, smoothness in first chew, oiliness, toothpacking, astringent and oiliness after swallow) and the following linear independent variables (sugar, peanuts, cocoa powder, roast) and the cross product terms (roast*roast, sugar*roast, peanut*roast, cocoa powder*roast, sugar*peanuts, sugar*cocoa powder and peanuts*cocoa powder). The effect on color of the different formulations was also analyzed using SAS (1985).

Response surface models were generated using the second degree polynomial (Scheffé, 1958):

$$Y = \beta_1x_1 + \beta_2x_2 + \beta_3x_3 + \beta_4x_4 + \beta_{11}x_1^2 + \beta_{12}x_1x_2 + \beta_{13}x_1x_3 + \beta_{14}x_1x_4 + \beta_{23}x_2x_3 + \beta_{24}x_2x_4 + \beta_{34}x_3x_4$$

where: Y = a sensory characteristic or response; $\beta_{1,}$ $\beta_{2,}$ $\beta_{3,}$ $\beta_{4,}$ $\beta_{12,}$ $\beta_{13,}$ $\beta_{14,}$ $\beta_{23,}$ $\beta_{24,}$ β_{34} = the corresponding parameter estimates for each linear and crossproduct term produced for the prediction models; x_1 = degree of roast, x_2 = sugar, x_3 = peanuts, x_4 = cocoa powder. Parameter estimates produced from prediction models that were significant ($\alpha = 0.05$) and had an R^2 of 0.50 or greater were used. Model significance at the 0.05 level was determined using the F-ratio of means square calculated as follows (Cornell, 1981):

$$F = \frac{\text{Sum of squares in full model} - \text{Sum of squares in reduced model}}{\text{Number of terms in full model} - \text{Number of terms in reduced model}} \times \frac{1}{\text{residual mean square of full model}}$$

Regression analysis was next performed on the means of the sensory attributes of the fitted models using the no intercept option to determine parameter estimates (Cornell and Linda, 1989). The parameter estimates from the no intercept option were used to predict the models for each sensory attribute. All models with $R^2 > 0.50$ were chosen. To determine the effects of the mixture components sugar, peanuts and cocoa powder on the properties of peanut chocolate bar, response surfaces were generated using PC SAS Graph (SAS, 1985).

Attaining the Optimum Formulation

The observation on each design point in sensory evaluation is usually represented by the mean score of several panelists (Gacula, 1993). The data from the two replicates were not significantly different from each other and were combined in the regression analysis. Models with a coefficient of determination (R^2) greater than 0.50 (Gills, 1998) and significant at $p < 0.05$ were used in prediction equations. These were overall liking color, flavor, sweetness and texture, while appearance with $R^2 < 0.50$ was not included in the development of prediction equations. Contour plots were generated from full models because the coefficient of determination (R^2) of the reduced models were low and could not be reduced further. In the descriptive tests, the dependent variables brown color, cocoa, roasted peanutty, peanut butter and burnt aroma had R^2 greater than 0.50 and were used to develop prediction equations.

Prediction models used in the optimization process were obtained from the regression analysis using the NOINT option. The acceptable regions on the contour plot for each dependent variable were defined as formulations that were predicted to result in consumer ratings ≥ 6.0 (6 = like slightly). The contour plots of the three degrees of roast for each dependent variable were superimposed to determine the areas of overlap or combinations of the components and roast that would result in optimum regions or formulations for peanut-chocolate bar.

Contour plots were plotted at each degree of roast where the lightness, Hunter L value, corresponding to a specific roast (light, $L = 51.0$; medium, $L = 48.0$; dark, $L = 45.0$), was substituted for the degree of roast for each response, there were three contour plots representing each attribute. All three plots were superimposed, and the area of overlap for all five attributes was considered the optimum region for maximum consumer acceptance.

In the descriptive test, the contour plots were likewise plotted at each degree of roast, superimposed, and the overlap region for the five attributes represented the intensity characteristics of formulations in the optimum region.

Technology Transfer of Peanut Chocolate Bar

The collaborator was informed through a telephone call and a letter about the completion of the optimization study and on the transfer of a formulation through a letter dated June 13, 2001. The letter is attached as Appendix B.

RESULTS

Physical Measurement (Color)

The results of color measurements made on peanut-chocolate bar are presented in Table 2.3. The *L* value of formulations containing 64% sugar was the lightest irrespective of the degree of roast used and was not affected by the amount of cocoa powder used in formulations with high amounts of sugar or peanuts. Peanut-chocolate bar containing 53% sugar, 43% peanuts and 4% cocoa powder had the darkest color for all degrees of roast.

Modeling of Consumer Acceptance of Peanut-Chocolate Bar

Table 2.4 shows the mean consumer ratings for overall liking, color, flavor, appearance, sweetness, texture and willingness to buy peanut-chocolate bar. The control sample had significantly low mean ratings for all attributes compared to the formulated peanut-chocolate bars, but these were not significantly different with blends containing 64% sugar and prepared from peanuts roasted to *L* value of 48 and 51. The consumers also expressed that they were not willing to buy a peanut-chocolate bar prepared from blends with 64% sugar with peanuts roasted to *L* value of 45, 48 or 51; and blends containing 61% sugar using peanuts roasted to an *L* value of 45.

Table 2.5 shows the prediction models generated from the regression analyses of acceptability mean scores for each attribute with the coefficients of determination (R^2) from the "with intercept option". Models which were significant at $p < 0.05$ and with $R^2 > 0.50$ were included, while the model for appearance was not included because it had an $R^2 < 0.50$.

Table 2.3 Color measurements of peanut-chocolate bar prepared from various levels of sugar, peanut, and cocoa powder (San Juan *et al*., 2007)

Formulation No.[a]	Degree of roast (*L* value)[b]	Lightness (*L* value)[c]
1	45	56.75
2	45	46.82
3	45	71.14
4	45	56.36
5	45	56.09
6	45	44.27
7	45	50.50
8	45	49.51
9	45	49.76
10	48	56.34
11	48	45.44
12	48	61.99
13	48	55.55
14	48	55.37
15	48	44.86
16	48	49.15
17	48	49.11
18	48	48.87
19	51	55.28
20	51	48.49
21	51	62.78
22	51	61.62
23	51	56.62
24	51	46.15
25	51	49.04
26	51	48.12
27	51	50.91

[a] The proportions of the components for the Formulation No. is found in Table 2.1.

[b] *L* value is the lightness of a color measured by the Hunter Color Lightness, *L* (Anonymous, 1979).

[c] Value is average of 4 measurements.

Table 2.4 Mean consumer ratings and standard deviations for acceptability of overall liking, color, appearance, flavor, sweetness, texture, and the willingness to buy peanut-chocolate bar with 2 replications[a] (San Juan *et al*., 2005)

Formulation	Factor levels[b]				Acceptability mean scores			
	Roast (x_1)	x_2	x_3	X_4	Overall liking	Color	Appearance	Flavor
1	45	0.450	0.540	0.010	6.78 (1.69)ab	6.65 (1.56)a	6.73 (1.45)a	6.98 (1.57)a
2	45	0.450	0.510	0.040	6.56 (1.76)abc	6.43 (1.66)abc	6.54 (1.63)abc	6.52 (1.75)abc
3	45	0.640	0.350	0.010	6.33 1.66)abcd	6.18 (2.01)abcd	6.10 (1.88)abcde	6.08 (1.84)bcde
4	45	0.610	0.350	0.040	5.90 (2.12)cde	6.08 (1.92)abcd	6.22 (1.87)abcde	5.68 (2.04)cde
5	45	0.550	0.440	0.010	6.54 (1.67)abc	6.40 (1.76)abcd	6.42 (1.77)abcd	6.42 (1.68)abc
6	45	0.530	0.430	0.040	6.56 (1.73)abc	6.62 (1.56)a	6.60 (1.55)abc	6.64 (1.60)ab
7	45	0.540	0.435	0.025	6.74 (1.38)abc	6.64 (1.35)a	6.54 (1.44)abc	6.76 (1.53)ab
8	45	0.490	0.485	0.025	6.49 (1.66)abc	6.31 (1.65)abcd	6.35(1.63)abcde	6.27 (1.78)abcd
9	45	0.580	0.395	0.025	6.06 (1.86)abcde	6.02 (1.75)abcd	6.14 1.62)abcde	6.10 (1.78)bcde
10	48	0.450	0.540	0.010	6.42 (1.95)abcd	5.78 (2.04)bcd	5.56 (2.07)e	6.50 (1.80)abc
11	48	0.450	0.510	0.040	6.67 (1.59)abc	6.63 (1.67)a	6.51 (1.71)abcd	6.84 (1.50)ab
12	48	0.640	0.350	0.010	5.61 (2.07)def	5.71 (2.02)cd	5.84 (2.07)cde	5.53 (2.21)def
13	48	0.610	0.350	0.040	6.27 (1.73)abcd	6.39 (1.52)abcd	6.39 (1.43)abcd	6.20 (1.70)abcde
14	48	0.550	0.440	0.010	6.85 (1.40)a	6.73 (1.45)a	6.73 (1.51)a	6.67 (1.54)ab
15	48	0.530	0.430	0.040	6.43 (1.61)abcd	6.53 (1.56)abc	6.55 (1.50)abc	6.22 (1.71)abcd
16	48	0.540	0.435	0.025	6.43 (1.58)abcd	6.43 (1.55)abc	6.35 (1.59)abcde	6.33 (1.74)abcd
17	48	0.490	0.485	0.025	6.33 (1.82)abcd	6.41 (1.73)abcd	6.43 (1.64)abcd	6.47 (1.96)abc
18	48	0.580	0.395	0.025	6.28 (1.57)abcd	6.50 (1.44)abc	6.20 (1.59)abcde	6.10 (1.70)bcde
19	51	0.450	0.540	0.010	6.64 (1.68)abc	6.12 (1.87)abcd	6.14 (1.87)abcde	6.48 (1.78)abc
20	51	0.450	0.510	0.040	6.82 (1.62)a	6.84(1.62)a	6.82 (1.29)a	6.71 (1.49)ab
21	51	0.640	0.350	0.010	5.39 (2.11)ef	5.59 (2.06)d	5.70 (1.95)de	5.37 (2.03)ef
22	51	0.610	0.350	0.040	5.94 (2.11)bcde	6.16 (1.90)abcd	6.10 (1.78)abcde	6.00 (1.89)bcde
23	51	0.550	0.440	0.010	6.10 (1.91)abcde	6.12 (1.78)abcd	6.44 (1.58)abcd	6.20 (1.81)abcde
24	51	0.530	0.430	0.040	6.10 (1.98)abcde	6.26 (1.76)abcd	6.20 (1.80)abcde	6.10 (2.06)bcde
25	51	0.540	0.435	0.025	6.50 (1.67)abc	6.56 (1.42)ab	6.40 (1.48)abcd	6.38 (1.65)abc
26	51	0.490	0.485	0.025	6.42 (1.72)abcd	6.34 (1.77)abcd	6.36 (1.77)abcd	6.46 (1.80)abc
27	51	0.580	0.395	0.025	6.86 (1.22)a	6.70 (1.20)a	6.70 (1.27)ab	6.69 (1.45)ab
28	Control [c]	-	-	-	4.99 (2.03)f	5.72 (1.80)cd	5.89 (1.56)bcde	4.87 (2.15)f
Range					1.87	1.13	1.26	2.11

Table 2.4 *continued…*

Formulation	**Factor levels**[b]				**Acceptability mean scores**		
	Roast (x_1)	**x_2**	**X_3**	**x_4**	**Sweetness**	**Texture**	**Willingness to buy**
1	45	0.450	0.540	0.010	6.61 (1.63)a	6.86 (1.44)a	1.17 (0.38)g
2	45	0.450	0.510	0.040	6.36 (1.75)ab	6.58 (1.62)abc	1.41 (0.93)bcdefg
3	45	0.640	0.350	0.010	5.59(2.07)bcde	5.96 (1.97)bcdef	1.53 (0.50)abcde
4	45	0.610	0.350	0.040	5.42 (2.20)cde	5.74 (2.05)cdef	1.60 (0.49)abcd
5	45	0.550	0.440	0.010	6.02 (1.90)abc	6.34 (1.73)abcd	1.30 (0.46)efg
6	45	0.530	0.430	0.040	6.31 (1.79)abc	6.28 (1.73)abcd	1.31 (0.47)efg
7	45	0.540	0.435	0.025	6.62 (1.56)a	6.66 (1.44)ab	1.17 (0.43)fg
8	45	0.490	0.485	0.025	5.90 (2.17)abcd	6.00 (1.92)bcdef	1.28 (0.45)efg
9	45	0.580	0.395	0.025	5.71 (1.84)abcde	6.08 (1.67)abcde	1.37 (0.49)cdefg
10	48	0.450	0.540	0.010	6.24 (1.81)abc	6.08 (1.88)abcde	1.40 (0.53)bcdefg
11	48	0.450	0.510	0.040	6.51 (1.72)ab	6.59 (1.54)abc	1.33 (0.48)efg
12	48	0.640	0.350	0.010	4.98 (2.29)e	5.59 (2.09)def	1.61 (0.49)abc
13	48	0.610	0.350	0.040	6.33 (1.67)ab	6.24 (1.64)abcde	1.43 (0.54)abcdef
14	48	0.550	0.440	0.010	6.47 (1.60)ab	6.88 (1.28)a	1.29 (0.46)efg
15	48	0.530	0.430	0.040	6.16 (1.83)abc	6.12 (1.81)abcde	1.34 (0.48)efg
16	48	0.540	0.435	0.025	6.27 (1.83)abc	6.53 (1.37)abc	1.27 (0.49)fg
17	48	0.490	0.485	0.025	6.14 (2.05)abc	6.37 (1.84)abcd	1.25 (0.44)fg
18	48	0.580	0.395	0.025	6.06 (1.62)abc	6.22 (1.61)abcde	1.37 (0.49)cdefg
19	51	0.450	0.540	0.010	6.42 (1.63)abc	6.46 (1.84)abc	1.24 (0.43)fg
20	51	0.450	0.510	0.040	6.48 (1.85)ab	6.72 (1.58)ab	1.18 (0.39)fg
21	51	0.640	0.350	0.010	5.10 (1.98)de	5.45 (2.14)ef	1.66 (0.94)a
22	51	0.610	0.350	0.040	5.82 (2.09)abcd	5.94 (1.87)bcdef	1.42 (0.57)bcdefg
23	51	0.550	0.440	0.010	6.14 (1.85)abc	6.26 (1.76)abcde	1.29 (0.46)efg
24	51	0.530	0.430	0.040	5.90 (2.10)abcd	6.30 (1.84)abcd	1.38 (0.49)cdefg
25	51	0.540	0.435	0.025	6.12 (1.70)abc	6.62 (1.48)ab	1.36 (0.48)defg
26	51	0.490	0.485	0.025	6.22 (1.90)abc	6.32 (1.79)abcd	1.29 (0.50)efg
27	51	0.580	0.395	0.025	6.29 (1.62)abc	6.55 (1.57)abc	1.38 (0.49)cdefg
28	Control	-	-	-	4.99 (1.98)e	5.21 (1.93)f	1.63 (0.49)ab
Range					1.64	1.67	0.49

[a] Numbers in parenthesis refer to standard deviation of 25 consumer responses. A 9-point hedonic scale was used for acceptability means scores (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely), and a yes or no response for willingness to but (1 = yes and 2 = no). Mean values in the same column not followed by the same letter are significantly different ($p \leq 0.05$). Range values were calculated as the differences between the highest and lowest mean scores for each dependent variable.

[b] Factors were the process variable roast (x_1) and the proportions of the components sugar (x_2), peanut (x_3) and cocoa powder (x_4).

[C] Control, commercially available peanut-chocolate bar.

Table 2.5 Prediction equations[a] for sensory attributes overall acceptability and acceptability of color, appearance, flavor, sweetness, and texture (San Juan *et al*., 2005)

Variable	**Model**	**R^2**
Overall acceptability	$2.36x_1 + 7.22x_2 - 5.48x_3 - 410.86x_4 - 0.0011x_1^2 - 2.47x_1x_2 - 2.17x_1x_3 + 24.04x_2x_3 + 336.17x_2x_4 + 320.52x_3x_4$	0.5733
Color acceptability	$2.89x_1 - 3.45x_2 - 5.11x_3 - 286.34x_4 - 0.0026x_1^2 - 2.72x_1x_2 - 2.72x_1x_3 + 33.06x_2x_3 + 178.61x_2x_4 + 194.40x_3x_4$	0.5279
Appearance acceptability	$0.47x_1 + 13.04x_2 + 11.0x_3 + 247.75x_4 + 0.0060x_1^2 - 1.08x_1x_2 - 1.10x_1x_3 + 40.82x_2x_3 - 289.26x_2x_4 - 257.95x_3x_4$	0.4551
Flavor acceptability	$2.60x_1 + 1.93x_2 + 8.92x_3 - 464.26x_4 - 0.00015x_1^2 - 2.64x_1x_2 - 2.71x_1x_3 + 20.25x_2x_3 + 386.52x_2x_4 + 351.89x_3x_4$	0.6653
Sweetness acceptability	$2.01x_1 - 19.45x_2 - 13.34x_3 - 211.61x_4 - 0.0078x_1^2 - 1.29x_1x_2 - 1.33x_1x_3 + 27.73x_2x_3 + 196.98x_2x_4 + 110.48x_3x_4$	0.6412
Texture acceptability	$2.51x_1 - 3.98x_2 - 4.72x_3 - 195.67x_4 - 0.0023x_1^2 - 2.36x_1x_2 - 2.34x_1x_3 + 32.75x_2x_3 + 103.72x_2x_4 + 96.72x_3x_4$	0.5521

[a] Equations used were the full model. Consumer ratings based on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

[b] Where x_1 is the process variable roast and x_2, x_3 and x_4 are the proportions of the components sugar, peanut and cocoa powder used in the mixture to formulate peanut-chocolate bar.

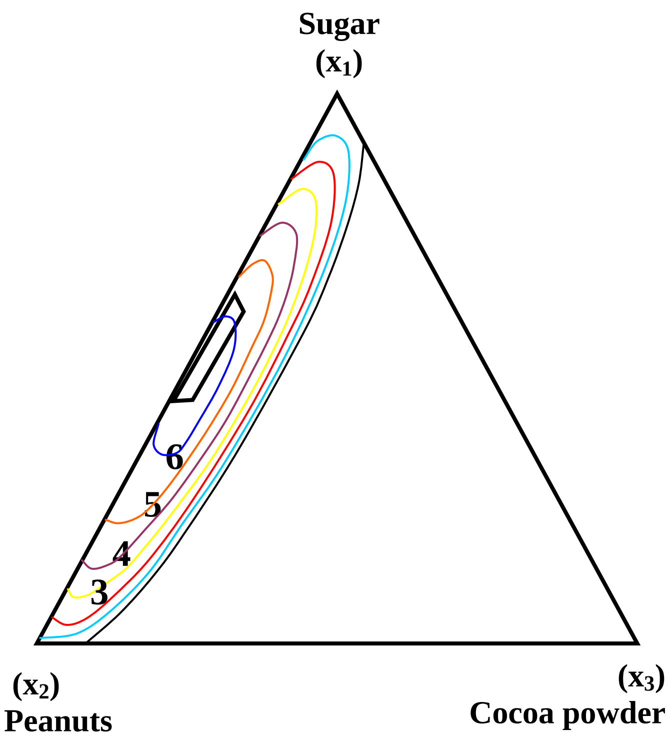
All models significant at $p < 0.05$.

Figures 2.2 to 2.6 show the contour plots for overall liking, color, flavor, sweetness, and texture obtained using the predictive models for consumer acceptance scores of the attributes tested. For each figure, four plots are shown. Three plots represent the contour plots for a sensory attribute at each degree of roast (*L*-value = 45, 48 and 51), and the fourth plot is the superimposed plot of the three degrees of roast for a sensory attribute. The shaded regions of the superimposed plots represent values for consumer acceptance for a particular sensory attribute corresponding to scores of 6 (like slightly) or greater.

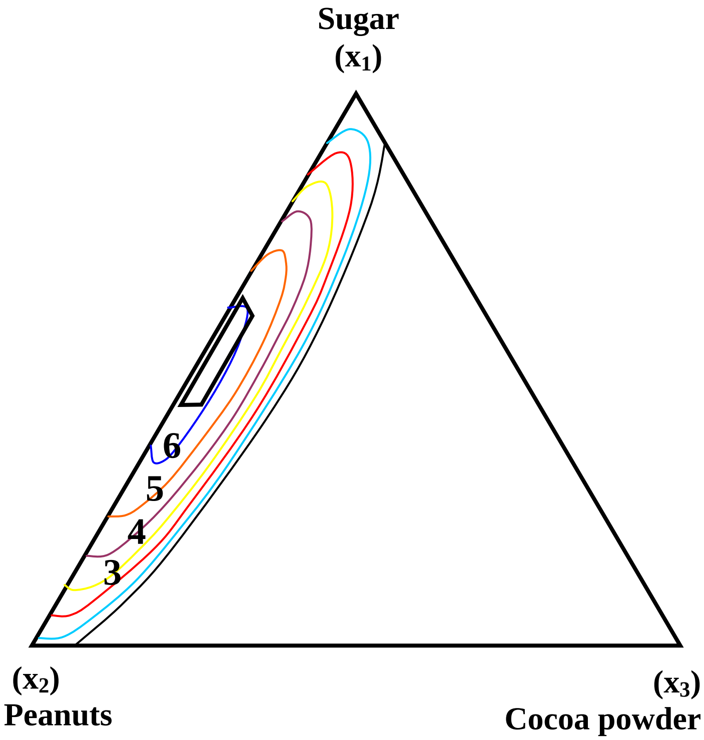
Figure 2.2 presents the contour plots for overall liking for the three degrees of roast. The overall liking of the formulations increased with the degree of roast. The acceptable number of formulations was greatest when the degree of roast was low (*L* value = 45) and least when the degree of roast was high (*L* value = 51). Overall liking of the product was influenced by sugar content wherein lower ratings were obtained by formulations containing 61-64% sugar.

Figure 2.3 shows the contour plots for color. The color of most of the formulations were acceptable within the constrained region. The number of acceptable formulations increased in peanut-chocolate bars prepared with peanuts roasted to L value of 51 to peanuts roasted to L value of 45.

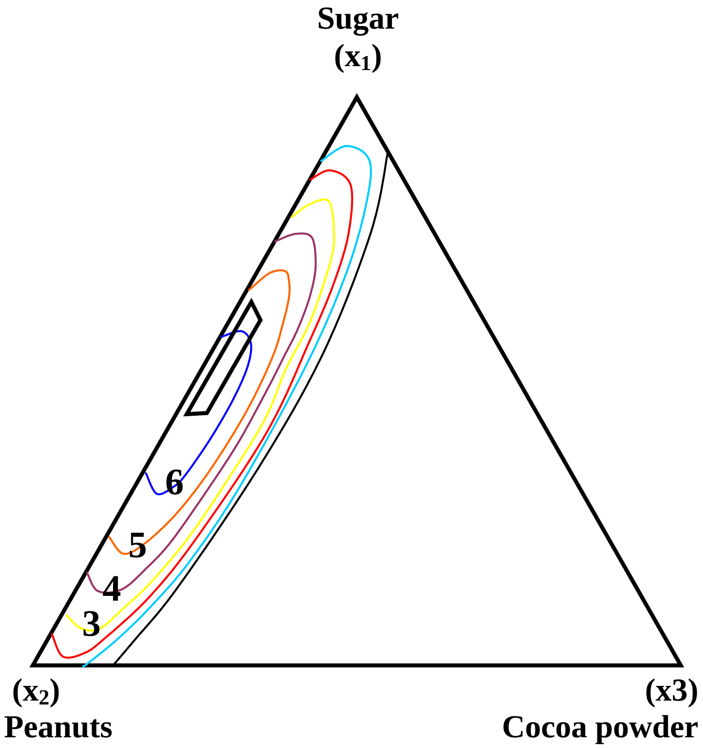
Acceptable formulations for flavor (Fig. 2.4) was greatest in peanut-chocolate bars prepared with peanuts roasted to *L* value of 48 and least in formulations prepared from peanuts roasted to an *L* value of 51.



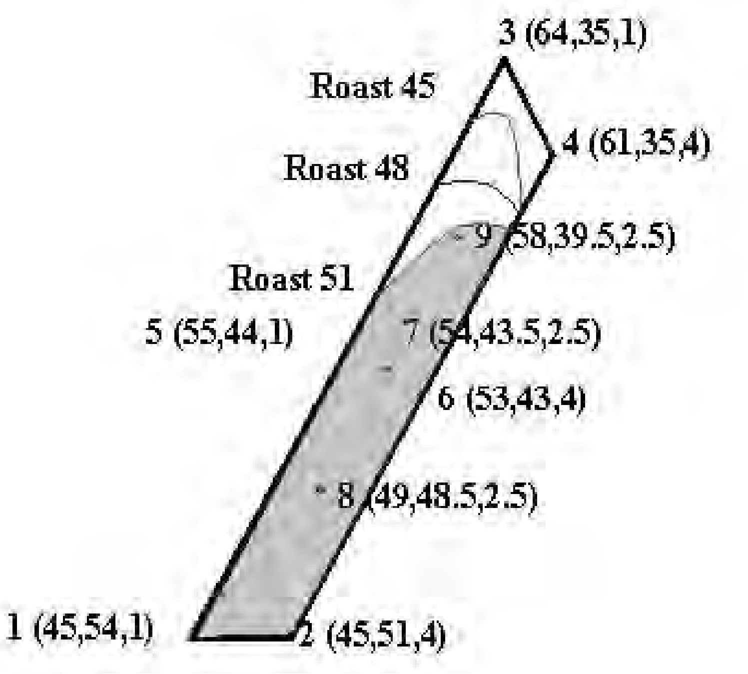
Roast 45 (*L* value = 45)



Roast 48 (*L* value = 48)

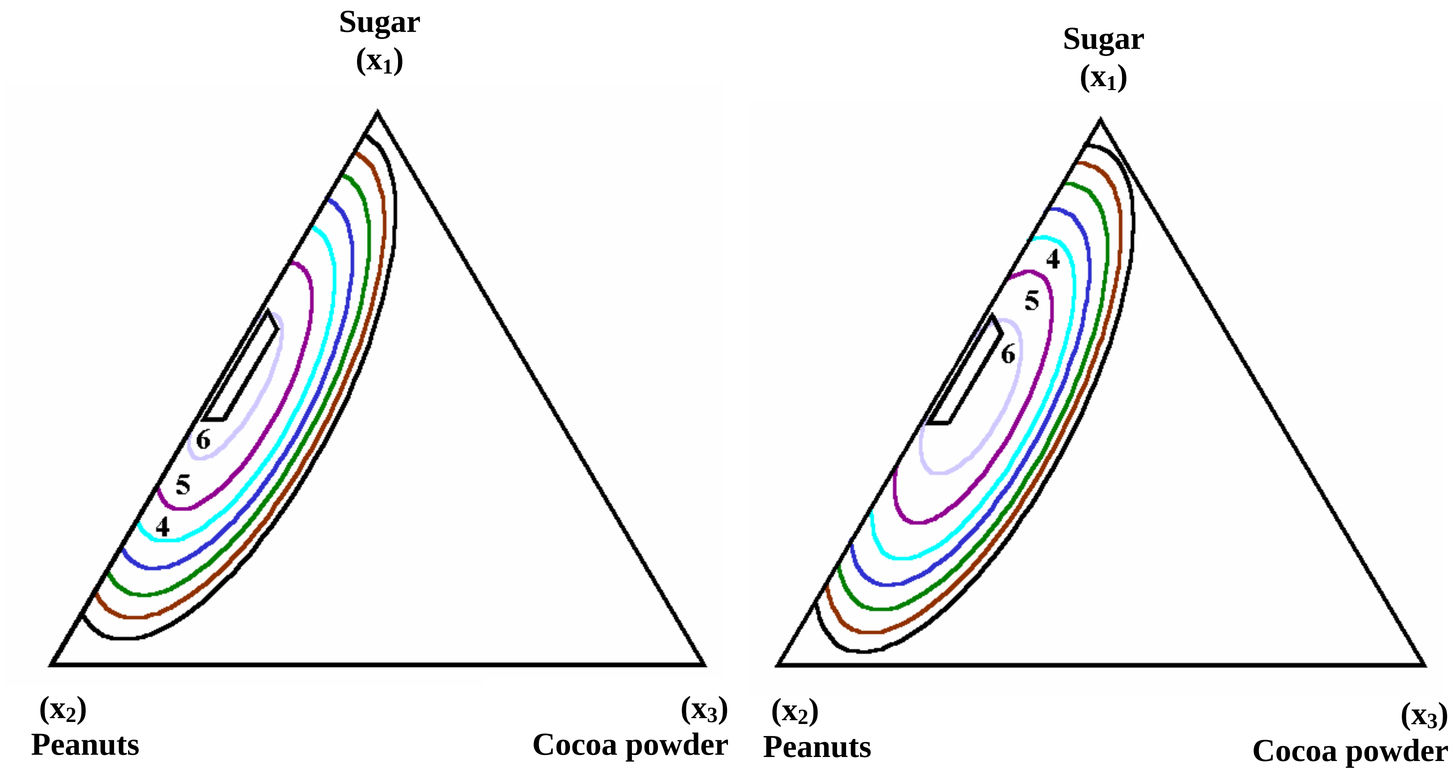


Roast 51 (*L* value =51)



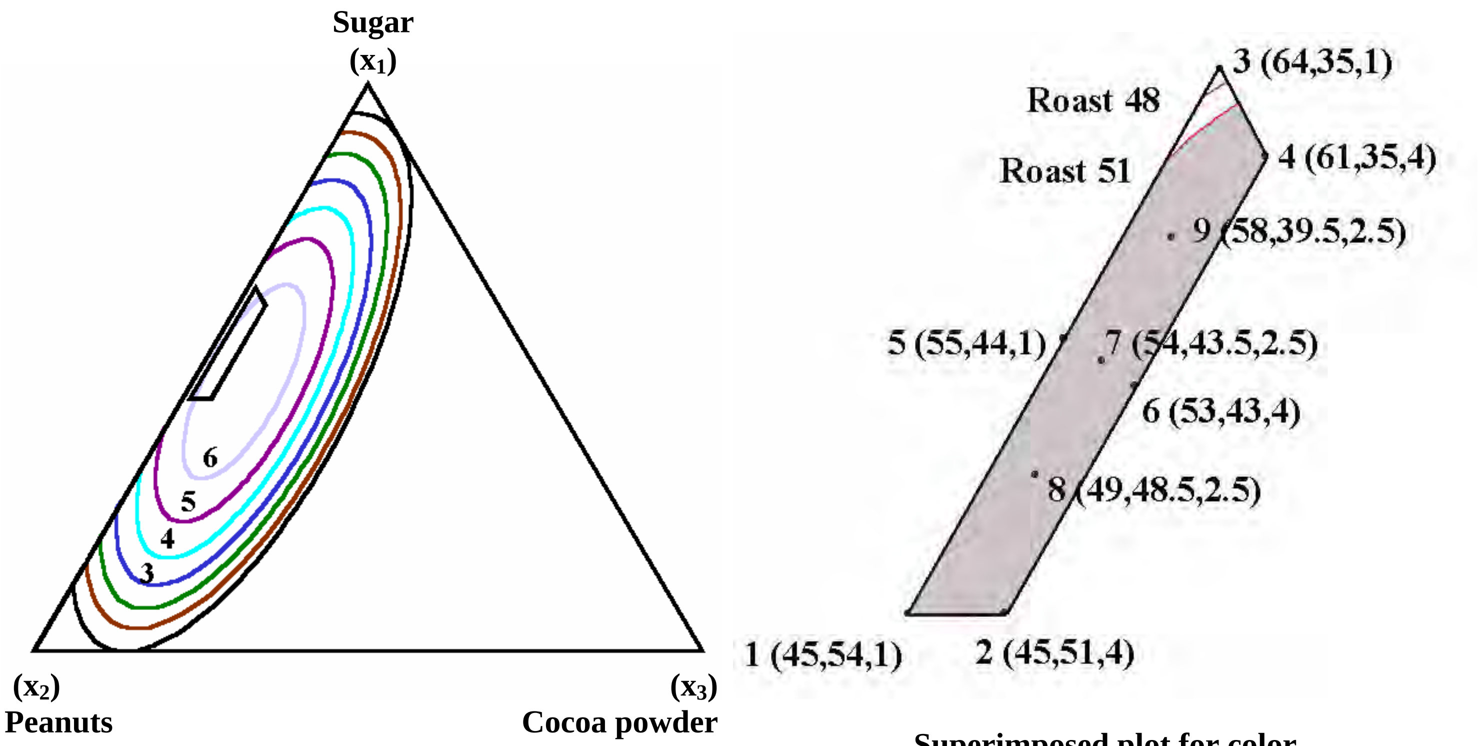
Superimposed plot for overall acceptability

Fig. 2.2 Contour plots for overall liking obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed contour plot for overall liking of peanut-chocolate bar.



Roast 45 (*L* value = 45)

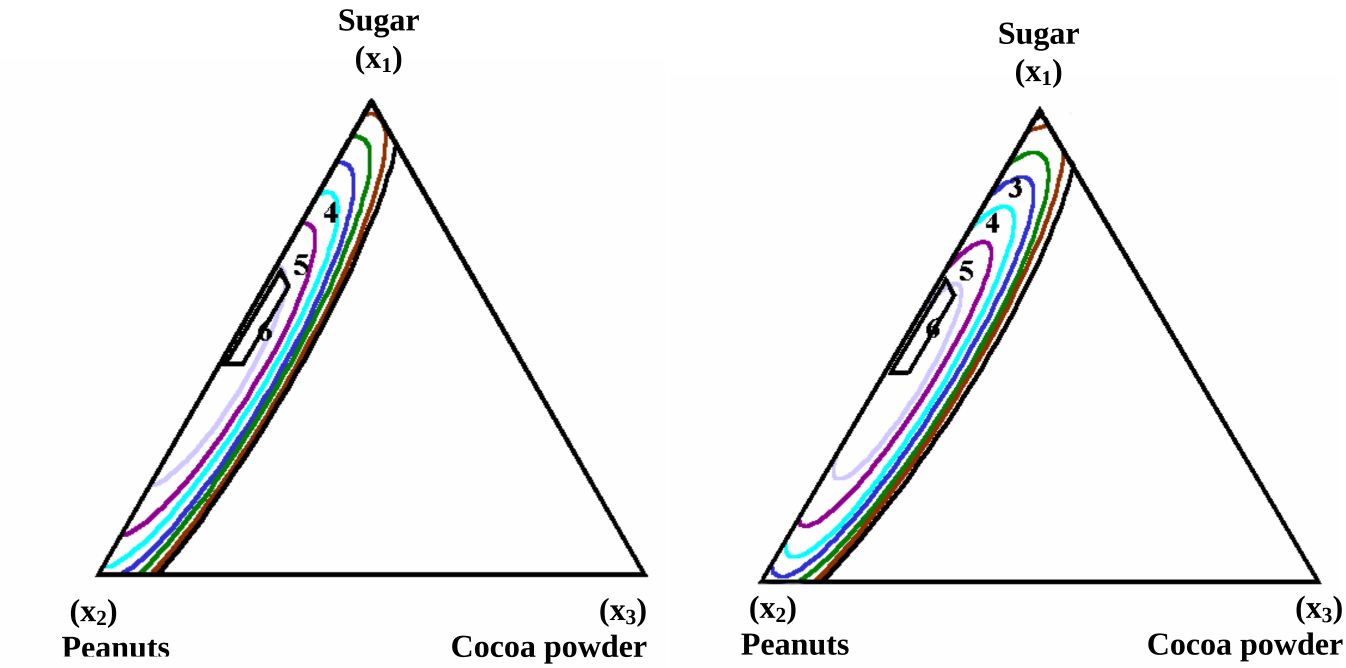
Roast 48 (*L* value = 48)



Roast 51 (*L* value = 51)

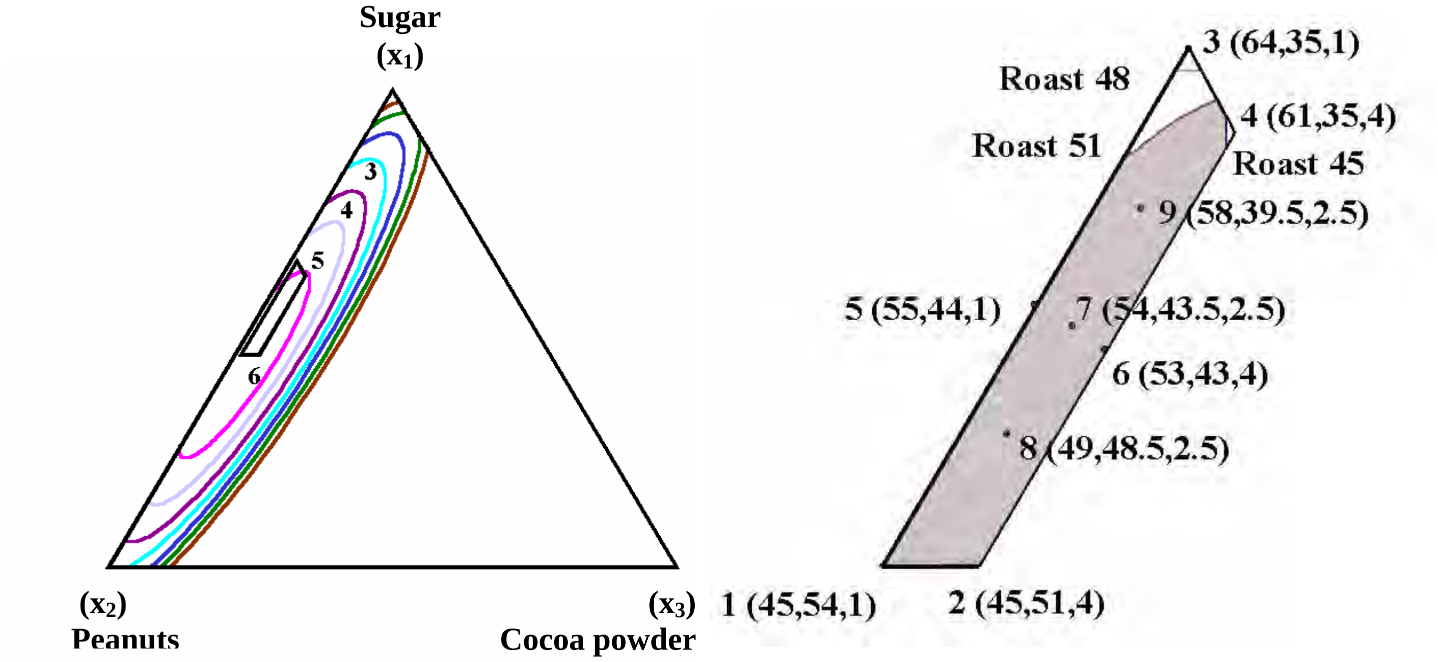
Superimposed plot for color

Fig. 2.3 Contour plots for color obtained from three different roasts (*L*- value = 45, 48, and 51) and a superimposed plot for color of peanut-chocolate bar.



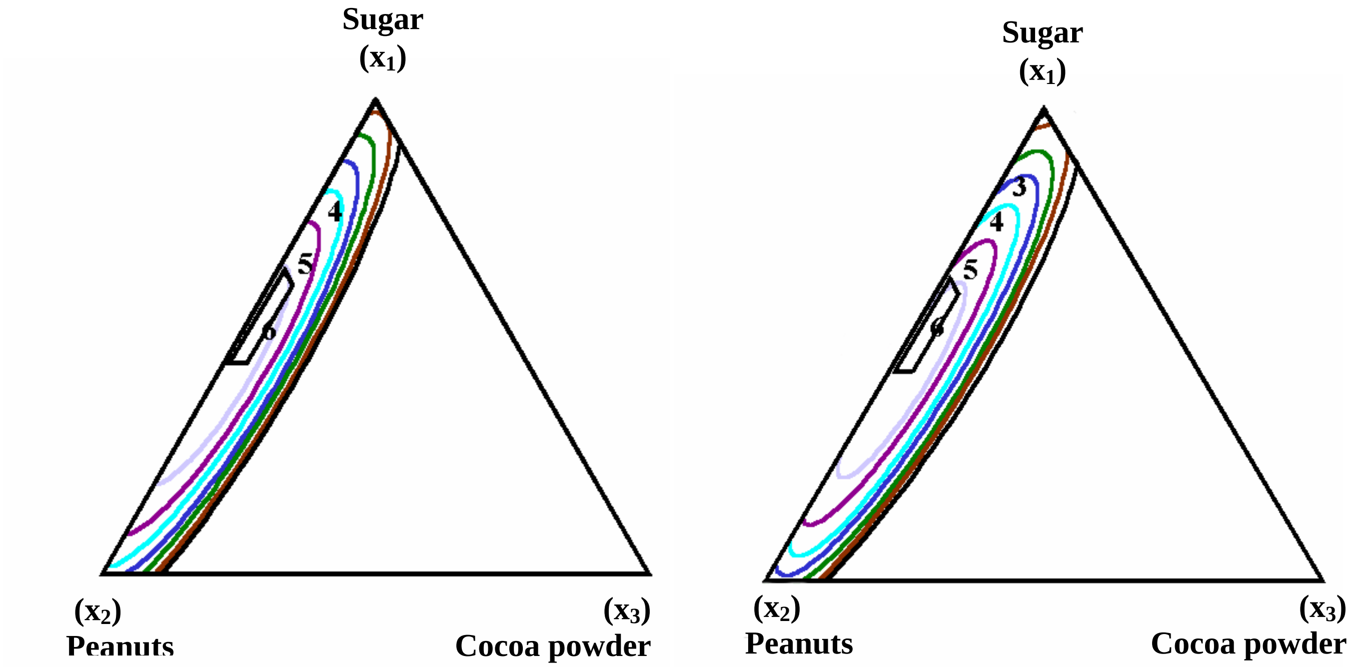
Roast 45 (*L* value = 45)

Roast 48 (*L* value = 48)



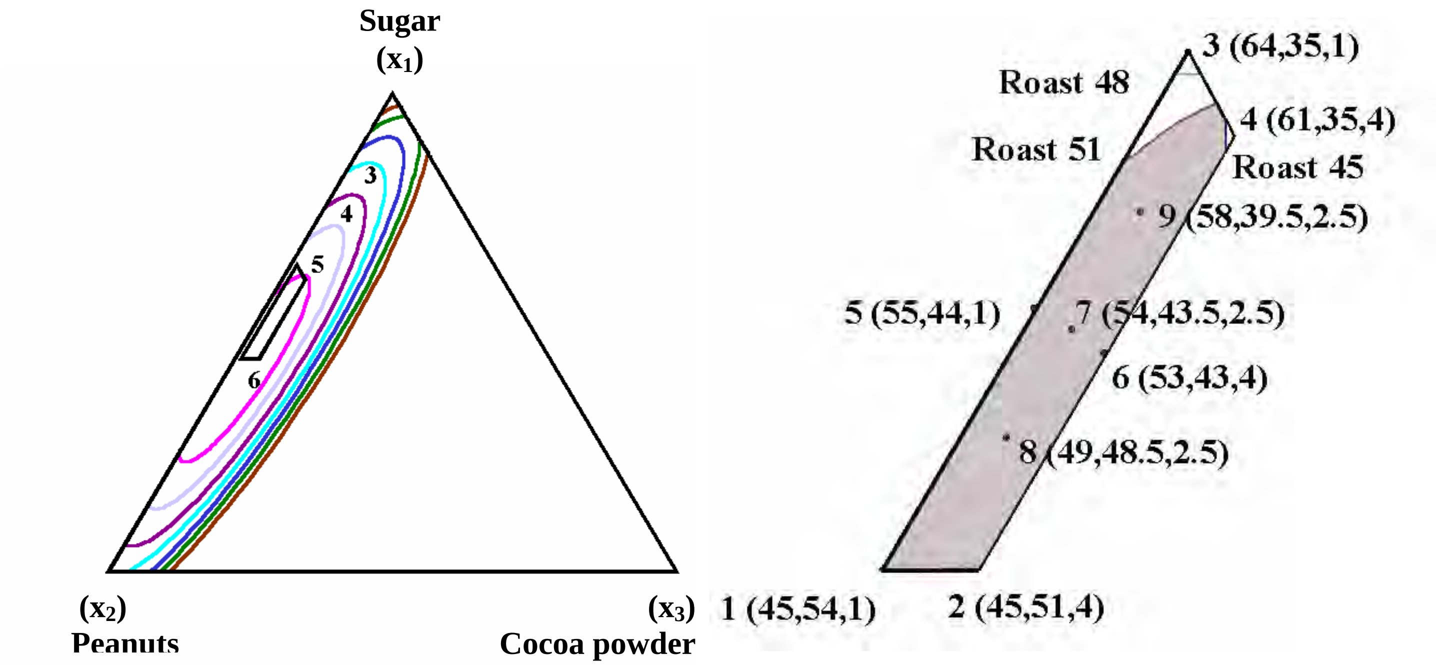
Roast 51 (*L* value = 51)

Fig. 2.4 Contour plots for flavor obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed plot for flavor of peanut-chocolate bar.



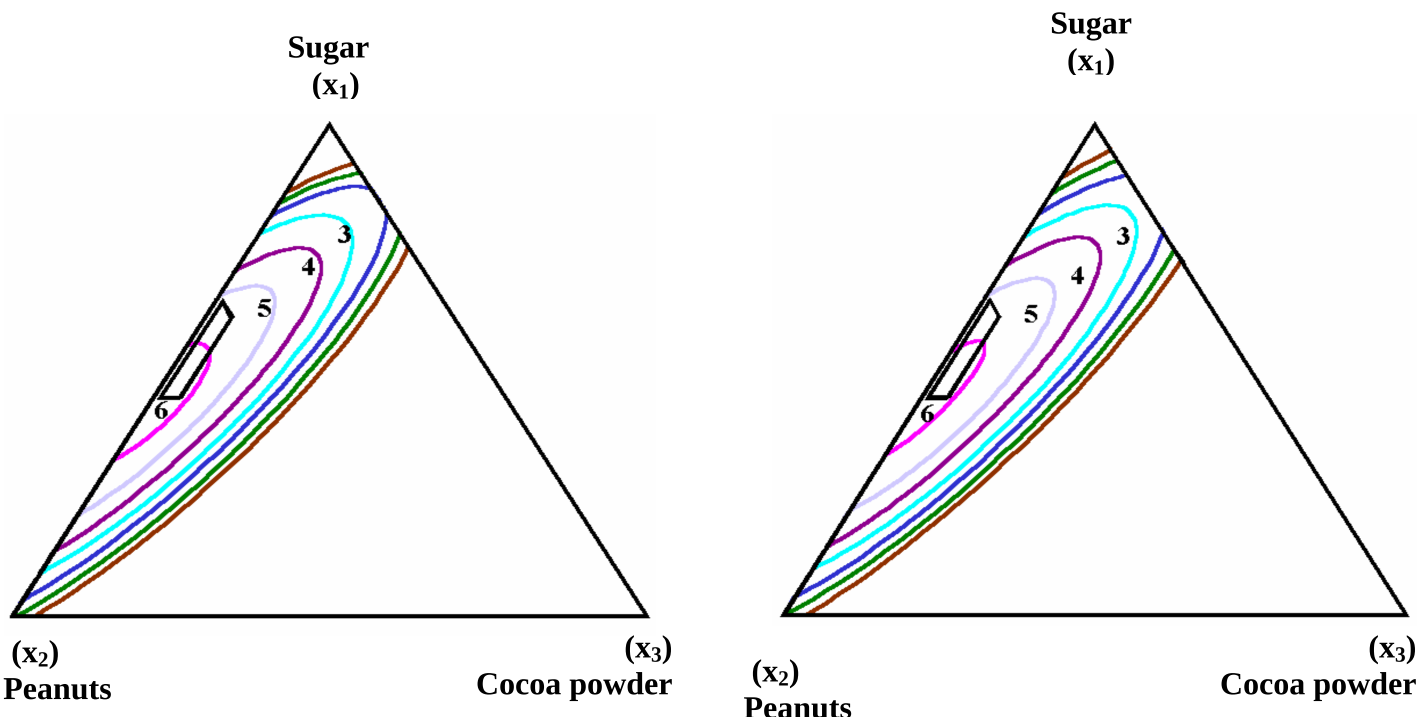
Roast 45 (*L* value = 45)

Roast 48 (*L* value = 48)



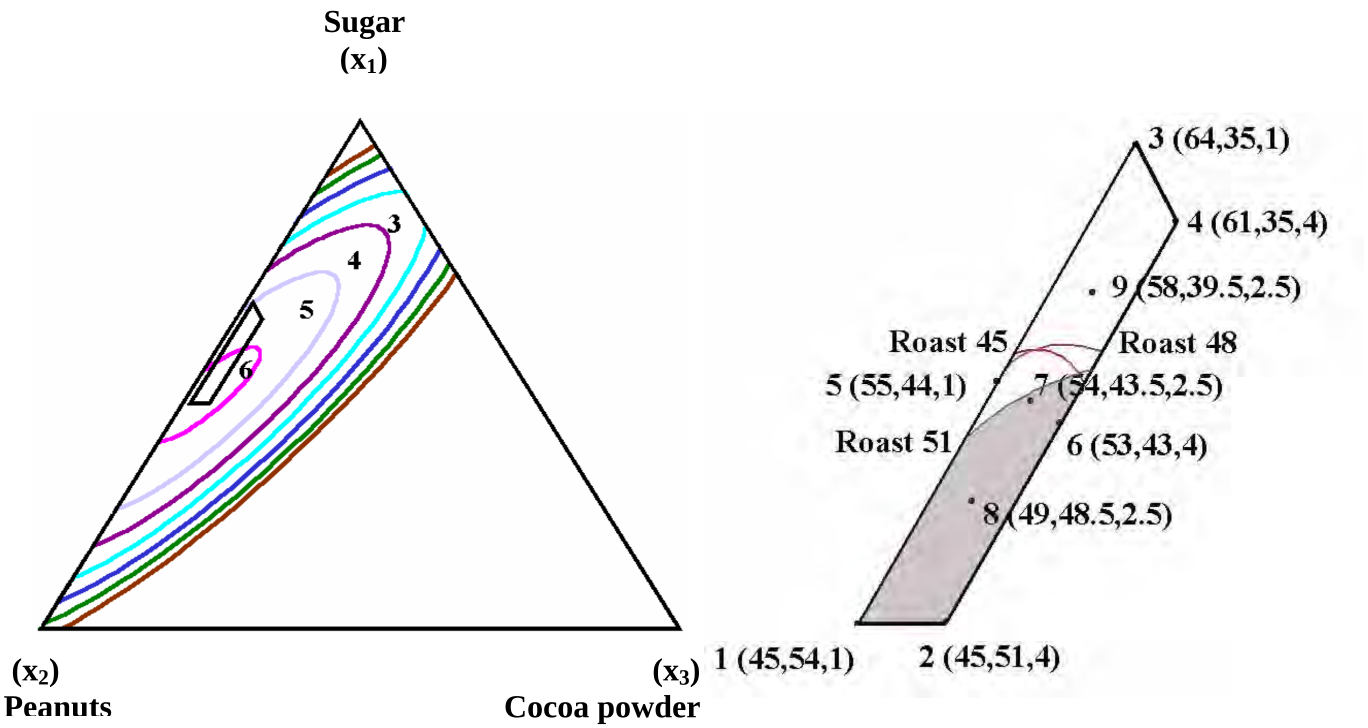
Roast 51 (*L* value = 51)

Fig. 2.4 Contour plots for flavor obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed plot for flavor of peanut-chocolate bar.



Roast 45 (*L* value = 45)

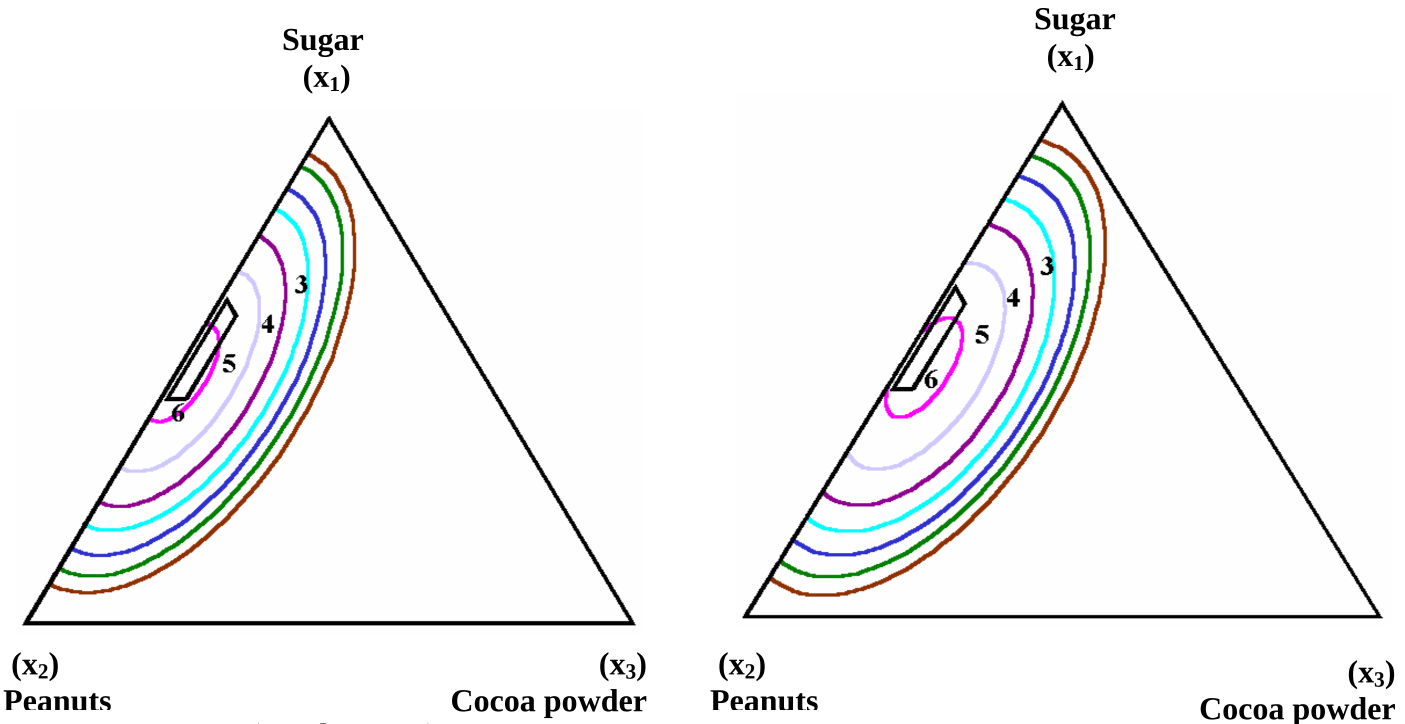
Roast 48 (*L* value = 48)



Roast 51 (*L* value = 51)

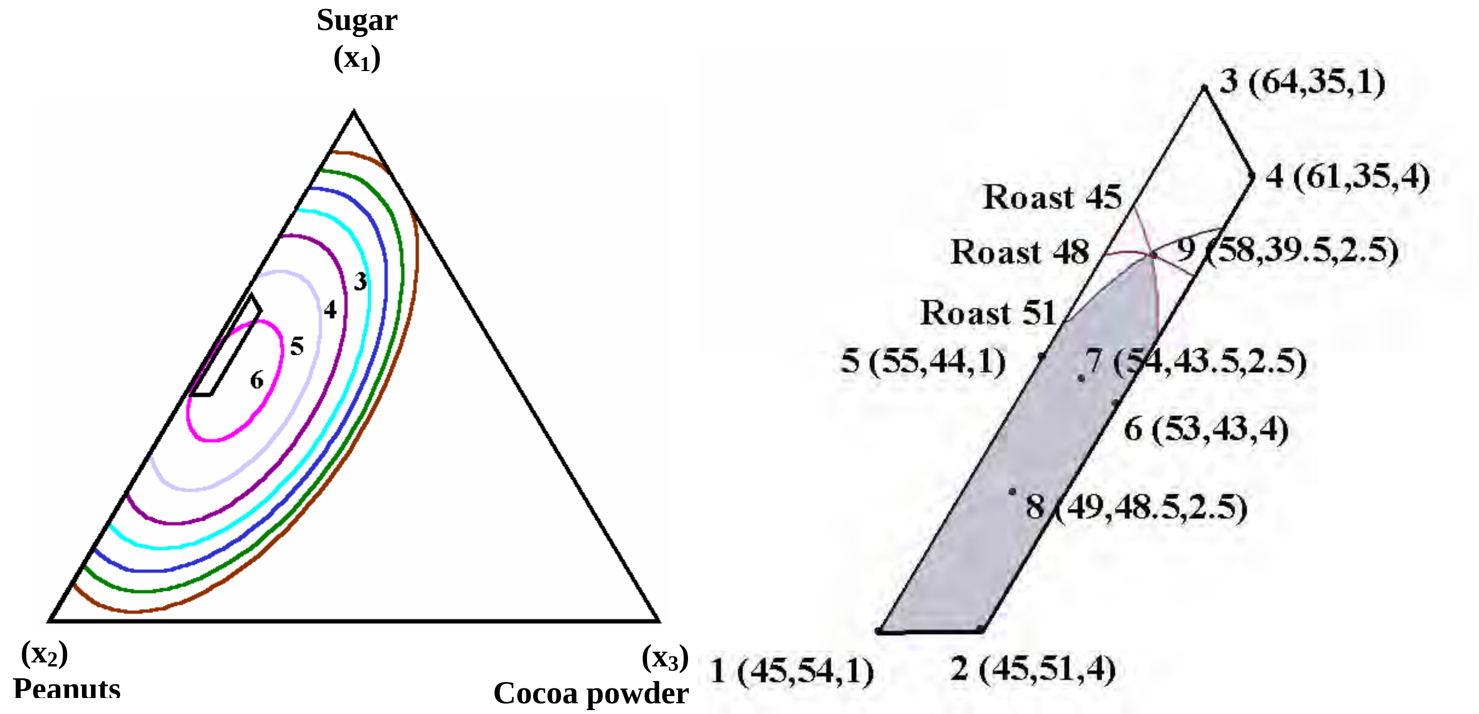
Superimposed plot for sweetness

Fig. 2.5 Contour plots for sweetness obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed plot for sweetness of peanut-chocolate bar.



Roast 45 (*L* value = 45)

Roast 48 (*L* value = 48)



Roast 51 (*L* value = 51)

Superimposed plot for texture

Fig. 2.6 Contour plots for texture obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed plot for texture of peanut-chocolate bar.

Figure 2.5 shows the negative effect of sweetness in the formulations. Acceptable formulations in any degree of roast were observed in formulations with sugar content of ≤ 55% Peanut-chocolate bars prepared from peanuts roasted to a medium roast (*L* value of 48) had the most number of acceptable formulations for sweetness, while the least number of acceptable formulations was observed in peanut-chocolate bars prepared with peanuts roasted to *L* value of 45.

Contour plots for texture (Fig. 2.6) shows that more acceptable formulations were obtained in peanut-chocolate bars prepared with peanuts roasted to *L* values of 45 or 51, than in peanuts roasted to an *L* value of 48. Acceptable texture could be obtained in formulations containing ≤ 55% when prepared with peanuts roasted to an *L* value of 45 or 51, or sugar content should be increased to 58% when prepared with peanuts roasted to an *L* value of 48.

The intensity of roasted peanutty aroma with the three degrees of roast is shown in Fig. 2.10. The intensity of roasted peanutty aroma was higher in peanut-chocolate bars prepared with peanuts roasted to an *L* value of 45 and lower when prepared with peanuts roasted to an *L* value of 51. Blends with more peanuts had higher intensity of the roasted peanutty aroma.

Figure 2.11 shows the contour plots for peanut butter aroma with the three degrees of roast. Peanut-chocolate bars prepared with peanuts roasted to a dark or medium roast (*L* value = 45) had higher intensity of the peanut butter aroma and lower when prepared with peanuts roasted to a light roast (*L* value = 51).

The effect of the degrees of roast on the burnt aroma in peanut-chocolate bars (Fig. 2.12) shows that the intensity of burnt aroma was minimal which ranged from 3 to 8 in samples with peanuts prepared to a dark roast (*L* value = 45), ranged from 2 to 6 in samples with peanuts prepared to a medium (*L* value = 48) or light roast (*L* value = 51).

Attaining the Optimum Formulation

The predicted models at each level of roast for overall acceptability, color, flavor, sweetness and texture were used to generate contour plots (Figs. 2.2 to 2.6). For each contour plot, the areas representing a consumer acceptance rating of ≥ 6.0 were shaded as illustrated in the superimposed plot for each attribute. This area of overlap was used to determine formulations of maximum consumer acceptance.

The regions of overlap representing the optimum formulations of a peanut-chocolate bar are outlined in Fig. 2.13 showing the boundaries of optimum regions at each degree of roast. The plots show that the intensity of sweetness was the limiting factor in its preparation. Optimum formulations for acceptable peanut-chocolate bars could be obtained at any degree of roast in formulations containing 41-55% sugar, 44-54% peanuts, and 1-4% cocoa powder totaling 100%. Since the intensity of sweetness affects the product's acceptability, formulations with sugar reduced to 56% could be acceptable when combined with peanuts roasted to a medium- (*L* = 48) or light-roast (*L* = 51). The range of optimum formulations will help a peanut-chocolate bar manufacturer conserve energy by choosing formulations with less sugar and more peanuts. Sweetness of the product could also be affected by the maturity and cultivar of peanuts. Thus, it is important to know the source or geographic location of peanuts used in processing.

Table 2.6 Mean intensity ratings[a] and standard deviations of sensory attributes of peanut-chocolate bar (San Juan et al., 2007)

Formulation No.	Factor Levels[b]				Sensory Attribute Ratings					
	Roast (x_1)	x_2	x_3	x_4	Maintains its form/shape	Brown color	Smooth surface	Speckledness	Homogeneous	Oiliness
1	45	0.450	0.540	0.010	90.78±7.41ab	48.84±18.38i	100.17±9.51ab	12.52±6.28ab	88.99±16.10cdefg	22.75±23.32abc
2	45	0.450	0.510	0.040	88.94±6.93ab	86.94±24.08abcd	91.76±23.05b	21.16±20.77a	92.96±5.62bcdefg	16.12±24.94bcd
3	45	0.640	0.350	0.010	86.39±8.12ab	42.18±20.83ij	98.41±8.79ab	15.95±12.83ab	90.75±7.08cdefg	8.09±20.05cd
4	45	0.610	0.350	0.040	89.33±8.87ab	65.70±16.04fgh	102.99±12.18a	17.20±8.11ab	89.82±15.23cdefg	4.37±5.38d
5	45	0.550	0.440	0.010	88.39±8.01ab	47.72±18.46i	99.04±9.47ab	12.14±9.79b	92.33±10.63bcdefg	16.84±26.52bcd
6	45	0.530	0.430	0.040	90.26±10.25ab	88.88±20.43abc	101.44±10.94ab	16.84±12.87ab	94.58±10.56abcdefg	12.31±16.14cd
7	45	0.540	0.435	0.025	89.17±6.22ab	67.27±22.90fgh	102.48±3.27a	15.94±9.48ab	89.76±5.48cdefg	13.83±24.98cd
8	45	0.490	0.485	0.025	88.28±8.77ab	80.70±19.15bcdef	99.38±15.17ab	16.15±8.78ab	92.54±5.29bcdefg	13.84±21.95cd
9	45	0.580	0.395	0.025	90.98±7.67ab	64.72±18.06gh	98.51±10.73ab	21.07±15.14a	90.53±5.38cdefg	15.81±25.07bcd
10	48	0.450	0.540	0.010	90.32±11.84ab	56.43±19.15ih	98.18±11.37ab	14.63±10.16ab	89.23±15.97cdefg	11.52±14.83cd
11	48	0.450	0.510	0.040	89.85±9.01ab	96.65±19.47a	98.81±14.62ab	13.44±10.05ab	98.44±14.17abc	31.63±28.18ab
12	48	0.640	0.350	0.010	90.41±9.58ab	43.59±20.01ij	101.49±9.74ab	13.11±8.91ab	92.70±14.38bcdefg	17.69±26.67bcd
13	48	0.610	0.350	0.040	86.63±21.90ab	71.92±21.94efg	94.40±23.89a	15.60±6.95ab	85.63±22.19g	12.47±20.57cd
14	48	0.550	0.440	0.010	94.37±7.80a	48.94±19.52i	103.27±14.74a	10.32±6.16b	103.28±10.68a	16.09±15.47bcd
15	48	0.530	0.430	0.040	87.88±7.72ab	92.14±21.98ab	98.12±12.11ab	18.27±15.37ab	92.06±11.43bcdefg	17.53±21.50bcd
16	48	0.540	0.435	0.025	87.72±17.35ab	73.68±21.33defg	98.98±13.49ab	17.44±14.02ab	88.18±12.80defg	21.33±30.84bc
17	48	0.490	0.485	0.025	88.06±22.68ab	87.15±26.59abcd	97.97±25.34ab	14.92±10.35ab	92.39±24.44bcdefg	23.52±21.01abc
18	48	0.580	0.395	0.025	83.42±21.41b	68.03±23.48fgh	93.68±23.41ab	16.40±14.07ab	85.75±20.61fg	11.26±22.30cd
19	51	0.450	0.540	0.010	93.43±9.87a	45.39±11.99i	99.86±12.20ab	12.56±6.73ab	91.59±12.31bcdefg	21.75±22.19abc
20	51	0.450	0.510	0.040	90.08±4.69ab	87.70±20.73abcd	100.25±7.93ab	18.64±15.70ab	86.86±8.54efg	15.61±20.30bcd
21	51	0.640	0.350	0.010	90.86±11.40ab	30.26±14.06j	101.55±10.43ab	15.68±7.95ab	95.40±12.88abcdef	9.65±16.80cd
22	51	0.610	0.350	0.040	89.91±7.03ab	75.89±22.30cdefg	101.04±9.09ab	16.47±12.74ab	93.28± 8.03bcdefg	9.73±22.05cd
23	51	0.550	0.440	0.010	87.91± 7.92ab	43.74±24.46ij	100.91±8.50ab	10.24±4.37b	95.76±7.23abcde	7.93±14.19cd
24	51	0.530	0.430	0.040	91.25±7.66ab	83.51±19.92abcde	99.63±12.15ab	16.32±10.18ab	94.05±10.80bcdefg	11.10±15.65cd
25	51	0.540	0.435	0.025	87.38±9.61ab	70.05±14.41efgh	101.17±6.37ab	17.41±7.83ab	90.82±7.65cdefg	13.41±21.39cd
26	51	0.490	0.485	0.025	90.13±12.48ab	70.73±27.32efgh	102.76±11.50a	11.76± 4.85b	100.36±14.54ab	36.40±32.78a
27	51	0.580	0.395	0.025	92.37±8.07a	72.03±15.80efg	100.25±14.36ab	14.95±7.15ab	89.99±8.11cdefg	9.73±16.29cd
28	Control	-	-	-	92.83±9.22a	87.11±19.60abcd	100.86±8.36ab	17.71±12.63ab	96.82±10.52abcd	21.02±17.62bc

Table 2.6 *continued . . . .*

Formulation No.	**Factor Levels**^{b}				**Sensory Attribute Ratings**					
	Roast (x_1)	**x_2**	**x_3**	**x_4**	**Cocoa**	**Roasted peanutty**	**Peanut butter**	**Burnt**	**Oxidized**	**Milky**
1	45	0.450	0.540	0.010	35.89±15.16gh	59.13±6.61a	67.80±6.39a	7.63±19.85a	2.61±6.98b	14.81±8.37a
2	45	0.450	0.510	0.040	47.60±10.94abcd	53.38±8.16abcd	62.03±8.22abcd	4.80±8.41abcd	2.91±5.38b	16.35±8.40a
3	45	0.640	0.350	0.010	36.32±7.62gh	54.18±7.70abcd	61.48±9.89abcd	1.10±2.31d	2.08±4.29b	16.11±7.54a
4	45	0.610	0.350	0.040	47.00±7.09abcde	53.89±6.50abcd	62.19±4.33abcd	4.93±13.56abcd	2.61±8.83b	13.66±8.08a
5	45	0.550	0.440	0.010	34.53±9.55gh	55.35±7.09abcd	64.70±7.33abc	3.20±6.79abcd	2.60±6.41b	16.02±8.61a
6	45	0.530	0.430	0.040	49.61±5.63abc	55.05±6.85abcd	63.00±7.94abc	5.49±6.06abcd	0.24±0.38b	15.11±9.26a
7	45	0.540	0.435	0.025	45.51±7.88abcdef	57.04±8.91ab	65.17±7.96abc	2.74±3.67abcd	2.03±4.60b	15.75±9.34a
8	45	0.490	0.485	0.025	44.69±4.81bcdef	55.98±7.76abcd	62.35±7.95abcd	7.15±7.68ab	3.24±7.52b	15.31±7.79a
9	45	0.580	0.395	0.025	40.95±9.66defg	54.77±9.84abcd	61.53±7.13abcd	5.94±10.58abcd	1.37±2.60b	15.27±6.87a
10	48	0.450	0.540	0.010	38.15±9.88fg	54.61±6.75abcd	62.52±9.84abcd	1.44±3.49cd	1.31±3.83b	17.81±8.52a
11	48	0.450	0.510	0.040	52.62±9.08a	54.15±10.08abcd	60.81±9.25abcd	6.15±7.47abcd	3.02±4.67b	16.05±9.01a
12	48	0.640	0.350	0.010	33.63±10.27gh	50.13±8.28bcd	59.67±7.48bcde	1.12±1.24d	2.91±5.12b	17.92±8.23a
13	48	0.610	0.350	0.040	45.44±12.59abcdef	52.43±15.65abcd	58.58±15.47cde	3.17±3.55abcd	2.13±3.65b	15.14±9.36a
14	48	0.550	0.440	0.010	35.36±12.54gh	56.86±6.85ab	66.41±7.66ab	1.49±2.39cd	2.19±5.26b	16.27±8.21a
15	48	0.530	0.430	0.040	51.83±8.96ab	52.34±11.18abcd	59.66±11.78bcde	4.25±5.05abcd	1.83±3.69b	15.17±7.45a
16	48	0.540	0.435	0.025	46.01±8.27abcde	56.45±6.63abc	62.49±5.90abcd	4.03±10.33abcd	2.20±4.63b	17.99±10.10a
17	48	0.490	0.485	0.025	43.65±13.16cdef	54.38±14.65abcd	61.27±16.28abcd	2.20±3.12abcd	1.82±4.76b	16.94±9.38a
18	48	0.580	0.395	0.025	40.78±11.41defg	49.02±12.25d	58.65±14.83cde	1.78±2.24bcd	2.20±4.08b	14.26±9.07a
19	51	0.450	0.540	0.010	35.85±11.20gh	57.37±8.38ab	64.88±8.12abc	2.34±6.45abcd	2.68±6.37b	17.11±8.58a
20	51	0.450	0.510	0.040	51.84±8.45ab	54.88±12.53abcd	62.54±12.37abcd	6.94±7.22abc	1.60±3.16b	14.27±7.40a
21	51	0.640	0.350	0.010	29.85±10.87h	50.92±9.06bcd	55.09±8.20de	0.93±1.20d	2.16±4.89b	17.07±6.12a
22	51	0.610	0.350	0.040	44.67±6.04bcdef	53.67±6.52abcd	61.28±7.20abcd	2.56±4.29abcd	2.28±3.90b	15.83±8.89a
23	51	0.550	0.440	0.010	34.78±12.92gh	54.03±10.30abcd	61.39±11.68abcd	2.41±6.14abcd	4.29±9.52b	14.75±7.69a
24	51	0.530	0.430	0.040	49.21±6.41abc	54.31±7.96abcd	62.22±6.72abcd	4.04±3.97abcd	0.96±2.20b	16.90±7.80a
25	51	0.540	0.435	0.025	46.04±5.84abcde	55.87±7.33abcd	63.16±6.01abc	2.48±3.41abcd	2.30±4.65b	14.52±6.98a
26	51	0.490	0.485	0.025	39.47±12.87efg	53.31±9.26abcd	66.16±9.27abc	3.62±10.25abcd	2.16±6.41b	15.36±7.09a
27	51	0.580	0.395	0.025	43.63±7.38cdef	53.17±6.88abcd	62.87±9.66abc	2.30± 3.42abcd	1.75±4.36b	14.84±7.87a
28	Control	-	-	-	44.17±13.30cdef	49.30±11.59cd	53.58±13.19e	4.98±6.67abcd	18.93±14.61a	14.64±9.90a

Table 2.6 *continued . . . .*

Formulation No.	Factor Levels^b				Sensory Attribute Ratings					
	Roast (x_1)	**x_2**	**X_3**	**x_4**	**Woody/hulls/ skins**	**Sweet**	**Bitter**	**Salty**	**First bite, Crumbliness**	**First bite, Hardness**
1	45	0.450	0.540	0.010	1.51±4.03ab	104.37±9.46abc	6.36±4.76cdef	14.10±4.36ab	118.25±7.11abc	33.65±5.56bc
2	45	0.450	0.510	0.040	0.65±1.13b	105.29±9.21abc	9.91±4.51abcd	12.94±4.32ab	117.26±13.64abcd	31.64±8.91bc
3	45	0.640	0.350	0.010	0.88±2.32b	108.84±11.54abc	6.69±5.87bcdef	12.73±3.93ab	123.90±11.08a	29.05±5.81c
4	45	0.610	0.350	0.040	0.48±0.47b	110.34±8.11ab	6.80±3.67bcdef	12.00±3.45ab	116.40±23.12abcd	34.67±9.56bc
5	45	0.550	0.440	0.010	1.06±2.14b	109.87±10.08ab	6.99±4.66bcdef	12.29±4.04ab	121.86±8.93a	30.92±3.53bc
6	45	0.530	0.430	0.040	0.84±1.94b	103.34±10.77abc	8.94±4.18bcde	11.97±2.98ab	119.73±13.13ab	32.37±5.58bc
7	45	0.540	0.435	0.025	1.37±2.86ab	108.51±8.10abc	7.39±3.87bcdef	12.39±3.70ab	122.24±7.62a	31.70±8.79bc
8	45	0.490	0.485	0.025	1.07±2.50b	104.98±13.24abc	10.63±4.55ab	13.29±3.21ab	117.03±22.73abcd	32.50±4.55bc
9	45	0.580	0.395	0.025	2.12±3.57ab	109.13±6.99abc	10.47±8.20abc	11.65±3.66b	118.05±18.83abc	30.14±5.44bc
10	48	0.450	0.540	0.010	0.49±0.73b	105.63±7.78abc	7.71±5.01bcdef	13.34±4.59ab	111.52±20.51abcd	34.67±9.50bc
11	48	0.450	0.510	0.040	0.96±1.92b	104.78±6.55abc	10.27±5.56abc	12.12±3.61ab	108.83±15.78bcd	37.47±12.85ab
12	48	0.640	0.350	0.010	0.65±2.18b	112.02±9.65a	4.85±4.74ef	12.82±5.20ab	117.96±21.64abc	29.89±5.31bc
13	48	0.610	0.350	0.040	4.07±16.00a	100.54±24.87c	9.33±4.91abcd	12.45±5.04ab	114.38±28.11abcd	34.88±19.10bc
14	48	0.550	0.440	0.010	0.47±1.02b	107.18±8.17abc	5.97±5.56def	13.32±4.89ab	112.72±14.10abcd	37.05±15.32abc
15	48	0.530	0.430	0.040	1.37±2.38ab	102.32±12.48c	10.35±5.65abc	12.10±5.61ab	114.85±12.59abcd	36.47±12.56abc
16	48	0.540	0.435	0.025	0.51±0.75b	108.76±9.42abc	6.66±4.08bcdef	12.99±5.17ab	114.16±24.06abcd	33.67±6.53bc
17	48	0.490	0.485	0.025	0.58±1.33b	100.01±23.79c	8.34±5.10bcdef	12.37±5.26ab	104.74±27.54d	32.77±9.47bc
18	48	0.580	0.395	0.025	0.59±0.89b	102.71±24.85abc	7.71±4.63bcdef	11.29±3.84b	116.25±28.43abcd	31.46±9.49bc
19	51	0.450	0.540	0.010	1.45±3.44ab	104.86±9.24abc	6.06±4.71def	13.75±3.73ab	113.83±8.67abcd	35.05±6.53bc
20	51	0.450	0.510	0.040	1.25±3.07ab	105.23±8.37abc	10.40±5.67abc	12.60±5.34ab	119.53±7.76ab	31.83±4.68bc
21	51	0.640	0.350	0.010	0.43±0.57b	110.55±6.30ab	4.65±4.08f	13.35±4.65ab	119.81±13.20ab	31.76±6.11bc
22	51	0.610	0.350	0.040	0.62±1.17b	107.80±6.32abc	8.44±4.67bcdef	12.34±3.65ab	119.98±9.96ab	33.00±7.43bc
23	51	0.550	0.440	0.010	0.50±1.17b	107.36±7.73abc	6.96±5.76bcdef	12.71±3.93ab	118.51±14.73abc	32.77±7.53bc
24	51	0.530	0.430	0.040	1.34±2.46ab	106.24±8.95abc	8.48±4.10bcdef	11.96±4.75ab	118.64±11.93abc	35.81±18.51abc
25	51	0.540	0.435	0.025	0.87±1.97b	105.67±7.46abc	8.74±6.13bcdef	13.46±5.30ab	115.70±19.30abcd	30.85±3.25bc
26	51	0.490	0.485	0.025	0.36±0.41b	110.18±10.83ab	7.65±4.08bcdef	15.24±5.20a	115.24±14.27abcd	34.45±7.04bc
27	51	0.580	0.395	0.025	1.48±3.49ab	107.55±6.27abc	7.24±3.61bcdef	11.74±5.54b	118.72±12.37abc	33.70±10.48bc
28	Control	-	-	-	3.16±5.62ab	100.30±13.82c	13.05±7.76a	12.79±4.15ab	106.00±16.06cd	42.50±16.33a

Table 2.6 *continued . . . .*

Formulation No.	Factor levels[b]				Sensory Attribute Ratings				
	Roast (x_1)	x_2	x_3	x_4	First chew, Smoothness	Chew down, Oiliness	Residual, Toothpack	Astringent	Oiliness after swallow
1	45	0.450	0.540	0.010	82.66±14.74a	31.90±10.20abcd	7.07±7.89abc	6.53±4.80b	22.55±7.07ab
2	45	0.450	0.510	0.040	87.25±7.64a	29.04±3.68cd	7.51±10.41abc	8.19±3.88ab	21.55±4.43ab
3	45	0.640	0.350	0.010	87.22±5.82a	27.30±6.89cd	5.73±5.92abc	8.75±3.90ab	19.04±6.16b
4	45	0.610	0.350	0.040	86.57±9.31a	30.61±12.32bcd	8.48±14.43ab	6.62±4.62b	19.91±6.16ab
5	45	0.550	0.440	0.010	82.28±13.31a	29.88±7.74bcd	7.86±7.79abc	7.00±4.26b	21.99±6.89ab
6	45	0.530	0.430	0.040	84.02±13.45a	28.39±7.05cd	6.28±6.99abc	8.45±4.44ab	20.44±6.97ab
7	45	0.540	0.435	0.025	85.65±10.24a	26.37±11.40d	5.31±5.59abc	7.78±4.98b	19.97±6.75ab
8	45	0.490	0.485	0.025	82.30±12.08a	30.35±5.70bcd	7.88±8.89abc	7.34±4.79b	22.48±4.74ab
9	45	0.580	0.395	0.025	85.62±10.10a	29.42±7.82cd	4.66±7.30abc	9.30±4.71ab	23.59±9.48ab
10	48	0.450	0.540	0.010	89.89±12.35a	31.00±9.69bcd	4.60±5.59abc	7.69±4.10b	21.62±6.44ab
11	48	0.450	0.510	0.040	92.70±8.04a	36.61±14.63ab	6.17±7.48abc	9.22±5.10ab	24.56±11.12a
12	48	0.640	0.350	0.010	92.75±11.87a	30.56±8.08bcd	4.10±4.35abc	7.55±5.31b	19.82±4.42ab
13	48	0.610	0.350	0.040	85.21±24.54a	27.24±8.34cd	1.42±1.95c	7.91±4.10b	18.41±5.67b
14	48	0.550	0.440	0.010	92.79±19.07a	32.78±6.80abcd	4.43±5.49abc	9.06±6.22ab	23.37±8.22ab
15	48	0.530	0.430	0.040	90.26±7.31a	29.22±9.18cd	4.37±7.07abc	9.33±5.89ab	21.62±6.80ab
16	48	0.540	0.435	0.025	88.91±11.20a	33.07±11.73abcd	6.82±14.61abc	9.77±4.79ab	22.01±7.19ab
17	48	0.490	0.485	0.025	86.67±22.60a	29.75±10.73bcd	2.95±4.69bc	8.67±5.09ab	20.52±9.61ab
18	48	0.580	0.395	0.025	85.80±20.69a	28.77±12.48cd	3.55±5.36bc	8.24±4.13ab	18.52±8.58b
19	51	0.450	0.540	0.010	89.91±12.06a	32.42±7.68abcd	6.89±7.99abc	6.44±5.89b	23.75±7.15ab
20	51	0.450	0.510	0.040	86.92±8.73a	33.89±8.67abc	4.32±5.61abc	9.72±4.17ab	22.59±5.67ab
21	51	0.640	0.350	0.010	88.53±9.05a	26.06±6.33d	4.85±7.67abc	7.57±4.65b	18.64±5.28b
22	51	0.610	0.350	0.040	89.93±6.27a	27.71±9.89cd	4.11±4.75abc	7.62±4.71b	21.60±6.23ab
23	51	0.550	0.440	0.010	87.72±13.30a	29.14±7.17cd	6.38±7.09abc	7.56±4.86b	19.81±7.44ab
24	51	0.530	0.430	0.040	88.73±11.20a	32.31±8.31abcd	7.58±6.19abc	9.23±5.70ab	22.24±5.31ab
25	51	0.540	0.435	0.025	83.70±16.07a	32.78±11.19abcd	8.41±13.69ab	8.11±5.78ab	22.54±7.15ab
26	51	0.490	0.485	0.025	92.21±9.88a	37.79± 9.10a	4.14±5.82abc	7.53±5.20b	25.25±7.62a
27	51	0.580	0.395	0.025	86.65±8.86a	30.24±6.72bcd	3.88±5.16abc	7.51±4.24b	21.16±5.80ab
28	Control	-	-	-	89.98±17.22a	33.05±9.13abcd	10.06±11.70a	11.85±7.44a	23.81±7.50ab

[a] Intensity ratings based on 150-mm unstructured line scales. Mean values in the same column not followed by the same letter are significantly different ($p<0.05$).

[b] Factors were the process variable roast x_1 and the proportions of the components sugar (x_2), peanut (x_3) and cocoa powder (x_4).

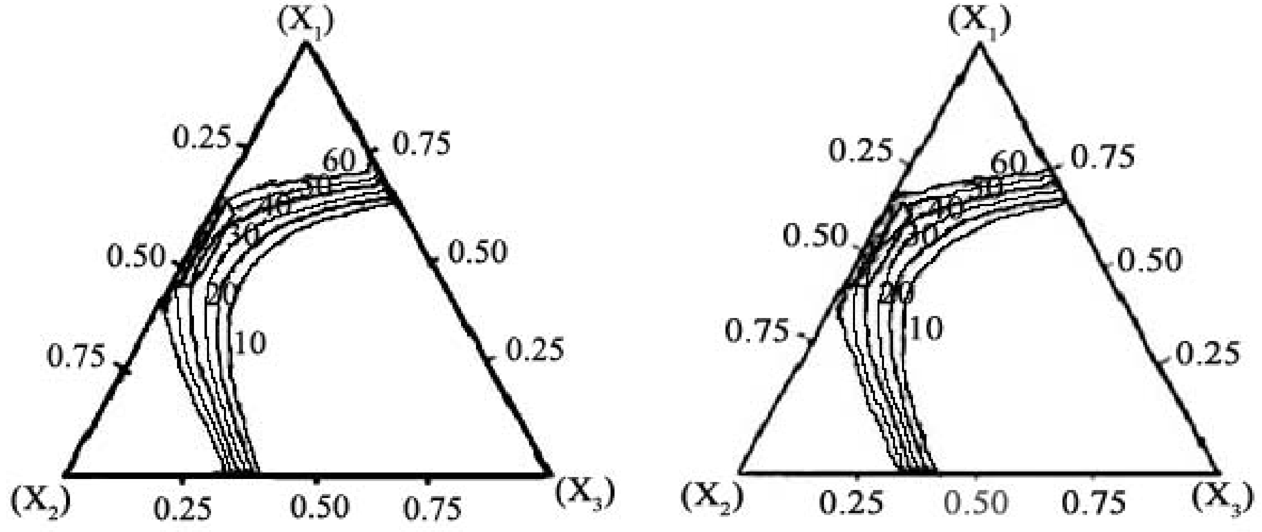
Table 2.7 Regression equations[a] for *L* value readings, brown color, cocoa aroma, roasted peanutty aroma, peanut butter aroma, and burnt aroma

Variable	**Model**	**R^2**
L value readings	$-0.06x_1 + 263.92x_2 + 303.49x_3 + 903.54x_2x_3$	0.8423
Brown color	$112.39x_1 - 1813.32x_2 - 1660.72x_3 - 33898x_4 - 0.73x_1^2 - 41.74x_1x_2 - 45.24x_1x_3 + 565.11x_2x_3 + 32274x_2x_4 + 34703x_3x_4$	0.9604
Cocoa aroma	$18.91x1 - 134.36x_2 - 292.84x_3 - 6930.27x_4 - 0.089x_1^2 - 12.05x_1x_2 - 9.01x_1x_3 + 177.93x_2x_3 + 6827.19x_2x_4 + 7493.26x_3x_4$	0.9169
Roasted peanutty Aroma	$1.79x_1 + 415.20x_2 + 459.05x_3 + 850.98x_4 + 0.16x_1^2 - 18.04x_1x_2 - 18.46x_1x_3 + 126.56x_2x_3 - 1075.56x_2x_4 - 1640.55x_3x_4$	0.6911
Peanut butter aroma	$3.32x_1 + 474.96x_2 + 393.96x_3 + 266.79x_4 + 0.17x_1^2 - 21.45x_1x_2 - 19.22x_1x_3 + 214.13x_2x_3 - 336.99x2x4 - 1368.05x_3x_4$	0.6157
Burnt aroma	$-2.81x_1 + 176.29x_2 + 189.23x_3 + 291.43x_4 + 0.79x_1^2 - 4.86x_1x_2 - 5.43x_1x_3 + 68.67x_2x_3 - 560.70x_2x_4 + 189.37x_3x_4$	0.6797

[a] Equation used was the full model. Descriptive ratings based on 150 mm line scales.

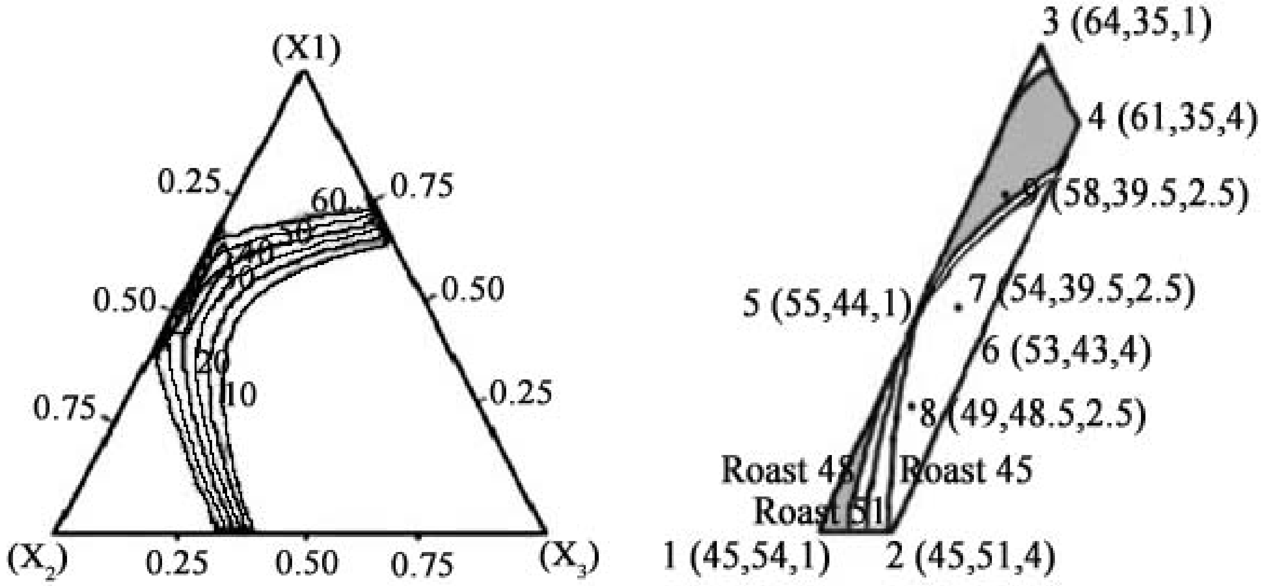
[b] Where x_1, x_2 and x_3 are proportions of the components sugar, peanut and cocoa powder used in the mixture to formulate peanut-chocolate bar.

All models significant at $p < 0.05$.



Roast 45 (*L* value = 45)

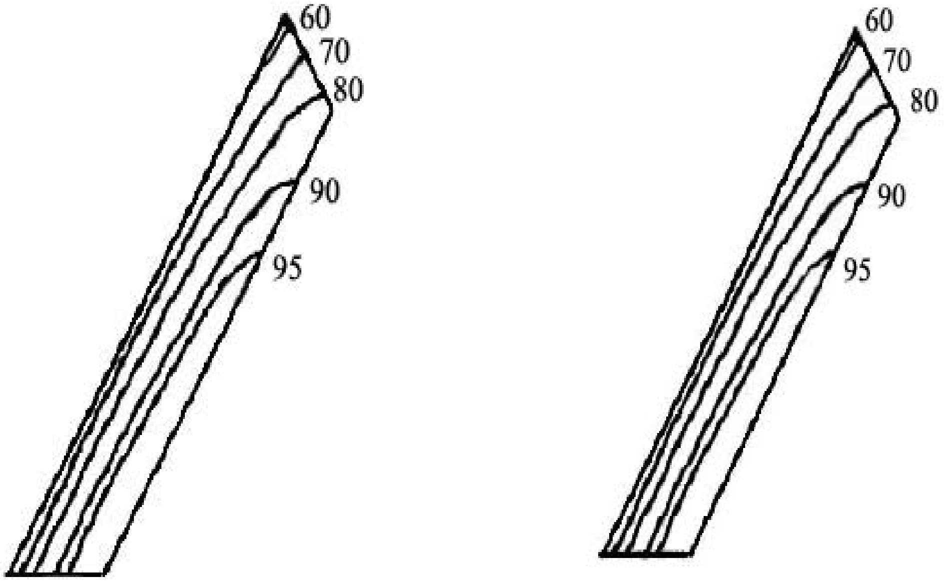
Roast 48 (*L* value = 48)



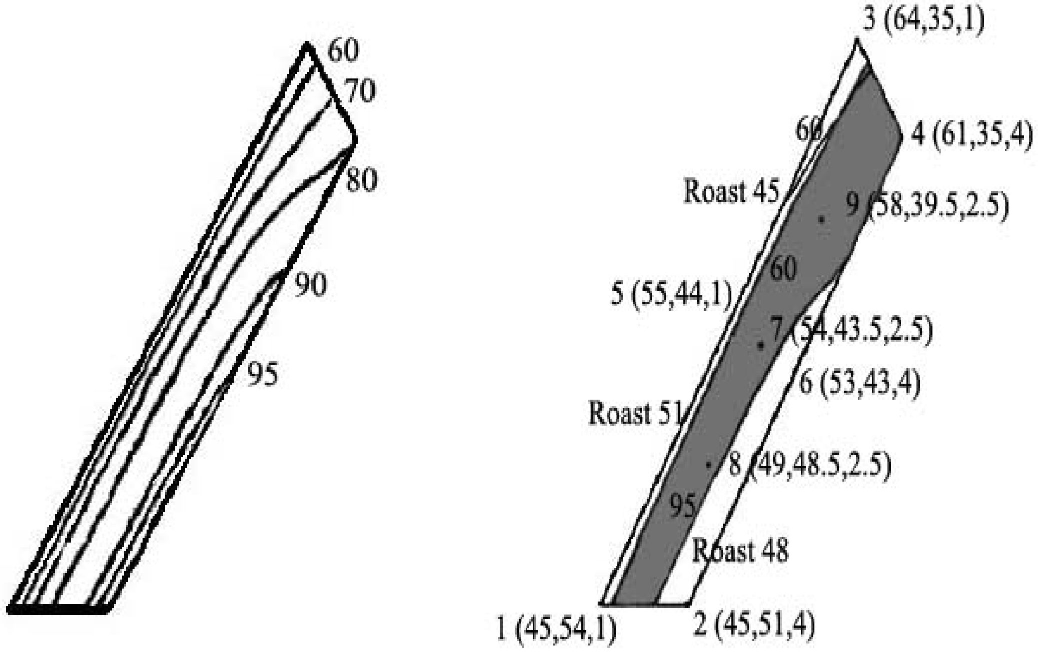
Roast 51 (*L* value = 51)

Superimposed plot for *L* value readings

Fig. 2.7 Contour plots for *L* value readings obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed contour plot for *L* value readings of peanut – chocolate bar.

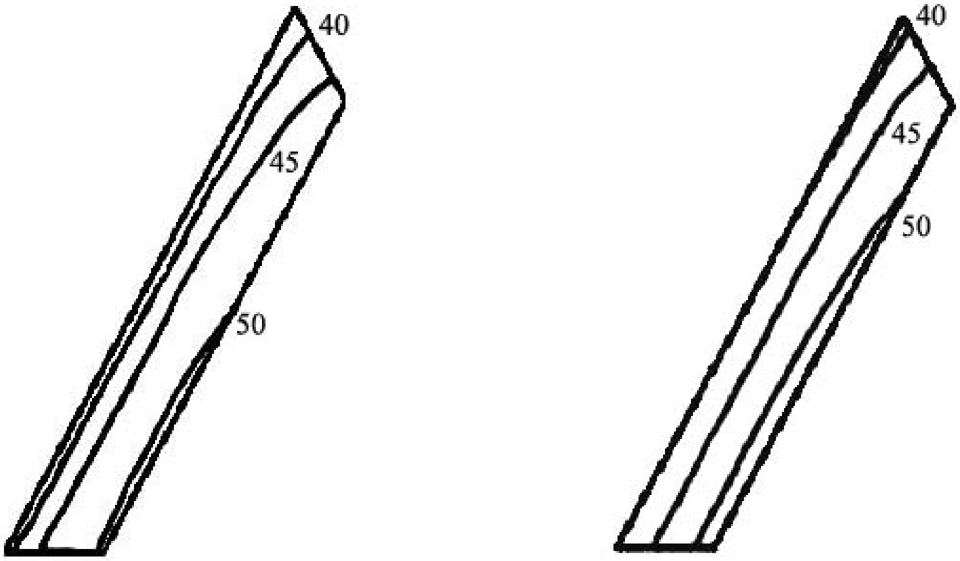


Roast 45 (*L* value = 45) **Roast 48 (*L* value = 48)**

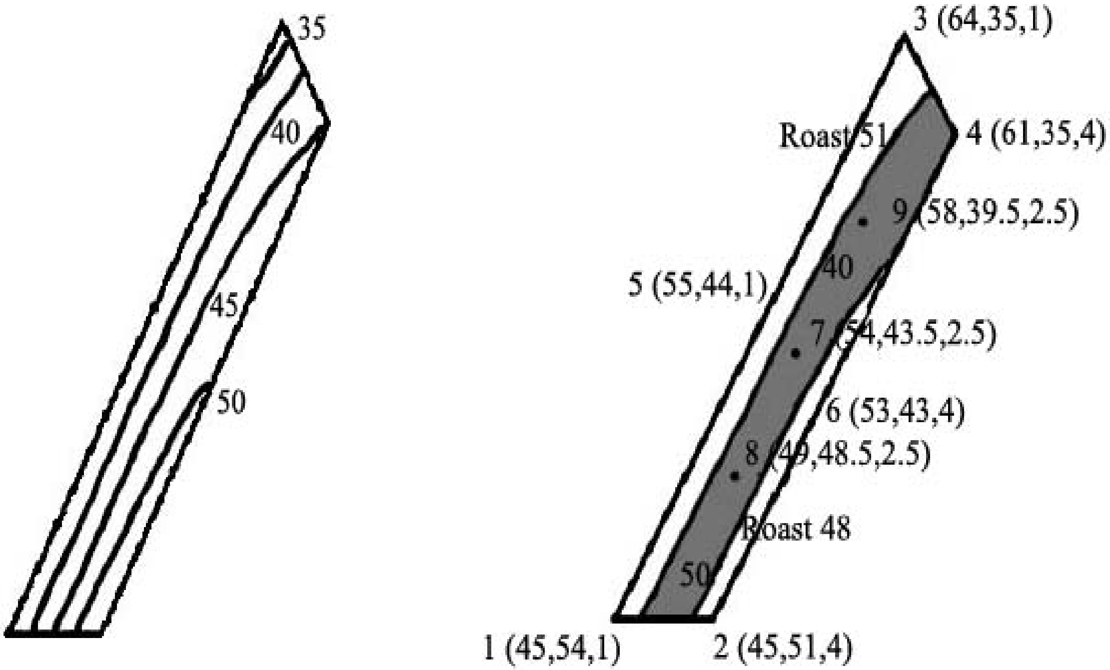


Roast 51 (*L* value = 51) **Superimposed plot for brown color**

Fig. 2.8 Contour plots for brown color obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed contour plot for brown color of peanut – chocolate bar.

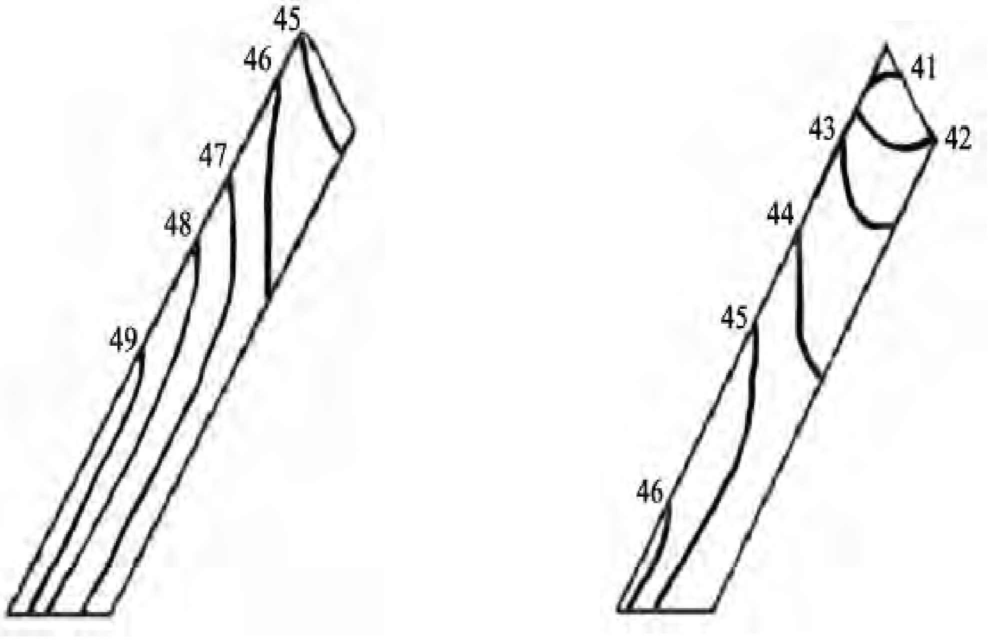


Roast 45 (*L* value = 45) **Roast 48 (*L* value = 48)**

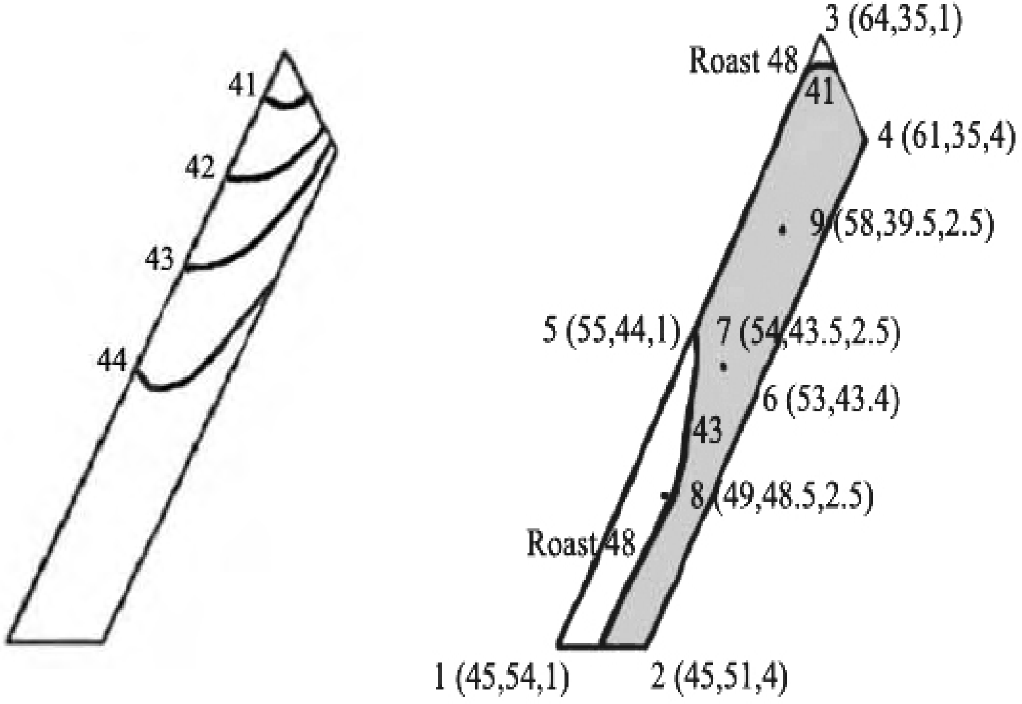


Roast 51 (*L* value = 51) **Superimposed plot for cocoa aroma**

Fig. 2.9 Contour plots for cocoa aroma obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed contour plot for cocoa aroma of peanut-chocolate bar.

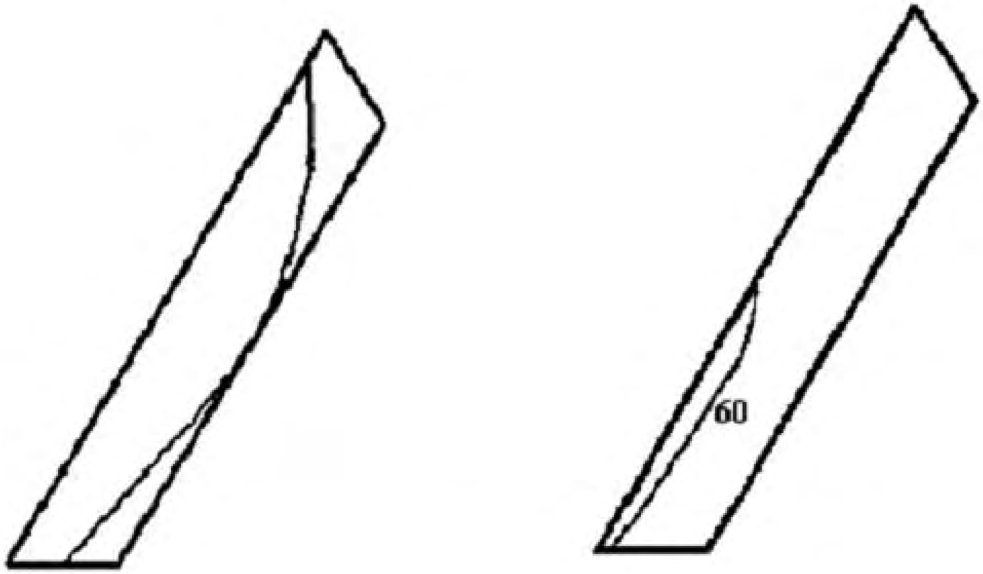


Roast 45 (*L* value = 45) **Roast 48 (*L* value = 48)**

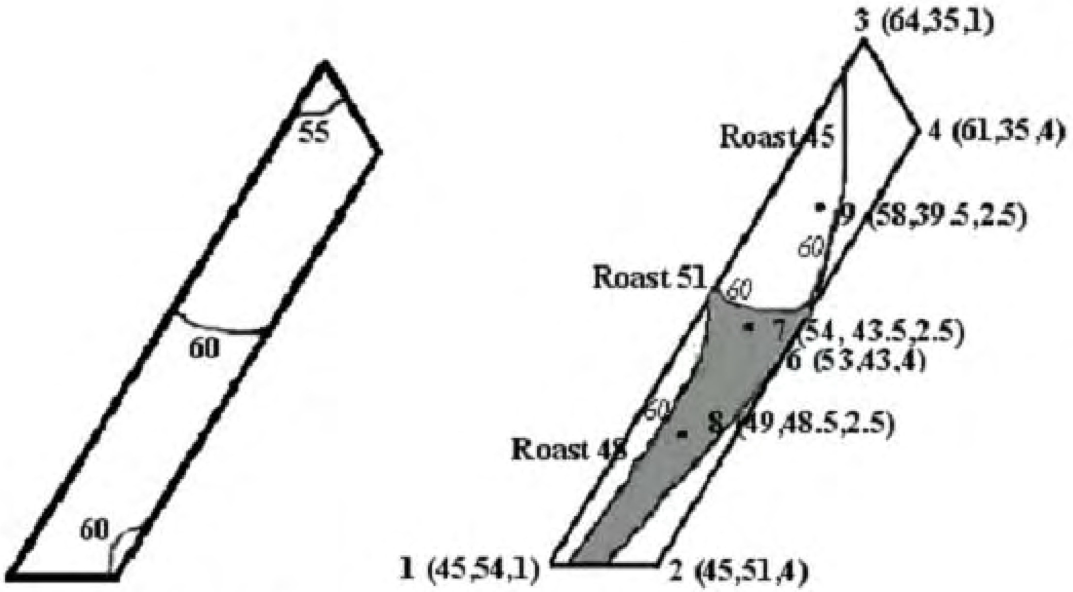


Roast 51 (*L* value = 51) **Superimposed plot for roasted peanutty aroma**

Fig. 2.10 Contour plots for roasted peanutty aroma obtained from three different roasts (*L* value = 45, 48, and 51) and a superimposed contour plot for roasted peanutty aroma of peanut – chocolate bar.

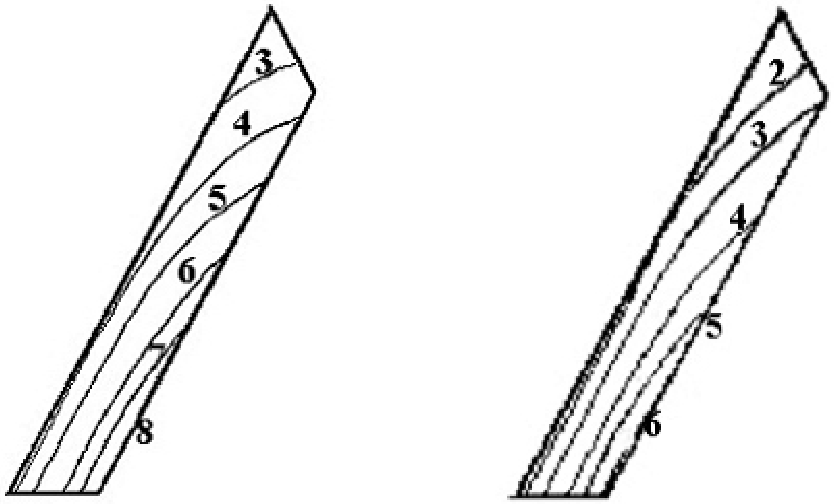


Roast 45 (*L* value = 45)　　Roast 48 (*L* value = 48)

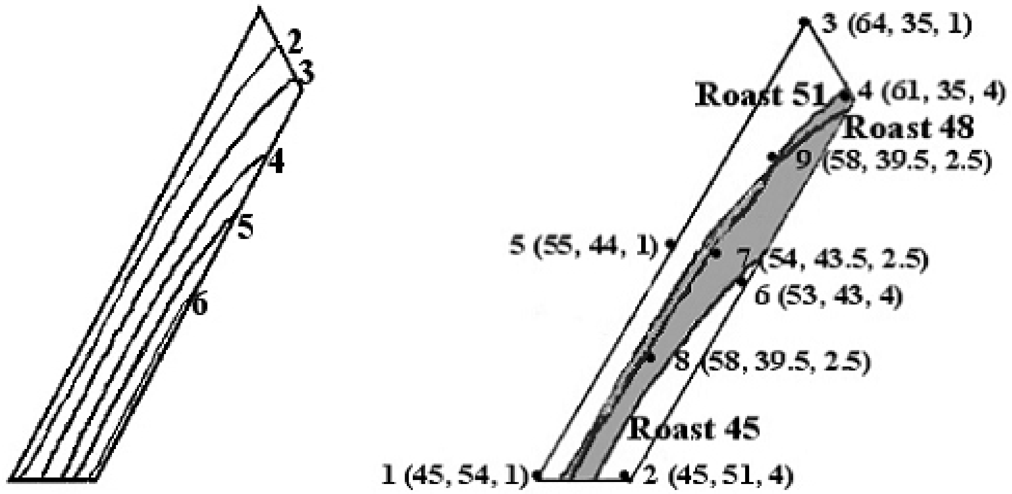


Roast 51 (*L* value = 51)　　Superimposed plot for peanut butter aroma

Fig. 2.11 Contour plots for peanut butter aroma obtained from three different roasts (*L*-value = 45, 48 and 51) and a superimposed contour plot for peanut butter aroma of peanut-chocolate bar.



Roast 45 (L value = 45) Roast 48 (L value =48)



Roast 51 (L value = 51)

Superimposed plot
for burnt aroma

Fig. 2.12 Contour plots for burnt aroma obtained from three different roasts (L value = 45, 48 and 51) and a superimposed plot for burnt aroma of peanut-chocolate bar.

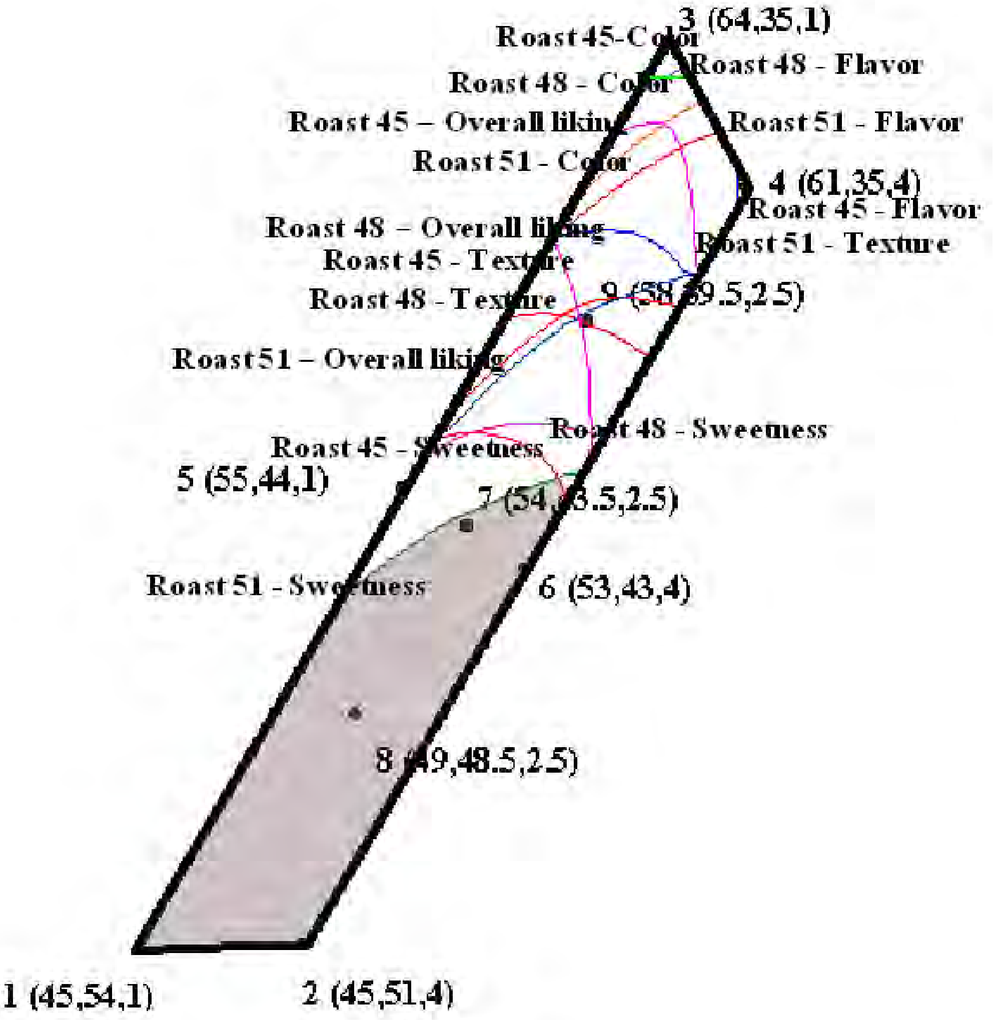


Fig. 2.13 Optimized regions obtained by overlaying contour plots of the constrained region for ratings of overall liking, color, flavor, sweetness and texture for each degree of roast (*L* value = 45, 48, or 51). Shaded areas represent areas of overlap for consumer acceptance ratings of 6 (like slightly or greater) for all attributes.

Results of Technology Transfer

The collaborator was informed through a letter, dated June 13, 2001 (Appendix B), that the best formulation for peanut-chocolate bar was ready for transfer. According to the collaborator, the formulation given was not totally adopted but was used instead as basis in modifying the amount of sugar in the formulation. The collaborator expressed that they preferred a product that is less sweet but with a pronounced degree of peanut aroma.

CONCLUSIONS

Mixture RSM was used to determine the effects of varying the percentages of sugar, peanuts and cocoa powder on the sensory attributes of 27 peanut-chocolate bar formulations. The preparation of the product is limited by sweetness. More acceptable formulations were obtained in peanut-chocolate bars prepared with lesser amounts of sugar. Optimum formulations could be obtained in blends containing 41-55% sugar, 44-54% peanuts, and 1-4% cocoa powder at any degree of roast. Formulations with sugar reduced to 56% could be acceptable when combined with peanuts roasted to a medium- (L = 48) or light-roast (L = 51). The formulations in these optimum regions were described as moderate in cocoa aroma, roasted peanutty aroma, and in peanut butter aroma. The brown color was moderate to strong, with minimal burnt aroma.

The best formulation for peanut-chocolate bar was given to the collaborator through a letter. According to the collaborator, they did not adopt the formulation given by FDC but instead used it as basis in reducing the sugar content of the product and increasing the amount of peanuts in the product.

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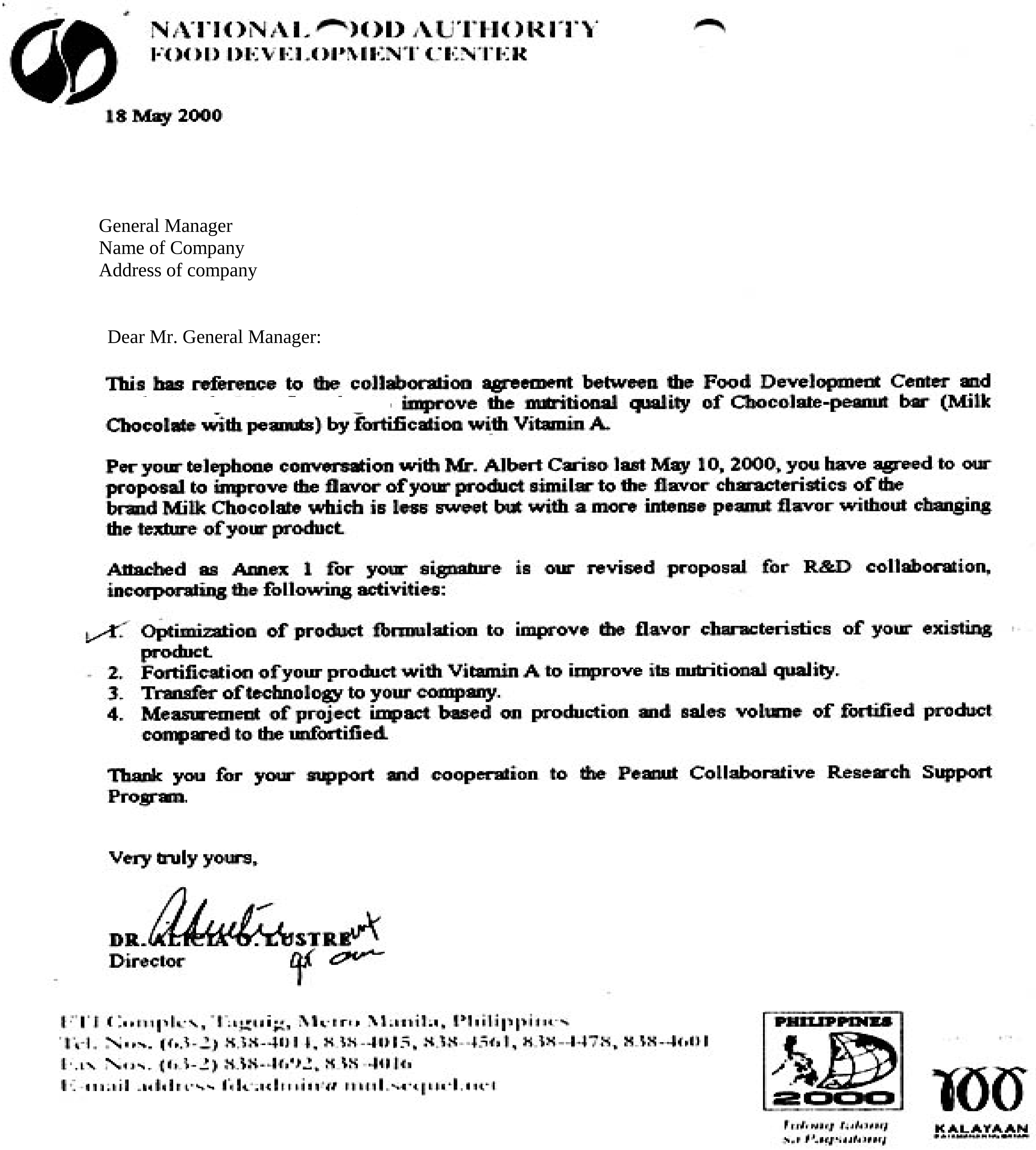
APPENDIX A

PROPOSAL FOR R&D COLLABORATION



NATIONAL FOOD AUTHORITY
FOOD DEVELOPMENT CENTER

18 May 2000

General Manager
Name of Company
Address of company

Dear Mr. General Manager:

This has reference to the collaboration agreement between the Food Development Center and improve the nutritional quality of Chocolate-peanut bar (Milk Chocolate with peanuts) by fortification with Vitamin A.

Per your telephone conversation with Mr. Albert Cariso last May 10, 2000, you have agreed to our proposal to improve the flavor of your product similar to the flavor characteristics of the brand Milk Chocolate which is less sweet but with a more intense peanut flavor without changing the texture of your product.

Attached as Annex 1 for your signature is our revised proposal for R&D collaboration, incorporating the following activities:

1. Optimization of product formulation to improve the flavor characteristics of your existing product.
2. Fortification of your product with Vitamin A to improve its nutritional quality.
3. Transfer of technology to your company.
4. Measurement of project impact based on production and sales volume of fortified product compared to the unfortified.

Thank you for your support and cooperation to the Peanut Collaborative Research Support Program.

Very truly yours,

DR. ALICIA O. LUSTRE
Director

FTI Complex, Taguig, Metro Manila, Philippines
Tel. Nos. (63-2) 838-4014, 838-4015, 838-4561, 838-4478, 838-4601
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E-mail address fdcadmin@mnl.sequel.net

PHILIPPINES 2000
Tulong Tulong sa Pagsulong

100 KALAYAAN

Annex 1

PROPOSAL FOR R&D COLLABORATION WITH CANDY MANUFACTURING

A. Title: Optimization of Product Formulation and Vitamin A Fortification of Chocolate-Peanut Bar (Milk Chocolate with Peanuts)

B. Objectives:

1. To strengthen the peanut flavor in chocolate-peanut bar (milk chocolate with peanuts) without causing undesirable texture changes by optimizing the product formulation.
2. To fortify the improved product to conform with the Recommended Dietary Allowance (RDA) for Vitamin A.

Rationale:

Chocolate-peanut (milk chocolate with peanuts) is a popular peanut product among Filipinos especially children. It is a confectionery product composed of roasted peanuts, sugar, milk powder and cocoa powder. Based on the results of a focus group test, the peanut flavor and sweetness of chocolate-peanut (milk chocolate with peanuts) can still be improved by optimizing the formulation of ingredients. Fortification of chocolate-peanut (milk chocolate with peanuts) with Vitamin A is also another way of improving the quality and nutritional value of the product. This will also help alleviate Vitamin A deficiency in poor children by making chocolate-peanut (milk chocolate with peanuts) available in remote areas.

C. Expected Output:

1. Chocolate-peanut bar (milk chocolate with peanuts) with flavor characteristics similar to brand Milk Chocolate and texture equivalent to the brand both of which are acceptable to the collaborator.
2. A technology for fortifying Chocolate-peanut bar (milk chocolate with peanuts) with Vitamin A content to conform with the Recommended Dietary Allowance (RDA) for fortified foods.

D. Duration: April 2000 to June, 2001

E. Activities and Cost Sharing Scheme:

Industry Collaborator (100% of total cost):

1. Manpower and transportation cost
2. Cost of raw materials such as peanuts, sugar, milk powder and cocoa powder.
3. Cost of Vitamin A fortificant.
4. Availability of collaborator's facilities and packaging materials.
5. Cost of Vitamin A analysis.

Items of Cost:

MANPOWER COST

1 Research Analyst II	=P 6,400.00

COST OF VITAMIN A ANALYSIS

5 treatments x 2 trials per treatment = 10 samples	
At P2,555.00 per sample, cost of Vitamin A analysis	=P 25,550.00

COST OF INGREDIENTS

Peanuts (at P36/kg x 30 kg)	=P 1,080.00
Sugar (at P24/kg x 40 kg)	=P 960.00
Milk Powder (at P130/kg x 10 kg)	=P 1,300.00
Cocoa Powder (at P40/160 g x 5 kg)	=P 1,250.00

COST OF FORTIFICANT

Cost of Vitamin A Palmitate 1 Million I.U. (1 kg)	=P 4,000.00

TRANSPORTATION COST

Use of vehicle from FDC to . Candy Mfg.	
5 trips x P1,000.00	=P 5,000.00

TOTAL COST	**= P 45,540.00**

F. Terms for Collaboration:

- Industry to have exclusive use of the technology.
- Industry to evaluate the optimized formulation until finally acceptable for unfortified and fortified chocolate-peanut bar (Milk chocolate with peanuts).
- Industry to provide information on production and sales volume of new product for the measurement of Project Impact.
- Industry to agree to the publication of generic portions of the study e.g. "Improving the nutritional quality of Chocolate-peanut bar by Vitamin A fortification" after due review of the material.

Proposed by: The Food Development Center

DR. ALICIA O. LUSTRE
Principal Investigator

Conforme:

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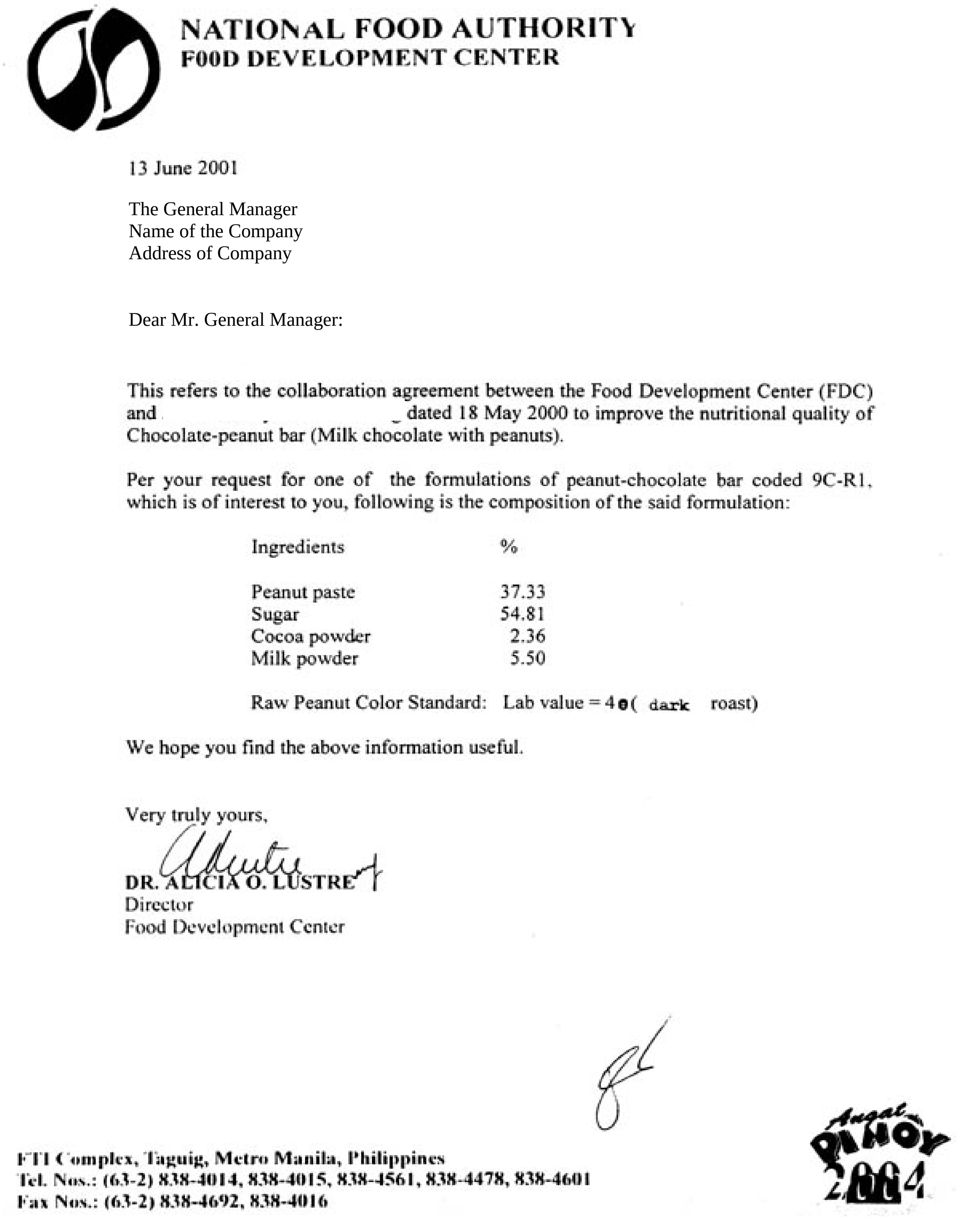
Company General Manager

APPENDIX B

LETTER TO COLLABORATOR ABOUT THE TRANSFER OF AN OPTIMUM FORMULATION OF PEANUT-CHOCOLATE BAR



NATIONAL FOOD AUTHORITY
FOOD DEVELOPMENT CENTER

13 June 2001

The General Manager
Name of the Company
Address of Company

Dear Mr. General Manager:

This refers to the collaboration agreement between the Food Development Center (FDC) and dated 18 May 2000 to improve the nutritional quality of Chocolate-peanut bar (Milk chocolate with peanuts).

Per your request for one of the formulations of peanut-chocolate bar coded 9C-R1, which is of interest to you, following is the composition of the said formulation:

Ingredients	%
Peanut paste	37.33
Sugar	54.81
Cocoa powder	2.36
Milk powder	5.50

Raw Peanut Color Standard: Lab value = 4e(dark roast)

We hope you find the above information useful.

Very truly yours,

DR. ALICIA O. LUSTRE
Director
Food Development Center

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Tel. Nos.: (63-2) 838-4014, 838-4015, 838-4561, 838-4478, 838-4601
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CHAPTER 3

CONSUMER-BASED OPTIMIZATION AND SENSORY PROFILING OF POLVORON USING PEANUT FINES

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Jocelyn M. Sales[3]
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ABSTRACT

Mixture response surface methodology (RSM) was used to optimize a peanut polvoron formulation. One hundred fifteen (n = 115) consumer panelists evaluated the color, appearance, flavor, texture, and overall acceptance of 15 experimental formulations and a control of peanut polvoron with different levels of sugar, peanut fines and butter. A descriptive panel (n = 11) identified and rated 11 attributes, using 150-mm unstructured line scales such as compactness, cream color, dryness, coarseness, roasted peanutty, buttery, sweet, softness, graininess, adhesiveness of mass, and tooth pack. Regression analysis was performed and models were developed. Models with R^2 >0.70 were selected for prediction. The effects of the components, sugar, peanut fines, and butter in peanut polvoron formulations and to determine optimum formulations were visualized through construction of contour plots. The plots show that texture limits the manufacture of the product. Blends containing 40-54% sugar, 22-36% peanut fines, and 10-38% butter, for a total of 100%, were found to be the optimum formulations for a peanut polvoron. The formulations in these optimum regions were described as moderate in cocoa aroma, roasted peanutty aroma, and in peanut butter aroma. The brown color was moderate to strong, with the burnt aroma described as slight.

The technology for an improved peanut polvoron was transferred to the second collaborator, the Nutcracker Homemade Products, Inc. on March 22, 2007 instead of the first collaborator, the Gordon Enterprises. The owner of Gordon Enterprises died in January 2003 and the children seemed to be not interested in the transfer of technology. On the other hand, another company, the Nutcracker Homemade Products, Inc. expressed interest for peanut polvoron, as this company is currently producing the product and wanted to improve it.

INTRODUCTION

Polvoron is categorized under the deserts and candy of Philippine ethnic foods, usually prepared with and without ground nuts to vary flavor and texture properties. Flavorings commonly used are nuts (peanut, pili and cashew), toasted rice or pinipig, and butter.

Peanut fines, the by-product of the roasted peanut manufacturing industry, are usually added as flavoring. Fines are particles that pass through a mesh opening of 0.75 mm and usually discarded during the grinding process of roasted peanuts. Its utilization as ingredient in peanut polvoron will provide added flavor, result in an additional product line, and help solve the problem of its disposal and subsequent economic loss.

Mixture experiments can be used to optimize consumer acceptance of a peanut polvoron that involve combinations of two or more ingredients to form a product. In mixture experiments, the ingredients are combined in different proportions according to an experimental design to determine the most liked or most preferred products. The independent or controllable variables in mixture experiments are expressed as volumes, weight or mole fraction in proportionate amounts of a mixture instead of unrestrained amounts (Cornell, 1983). In optimization, the most preferred formulations are maximized according to a fixed combination of the ingredients (Fishken, 1983).

Response surface methodology (RSM) is a statistical technique that can be used to systematically determine the effects of multiple variables on response variables (such as quality attributes) while minimizing the number of evaluations that must be conducted (Henika, 1982). RSM is a designed regression analysis used to predict the value of a response or dependent variable based on controlled values of the experimental factors, or independent variables (Meilgaard *et al.*, 1993). The independent variables represent the proportionate amounts of ingredients and the dependent variables are the responses such as sensory attributes.

OBJECTIVES

The study was conducted to : (1) identify the levels of sugar, peanut fines and butter that will result in an acceptable peanut polvoron, (2) determine the effects of the each component on the intensity of sensory attributes, and (3) transfer the technology of peanut polvoron to a collaborator for adoption.

METHODS

Establishment of Industry Collaboration

The collaborator for the study, who initially was Gordon Enterprises, was identified based on an existing database of clients at FDC. The owner/president of the company was invited to collaborate in the optimization of a peanut polvoron by utilizing its peanut fines. Since the company had peanut polvoron as one of its products and had peanut fines as one of the company's by-products, the owner/president readily agreed with the proposal. The collaborator agreed to provide 100% of peanut fines and to provide FDC with the basic formulation of their peanut polvoron.

The collaboration, however, was short-lived because the owner/president died before the technology was transferred. Effort was made to transfer the technology to other stakeholders. The Nutcracker Homemade Products, Inc. was identified to be the collaborator in the transfer of technology of peanut polvoron based on FDC's good experience with the company in providing FDC with information regarding the impact assessment of another peanut product, fine peanut bar.

Location of Where Research Was Conducted

The samples used in this study were prepared at the Product Development Laboratory of the Food Development Center – National Food Authority, Food Terminal Inc. Complex, Taguig Metro Manila, Philippines. The consumer tests were conducted at the National Food Authority, Central Office, Quezon City, while the descriptive and statistical analyses were conducted at the Food Development Center–National Food Authority, Food Terminal Inc. Complex, Taguig, Metro Manila, Philippines.

Experimental Design

A mixture design as described by Cornell (1983) consisting of three components, sugar, peanuts and butter was used to optimize the formulation for the preparation of an acceptable peanut polvoron. Preliminary experiments were conducted to determine the levels at which the components of peanut polvoron could be optimized such as identification of the components and levels that are important for acceptance of the product (Schutz, 1983). These components were found to be sugar, peanuts and butter. The formulation of the collaborator was initially used as basis for varying the levels of ingredients. Samples of peanut polvoron with highest and lowest levels of the ingredients that would result in a product were prepared. These proportions were used as constraints in the mixture experiment where the highest and lowest levels were identified as the extreme vertices in the constrained region. Based on the components to be studied, 15 formulations were obtained.

The three mixture components studied were sugar (x_1), peanut fines (x_2), and butter (x_3) consisting of a total of 72.5% of a peanut polvoron formulation. The remaining 27.5% of the peanut polvoron consists of milk powder and flour, which was a fixed amount in the formulation, consisting of 15.0% flour and 12.5% milk powder. The constraints or ranges of the components in the mixture, based on preliminary experiments, were determined to be 0 to 80% sugar, 10 to 95% peanut fines and 5 to 50% butter, adding to a total of 100% in the mixture.

In this design, the number of points (n) necessary to run a mixture experiment is

$$n = 2^q - 1$$

where q is the number of components being studied. Therefore, the minimum number of points to be studied is $\{2^3 - 1\}$ or 7 points (Scheffe', 1963) as shown in Fig. 3.1. The constrained region consisted of the following points: five points represent the five extreme vertices (formulations 1, 3, 5, 7 and 9) outlining the constrained region, 4 midpoints (formulations 2, 4, 6, and 8), a centerpoint (formulation 13) or overall centroid (Snee, 1975) and replicated as formulations 14 and 15. Three other points were selected to support the second-order polynomial (formulations 10, 11 and 12). The 13 formulations and 2 replications of the 13th formulation are shown in Table 3.1.

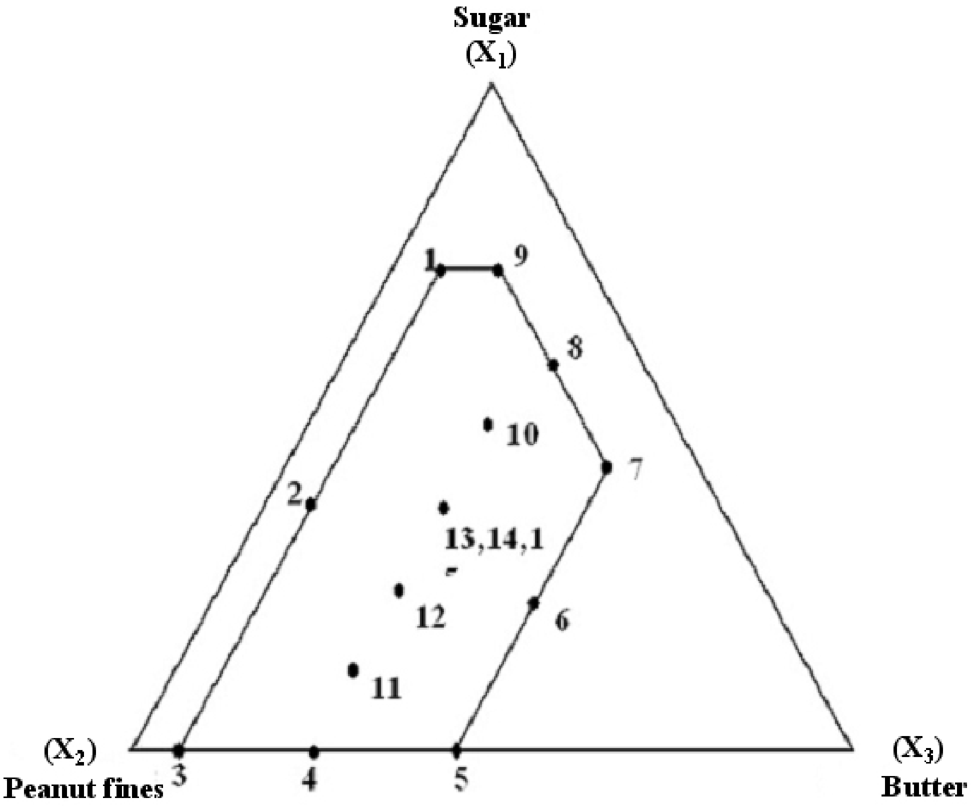


Fig. 3.1 Constrained region in the simplex coordinate system defined by the following restrictions: $0.12 \leq x_1 \leq 0.80$, $0 \leq x_2 \leq 0.95$, $0.05 \leq x_3 \leq 0.50$ for sugar, peanut fines, and butter, respectively.

Table 3.1 Composition of peanut polvoron used in a three-component constrained simplex lattice mixture design (San Juan *et al*., 2006)

Formulation No.	Component Proportion (%)[a]		
	Sugar (x_1)	Peanut Fines (x_2)	Butter (x_3)
1	80.0	15.0	5.0
2	40.0	55.0	5.0
3	0	95.0	5.0
4	0	72.5	27.5
5	0	50.0	50.0
6	20.0	30.0	50.0
7	40.0	10.0	50.0
8	60.0	10.0	30.0
9	80.0	10.0	10.0
10	54.0	22.0	24.0
11	12.0	64.0	24.0
12	26.0	50.0	24.0
13	40.0	36.0	24.0
14	40.0	36.0	24.0
15	40.0	36.0	24.0

[a] The three components total to 72.5% of the peanut polvoron formulation. Flour and milk powder are the ingredients added in a fixed amount in the different formulations.

Processing of Peanut Polvoron

The following ingredients were used in the preparation of peanut polvoron: peanut fines obtained from the collaborator was sifted to remove lumps and to aerate the ingredients using a strainer (EKCO, Elmira, New York) with mesh screen of 1 mm, refined sugar (NFA, FTI Complex, Taguig, Metro Manila, Philippines), flour (Gold Medal, Liberty Commodities Corp., Cupang, Muntinlupa City, Philippines), and full cream milk powder (Nido, Nestle Philippines, Inc., Cabuyao, Laguna, Philippines).

Peanut polvoron mixtures were prepared by blending 15 combinations of the ingredients (sugar, peanut fines and butter) based on the experimental design in Table 3.1. The ingredients full cream milk powder (12.5%) and flour (15.0%), comprising 27.5% of the formulation, were added in fixed amounts. The dry ingredients were mixed in a stainless steel bowl until a uniform blend was obtained. The melted butter was added to the mixture and manually stirred until all the dry ingredients were thoroughly moistened and the butter was evenly dispersed. Ten to 12 g portions of the mixture were molded using a fabricated aluminum polvoron molder to produce compact oval cakes 10 mm in height then dredged in sugar. The products were stored in plastic cups (30 mL capacity) with cover, coded, and stored in a storage freezer (–18°C, Sanyo, Model SRF-T681A, Moriguchi-shi, Osaka-fu, Japan) until time of use.

A top loading balance (Sartorius AG, Model #E5500S, Goettingen, Germany) was used in weighing the dry ingredients and unsalted pure and creamy butter (Magnolia Gold, Philippine Dairy Products Corp., Pasig City, Philippines). Toasting of flour was done in a 304.5 mm diameter aluminum alloy frying pan (SEB, Ecully Cedex, France) over moderate heat to a light brown color with L value of 94 and measured using the SZ 80 II color Measuring System (Nippon Denshoku Kogyo Co., Ltd, Tokyo, Japan). During toasting, the flour was stirred constantly to prevent burning resulting in burnt or bitter flavor. The flour was immediately cooled after toasting. Butter was melted over low heat in a stainless steel container.

The dry ingredients were mixed in a stainless steel bowl and sifted twice to evenly distribute the ingredients in the mixture. The melted butter was added to the mixture and stirred manually until the dry ingredients were thoroughly moistened and the butter was evenly dispersed. The mixture was molded into 10 to 12 gram portions using an oval-shaped fabricated aluminum polvoron molder (C.S. Barrera Corp., Tondo, Manila, Philippines) to produce 10 mm compact cakes then dredged in sugar. Samples of peanut polvoron were stored in plastic cups (30 mL capacity) with cover, coded and stored in a freezer (-18°C, Sanyo, Model SRF T681A, Moriguchi shi, Osaka fu, Japan) until time of use.

Sensory Evaluation

Consumer Test

Consumer tests were conducted at the National Food Authority (NFA) Central Office, Quezon City, Philippines. Panelists were recruited based on the following criteria: (1) had no food allergies, (2) were between the ages of 18 and 70, (3) had satisfied gender balance requirement consisting of 50% male and 50% female (only one of each gender per immediate family) and (4) had eaten peanut polvoron or other related products at least three times a month.

A total of 15 formulations in two replications were evaluated. The study required twenty-five responses for each of the 15 formulations (IFT, SED, 1981). A total of 115 consumers evaluated the color Attributes evaluated were overall acceptance and acceptance of appearance, color, flavor, and texture using a 9-point hedonic scale, where 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely. A control sample, which was a popular commercial peanut polvoron was also evaluated by each panelist.

One section of an open room was set up with tables lined with white paper, and the other section of the room was set up with tables for panelists to fill-out their demographic questionnaires prior to the test. The ballots were given to the panelists in the order of evaluation, the order of which was randomized for each panelist. The evaluation order of the 8 peanut polvoron samples was randomized for each panelist. Panelists were instructed to evaluate 4 samples, take a 1-minute break and evaluate 4 more samples. Panelists were asked to place at least ¼ of the sample in their mouths when evaluating. The panelists were also instructed to drink water after every sample and not to make comments during evaluation to prevent influencing other panelists.

Sensory Profiling of Peanut Polvoron

Panel selection. Eleven panelists were recruited from a pool of employees from the Food Development Center, National Food Authority, Philippines. The criteria for selection of panelists were as follows: (1) willingness to participate and ability to discriminate differences in sensory properties of peanut polvoron, (2) had natural dentition, (3) no food allergies, and (4) did not smoke. The screening test consisted of an aroma and taste test to determine the panelist's ability to differentiate tastes and aroma. The taste test consisted of identifying the four basic tastes (solutions of sweet, salty, bitter and sour) in small plastic cups with cover, while the aroma test consisted of identifying or describing the seven aromatics impregnated in cotton, stored in 120 mL amber glass bottles, in 10 minutes. Prospective panelists who passed the test were trained for a 2-hr per day training session for a period of 4 days.

Training. A 150-mm unstructured line scale with anchors at 12.5 mm from each end (Meilgaard *et al.*, 1993) was used. The panelists developed terminology, definitions, and evaluation techniques and agreed on references (Table 3.2) to be used. The attribute's definitions were obtained from Meilgaard *et al*. (1993). All sensory properties of the product and their intensities such as appearance (cream color, compactness, dryness, coarseness), aromatics (creamy, roasted peanutty, buttery), tastes (sweet, salty), and texture (softness, graininess, adhesiveness of mass, toothpack) were evaluated. Ballots were generated by the panelists using reference samples and descriptors that represented attributes likely to be encountered in the product.

Table 3.2 Descriptors and definitions of attributes developed in the descriptive analysis of peanut polvoron with references and intensity ratings (San Juan *et al*., 2007 unpublished)

Attribute	Definition	Standard Reference	Intensity of reference standards[a]	Intensity of control (warm-up) samples[b]
1. Appearance				
Cream color	Color associated with cardboard	Cardboard	10	41
Compactness	Absence of cracks or chips in the product	Full cream milk powder (Nido, Nestle Phils.)	0	135
		Flat tops milk chocolate (Ricoa, Commonwealth Foods, Phils.)	150	
Dryness	Absence of wetness on surface	Skimmed milk powder (Family, New Hamilton Foods Corp., Phils.)	0	6
		Full cream milk powder (Nido, Nestle Phils.)	5	
Coarseness	Presence of granules on surface	Gelatin[c]	0	113
		Gummy candies (Yupi, PT Yupi Indo Jelly Gum, Indonesia)	147	
2. Aromatics				
Creamy	Aromatics associated with full cream powdered milk	Skimmed milk powder (Family, New Hamilton Foods Corp., Phils.)	108	93
		Full cream milk powder (Nido, Nestle Phils.)	135	
Roasted peanutty	Aromatic associated with medium roasted peanuts	Roasted peanuts[d]	60	90
Buttery	Aromatic associated with butter	Butter ball (P.P. Confectioneries Inc., Phils.)	60	68

Table 3.2 *continued . . . .*

Attribute	**Definition**	**Standard Reference**	**Intensity of reference standards**[a]	**Intensity of control (warm-up) samples**[b]
3. Tastes				
Sweet[e]	Taste on the tongue associated with sugars	2% sucrose solution 5% sucrose solution 10% sucrose solution 15% sucrose solution	20 50 100 150	84
Salty[e]	Taste on the tongue associated with sodium chloride	0.2% NaCl solution 0.35% NaCl solution 0.5% NaCl solution	25 50 85	30
4. Texture				
4.1 First bite				
Softness	Force required to bite through sample	Pasteurized filled cheese spread (Eden, Kraft Foods, Phils.)	9	14
4.2 Chewdown				
Graininess	Amount of particles resulting from bite, or detected in center of sample	Corn chips (Nacho, Leslie Corp., Phils.)	110	95
Adhesiveness of mass	Degree to which the product sticks to the root of the teeth	Pasteurized filled cheese spread (Eden, Kraft Foods, Phils.)	123	98
4.3 Residual				
Toothpack	Amount of product left on mouth or teeth	Pasteurized filled cheese spread (Eden, Kraft Foods, Phils.)	123	106

[a] A 150 mm unstructured line scale was used. Intensity ratings were agreed upon by consensus by the descriptive panel during the training.

[b] Peanut polvoron sample used was a popular commercial peanut polvoron.

[c] Prepared from one bar of gelatin (unbranded) added with three cups water, boiled and placed in molding pan.

[d] Prepared from peanut roasted in a peanut roaster for 1.5 to 2 hours at 127°C.

[e] Meilgaard *et al.*, 1993

A commercial sample was used as the control sample during evaluation. The control sample was presented to the panelists as the initial sample during training and was also used as a warm-up sample (Plemmons and Resurreccion, 1998). Intensity ratings for the warm-up samples, shown in Table 3.2, were obtained by taking the average of individual panelist ratings for each attribute during the training sessions and evaluation of test samples.

Sample evaluation. Thirty formulations (15 formulations x 2 replicates) of peanut polvoron were evaluated by 11 trained panelists using a combination of the Spectrum and Quantitative Descriptive Analysis (Resurreccion, 1998). The panelists evaluated 7-8 samples and 1 control sample per session for 4 nonconsecutive sessions. The samples, coded with three-digit random numbers, were randomly presented using a complete random block design. All references (Table 3.2), soda crackers, water and cups for expectoration were provided. Each panelist evaluated the samples in designated individually partitioned booths under white incandescent lights under environmentally controlled conditions using paper ballots. Panelists evaluated the samples one at time with a three-minute break after the fifth sample.

Statistical Analyses and Modeling

All data were analyzed using Statistical Analysis System (SAS Institute, Inc., 1985). Development of prediction models and model fitting were as described by Cornell (1982). Parameter estimates were determined by performing regression analysis (PROC REG) on raw data using the NOINT option because SAS (1985) automatically inserts an intercept. In this experiment, a mixture design has the limitation of $x_1 + x_2 + x_3 = 1.0$. Regression analysis was performed on each dependent variable used in the consumer test (overall acceptability and acceptance of color, appearance, flavor, and texture) and descriptive test (compactness, cream color, dryness, coarseness, creamy aroma, roasted peanutty aroma, buttery aroma, sweet taste, salty taste, softness, graininess, adhesiveness of mass, and tooth packing) and the following linear independent variables (sugar, peanut fines, butter) and the cross product terms (sugar*peanut fines, sugar*butter and peanut fines*butter). When running regression analyses, the intercept is included in model building to determine the coefficients of determination, R^2 ,and values for calculating the F ratio.

Response surface models were generated using the second degree polynomial (Scheffé, 1958):

$$Y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_{11} x_1^2 + \beta_{12} x_1 x_2 + \beta_{13} x_1 x_3 + \beta_{23} x_2 x_3$$

where: Y = a sensory characteristic or response; $\beta_{1,}\ \beta_{2,}\ \beta_{3,}\ \beta_{12,}\ \beta_{13,}\ \beta_{23,}$= the corresponding parameter estimates for each linear and crossproduct term produced for the prediction models; x_1 = x_1 = sugar, x_2 = peanut fines, x_3= butter. Parameter estimates produced from prediction models that were significant ($\alpha = 0.05$) and had an R^2 of 0.50 or greater were used. Model significance at the 0.05 level was determined using the F-ratio of means square calculated as follows (Cornell, 1981):

$$F = \frac{\text{Sum of squares in full model} - \text{Sum of squares in reduced model}}{\text{Number of terms in full model} - \text{Number of terms in reduced model}} \times \frac{1}{\text{residual mean square of full model}}$$

Regression analysis was performed on the means of the sensory attributes of the fitted models using the no intercept option to determine parameter estimates (Cornell and Linda, 1989). The parameter estimates from the no intercept option were used to predict the models for each sensory attribute. All models with $R^2 > 0.50$ were chosen. To determine the effects of the mixture components sugar, peanut fines and butter on the properties of peanut polvoron, response surfaces were generated using PC SAS Graph (SAS, 1985).

Attaining the Optimum Formulation

The observation on each design point in sensory evaluation is usually represented by the mean rating of several panelists (Gacula, 1993). The data from the two replicates were not significantly different from each other and were combined in the regression analysis. Models with a coefficient of determination (R^2) greater than 0.50 (Gills, 1998) and significant at $p < 0.05$ were used in prediction equations. These were overall liking color, appearance, flavor, and texture. Contour plots were generated from full models because the coefficient of determination (R^2) of the reduced models were low and could not be reduced further. In the descriptive tests, the dependent variables compactness, cream color, dryness, coarseness, roasted peanutty aroma, buttery aroma, sweet taste, softness, graininess, adhesiveness of mass and tooth packing had R^2 greater than 0.70 and were used to develop prediction equations.

Prediction models used in the optimization process were obtained from the regression analysis using the NOINT option. The acceptable regions on the contour plot for each dependent variable were defined as formulations that were predicted to result in consumer ratings ≥ 6.0 (6 = like slightly). The contour plots for each dependent variable were superimposed to determine the areas of overlap or combinations of the components that would result in optimum regions or formulations for peanut polvoron.

In the descriptive test, the contour plots were likewise plotted, superimposed, and the overlap region for the eleven attributes represented the intensity characteristics of formulations in the optimum region.

Optimization

Contour plots were generated for each sensory attribute using the significant prediction models. Ranges of acceptable formulations were determined for each attribute based on the area covered by an acceptance rating of 6.0 or greater. Acceptable regions for each attribute were outlined onto contour plots, which were then superimposed to determine a region of overlap for all attributes. This region of overlap was defined as the optimum region. All formulations within the optimum region would result in polvoron that would be acceptable, overall and in all attributes modeled.

Model Verification

Model verification was performed on two replicates of the two formulations, one predicted to result in an acceptable product and another predicted to result in an unacceptable product. Twenty-five consumers evaluated each replication of each of the two formulations. Each consumer was presented with one acceptable and one unacceptable product. Samples were evaluated for overall acceptance and acceptance for appearance, color, flavor and texture acceptance. The Student's t-test was performed to determine whether a significant difference exists between the predicted and observed ratings.

Technology Transfer of Peanut Chocolate Bar

The study related to optimization of the formulation was done and completed in 2002. The technology on the preparation of an acceptable peanut polvoron was not transferred to the first collaborator of the project due to death of the owner/president of the company of Gordon Enterprises. Efforts were done to transfer the technology to peanut processors in Northern Mindanao. The Nutcracker Homemade Products, Inc. accepted the offer to transfer the technology of an improved polvoron. The transfer took place last March 22, 2007. The collaborator promised to provide the project with the sales performance, production volume and socio-economic benefits as a result of adoption of the technology.

RESULTS

Modeling of Consumer Acceptance of Peanut Polvoron

Mean values for consumer acceptance ratings for the attributes tested for peanut polvoron are shown in Table 3.3. Peanut polvoron prepared from mixtures containing 40-54% sugar, 22-36% peanut fines, and 24% butter had acceptance ratings of 6.0 or greater for overall acceptance, flavor, and texture. Acceptance ratings were low ≤ 5.30 for all attributes in blends without sugar. Blends without sugar (formulations 3, 4 and 5) had the lowest overall acceptance ratings and significantly lower color ratings compared to all formulations. These and the very high sugar (formulation 1) had significantly lower appearance ratings compared to the other blends with sugar.

Results of the regression analyses are presented in Table 3.4, listing the coefficients of determination (R^2) and parameter estimates for the prediction models for all acceptance ratings and intensity ratings of sensory attributes evaluated. Significant models ($p < 0.05$) for acceptance ratings (Table 3.4) with high coefficient of determination were overall liking, and liking for color, appearance, flavor and texture. Response surfaces representing plots produced from the parameter estimates for each of these variables were also generated (Fig. 3.2).

Table 3.3 Mean consumer acceptance ratings observed for peanut polvoron with two replications[a] (San Juan *et al*., 2006)

Treatment	Factors[b]			Acceptance mean ratings				
	x_1	x_2	x_3	Overall liking	Color	Appearance	Flavor	Texture
1	0.800	0.150	0.050	5.33d	6.02ab	5.20de	5.44c	5.19e
2	0.400	0.550	0.050	5.87bcd	6.04ab	5.96bc	5.70bc	5.44cde
3	0.000	0.950	0.050	3.69e	5.13cd	5.10de	3.494c	3.92f
4	0.000	0.725	0.275	3.83e	4.70d	4.77e	3.75d	4.11f
5	0.000	0.500	0.500	3.85e	4.62d	4.61e	3.65d	3.91f
6	0.200	0.300	0.500	5.23d	5.79bc	5.72cd	5.28c	5.30de
7	0.400	0.100	0.500	5.68cd	5.83bc	6.06abc	5.60c	5.66bcde
8	0.600	0.100	0.300	5.88bcd	6.27ab	6.15abc	5.75bc	5.58bcde
9	0.800	0.100	0.100	5.75bcd	6.00ab	5.15de	5.51c	5.24de
10	0.540	0.220	0.240	6.56ab	6.46ab	6.62ab	6.50ab	6.21abc
11	0.120	0.640	0.240	5.69cd	5.72bc	5.80cd	5.48c	5.46cde
12	0.260	0.500	0.240	6.00bcd	6.08ab	6.23abc	6.06abc	6.02abcde
13	0.400	0.360	0.240	6.54ab	6.30ab	6.39abc	6.50ab	6.07abcd
14	0.400	0.360	0.240	6.82a	6.74a	6.84a	6.70a	6.56a
15	0.400	0.360	0.240	6.41abc	6.47ab	6.43abc	6.49ab	6.35ab
Control	-	-	-	**7.42**	**7.42**	**7.24**	**7.47**	**7.42**

Mean values in the same column not followed by the same letter are significantly different ($p < 0.05$).

[a] Ratings are based on a 9-point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like exteremely.

[b] Factors were: x_1 = proportion of sugar; x_2 = peanut fines; x_3 = butter.

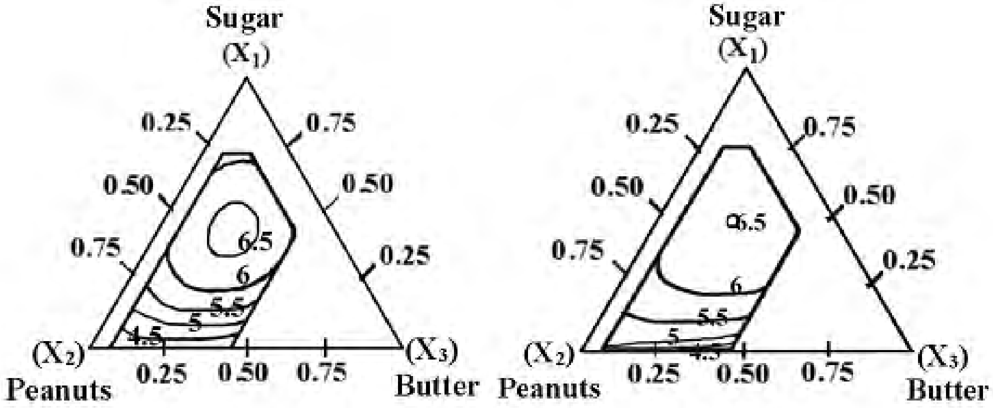
Table 3.4 Regression equations[a] describing the response for each dependent variable (overall acceptance, and acceptance for color, appearance, flavor, sweetness, and texture) for peanut polvoron containing the proportion of the components sugar (x_1), peanut fines (x_2), and butter (x_3)[b] (San Juan *et al*, 2006)

Variable	Model	R^2
Overall acceptance	$4.40x_1 + 3.58x_2 + 0.51x_3 + 6.58x_1x_2 + 10.30x_1x_3 + 6.84x_2x_3 + 25.39x_1x_2x_3$	0.9361
Color acceptance	$5.72x_1 + 5.12x_2 + 3.91x_3 + 1.74x_1x_2 + 2.78x_1x_3 + 0.14x_2x_3 + 25.35x_1x_2x_3$	0.7629
Appearance acceptance	$3.91x_1 + 4.98x_2 + 2.38x_3 + 4.99x_1x_2 + 10.55x_1x_3 + 3.23x_2x_3 + 17.37x_1x_2x_3$	0.8916
Flavor acceptance	$4.45x_1 + 3.35x_2 + 0.78x_3 + 6.08x_1x_2 + 8.48x_1x_3 + 6.21x_2x_3 + 33.78x_1x_2x_3$	0.8750
Texture acceptance	$4.30x_1 + 3.84x_2 + 1.50x_3 + 4.16x_1x_2 + 7.73x_1x_3 + 4.94x_2x_3 + 31.77x_1x_2x_3$	0.8757

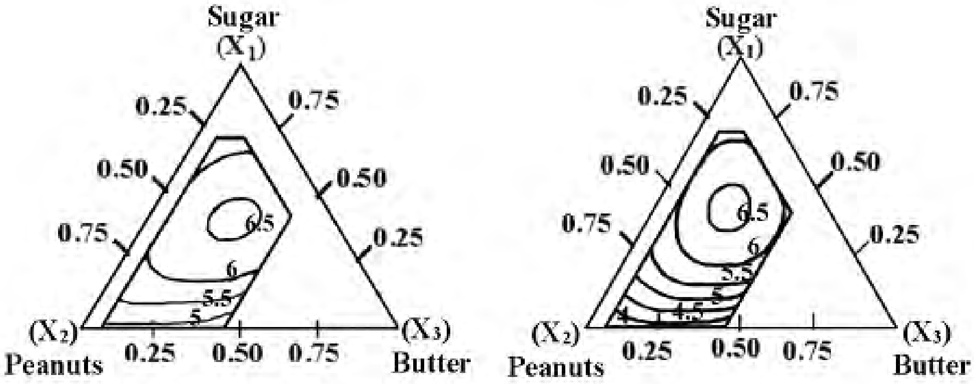
All models significant at $p< 0.05$.

[a] Equations used were the full model. Consumer rating based on a 9-point hedonic scale where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

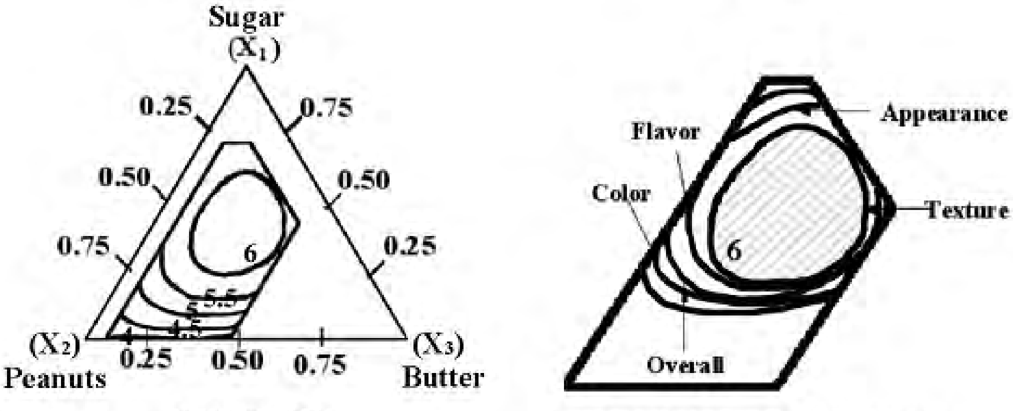
[b] x_1, x_2 and x_3 are proportions of the components sugar, peanut and butter in the mixture.



OVERALL **COLOR**



APPEARANCE **FLAVOR**



TEXTURE **REGIONS OF OVERLAP**

Fig. 3.2 Contour plots for overall acceptance, color, appearance, flavor and texture, and their regions of overlap for formulations with ratings $\geq$ 6.0.

Modeling of Sensory Profile of Peanut Polvoron

The mean sensory ratings of the commercial control and the different formulations of peanut polvoron are presented in Table 3.5. Comparison of the mean sensory ratings of the different formulations shows that peanut polvoron with 80% sugar were less compact, had lower intensity of cream color, roasted peanutty aroma, salty taste, softness, adhesiveness of mass, and tooth packing, was significantly different from the rest for cream color and sweet taste.

In terms of coarseness, peanut polvoron with 50% peanut fines and 50% butter, or peanut polvoron with 20% sugar, 30% peanut fines and 50% butter were significantly different from the other formulations ($p < 0.05$). The creamy aroma of peanut polvoron containing 95% peanut fines and 5% butter, and containing 50% peanut fines and 50% butter were significantly different from the other peanut polvoron formulations, but were not significantly different from those formulations containing 72.5% peanut fines and 27.5% butter.

Results of the regression analysis for the sensory properties of peanut polvoron are presented in Table 3.6 listing the coefficients of determination (R^2) and parameter estimates for the predictive models evaluated. The parameter estimates of the sensory properties of peanut polvoron ranged from 0.74 to 0.93. Response surfaces were also generated. Compactness and cream color (Figs. 3.3a and b) increased with increase in butter and peanut fines but decreased with increase in sugar content. With more peanut fines, dryness (Fig. 3.3c), roasted peanutty aroma (Fig. 3.3e), adhesiveness of mass (Fig. 3.3j) and tooth packing (Fig. 3.3k) increased. Coarseness (Fig. 3.3d), sweet taste (Fig. 3.3g) and graininess (Fig. 3.3i) of peanut polvoron were observed to increase with increase in sugar content. Increasing the amount of butter resulted in increased intensity of buttery aroma (Fig. 3.3f), but a higher intensity of softness (Fig. 3.3h) of peanut polvoron.

Deriving the Optimum Formulation

The region of overlap for formulations that were rated 6.0 or higher for overall acceptance, color, appearance, flavor, and texture are shown in Fig. 3.2. Texture was the limiting factor defining the area of overlap and therefore, outlined the optimum formulations, which corresponds to compactness in Fig. 3.3a. The optimum regions show that acceptable peanut polvoron formulations should contain 22-36% peanut fines, 10-38% butter, and 40-54% sugar.

Table 3.5 Mean intensity ratings[a] and standard deviations of sensory attributes of peanut polvoron (San Juan *et al*., 2007, unpublished)

Formulation No.	Factors[b]			Sensory attributes				
	X_1	X_2	X_3	Compactness	Cream Color	Dryness	Coarseness	Creamy
1	0.800	0.150	0.050	92.78±34.35d	47.28±9.87h	7.39±4.54f	113.39±16.04abc	81.94±19.78ab
2	0.400	0.550	0.050	106.16±21.80c	71.68±12.62g	15.16±22.08ef	118.63±14.00a	78.84±14.30ab
3	0.000	0.950	0.050	114.47±24.66bc	86.47±10.54f	8.24±2.28f	120.82±15.74a	58.88±31.16c
4	0.000	0.725	0.275	129.05±13.90a	121.60±12.79a	52.25±45.07a	104.60±34.53bc	70.15±25.29bc
5	0.000	0.500	0.500	121.26±26.70ab	120.84±13.17a	123.00±31.8a	83.37±38.33d	65.26±30.34c
6	0.200	0.300	0.500	123.45±21.50ab	115.25±14.06ab	122.20±30.20a	85.25±38.79d	83.25±19.64a
7	0.400	0.100	0.500	127.47±19.84a	97.53±13.85de	91.47±52.82b	99.26±30.56c	88.10±18.45a
8	0.600	0.100	0.300	133.05±7.09a	89.00±13.87ef	42.37±45.66cd	110.00±10.35abc	92.05±8.89a
9	0.800	0.100	0.100	104.20±21.24cd	49.85±13.45h	12.85±26.61f	113.75± 7.91abc	78.30±25.28ab
10	0.540	0.220	0.240	129.94±9.58a	94.89±12.17ef	25.94±30.43cdef	121.28±12.10 a	90.11±8.90 a
11	0.120	0.640	0.240	129.33±13.86a	110.22±27.26bc	42.61±46.75cd	117.22±18.06ab	81.50±13.29ab
12	0.260	0.500	0.240	130.10±8.46a	113.74±15.22abc	39.21±44.15cde	115.21±13.80ab	85.05±10.84a
13	0.400	0.360	0.240	131.42±8.50a	107.16±12.87c	17.58±26.71def	118.37±14.28ab	87.58±9.68a
14	0.400	0.360	0.240	126.00±10.25ab	104.58±12.26cd	20.27±21.85def	121.79±18.51a	87.79±7.50a
15	0.400	0.360	0.240	130.94±9.90a	106.17 ±12.30cd	31.94±40.63cdef	119.61±12.14ab	89.78±7.50a

Table 3.5 *continued …*

Formulation No.	**Factors**^{b}			**Sensory attributes**			
	X_1	**X_2**	**X_3**	**Roasted peanutty**	**Buttery**	**Sweet**	**Salty**
1	0.800	0.150	0.050	63.39±25.63a	50.23±23.71cde	106.67±17.90a	25.22±8.60bc
2	0.400	0.550	0.050	89.00±10.97a	53.06±20.45bcde	76.89±11.42e	27.00±5.70bc
3	0.000	0.950	0.050	93.06±8.00 a	44.00±23.81e	26.70±19.68g	26.53 ±10.58bc
4	0.000	0.725	0.275	91.90±11.31a	51.83±24.80cde	37.05±21.01g	28.45±7.75abc
5	0.000	0.500	0.500	86.53±11.27a	56.00±25.63bcde	40.42±22.25g	31.37±7.920ab
6	0.200	0.300	0.500	87.40±11.35a	71.25±30.08ab	73.80±17.56e	29.50±6.23abc
7	0.400	0.100	0.500	66.53±27.04a	78.47±34.51a	90.68±12.31cd	26.53±7.95bc
8	0.600	0.100	0.300	68.63 ±22.70a	71.72±30.80abc	101.37±18.04ab	27.95±6.03abc
9	0.800	0.100	0.100	63.90±23.16a	47.31±24.39de	109.25±13.30a	23.60±7.65c
10	0.540	0.220	0.240	85.78±10.41a	64.47±28.92abcd	94.61±10.47bc	27.61±5.50bc
11	0.120	0.640	0.240	89.83±10.48a	58.97±22.27abcde	61.55±20.84f	27.50±6.14bc
12	0.260	0.500	0.240	91.00±9.79a	61.08±24.81abcde	78.84±11.60de	28.58±4.88abc
13	0.400	0.360	0.240	85.62±12.36a	63.97±24.58abcde	86.05±8.28cde	26.42±5.40bc
14	0.400	0.360	0.240	89.42+8.44a	61.18+22.45abcde	85.47+6.96cde	34.00+21.30a
15	0.400	0.360	0.240	88.72±9.22a	67.75±28.46abcd	89.56±7.63cd	26.61±5.61bc

Table 3.5 *continued ….*

Formulation No.	**Factors**[b]			**Sensory attributes**			
	X_1	**X_2**	**X_3**	**Softness**	**Graininess**	**Adhesiveness of mass**	**Toothpack**
1	0.800	0.150	0.050	4.17±3.52 e	101.00±13.09ab	88.00±13.36bc	91.11 ±15.22bc
2	0.400	0.550	0.050	7.42±4.92de	95.63±8.91ab	94.74±7.56ab	99.10±8.54ab
3	0.000	0.950	0.050	7.12±2.76de	77.29±28.39de	92.12±25.85ab	101.12±16.09a
4	0.000	0.725	0.275	15.75±3.89abc	81.35±28.08cd	97.20±10.98a	100.45±11.53a
5	0.000	0.500	0.500	10.74±3.83cd	68.37±27.57e	96.47±10.47ab	100.63±10.67a
6	0.200	0.300	0.500	10.65 ±3.18cd	92.95±8.78ab	96.65±9.67ab	100.95±10.10a
7	0.400	0.100	0.500	19.47±23.36a	92.53±20.27ab	92.63±13.54ab	100.16±13.42a
8	0.600	0.100	0.300	17.57±2.67ab	101.68±8.29a	94.68±8.99ab	98.68±9.14ab
9	0.800	0.100	0.100	5.80±4.38de	103.80±11.81a	84.05±9.43c	87.55±11.38c
10	0.540	0.220	0.240	14.05±2.55abc	98.28±8.61ab	94.33±7.23ab	98.89±8.79ab
11	0.120	0.640	0.240	14.94±16.39abc	89.44±7.92bc	93.00±9.24ab	96.11±23.56abc
12	0.260	0.500	0.240	14.79 ±3.55abc	96.79±9.20ab	96.21±10.48ab	100.10±11.14ab
13	0.400	0.360	0.240	12.84±3.13bc	97.79±8.51ab	94.63±7.37ab	98.58 ±8.36ab
14	0.400	0.360	0.240	12.84 ±3.93bc	98.37±8.08ab	96.58±9.11ab	99.79±9.99ab
15	0.400	0.360	0.240	13.83±2.87abc	96.72±7.57ab	94.78±8.76ab	99.44 ±9.74ab

[a] Intensity ratings based on 150-mm unstructured line scales. Mean values in the same column not followed by the same letter are significantly different ($p < 0.05$).

[b] Factors were: x_1 = proportion of sugar; x_2 = peanut fines; x_3 = butter.

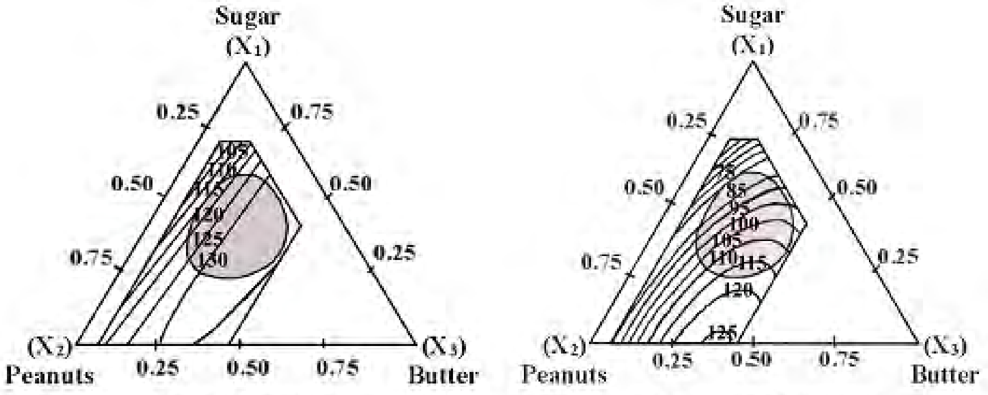
Table 3.6 Regression equations[a] describing the response for each dependent variable for peanut polvoron containing the proportions of the components sugar (x_1), peanut fines (x_2), and butter (x_3)[b] (San Juan *et al*., 2007 unpublished)

Variable	Model	R^2
Compactness	$71.63x_1 + 105.88x_2 – 11.90x_3 + 14.51x_1x_2 + 402.83x_1x_3 + 287.43x_2x_3$	0.8581
Cream color	$9.60x_1 + 70.32x_2 – 15.50x_3 + 72.93x_1x_2 + 372.27x_1x_3 + 374.98x_2x_3$	0.8888
Dryness	$16.36x_1 + 6.52x_2 + 423.67x_3 – 7.17x_1x_2 – 516.24x_1x_3 – 349.76x_2x_3$	0.8627
Coarseness	$128.67x_1 + 126.01x_2 + 62.60x_3$	0.9303
Roasted peanutty	$54.54x_1 + 91.61x_2 + 58.78x_3 + 38.27x_1x_2 – 0.83x_1x_3 + 41.78x_2x_3 + 300.03x_1x_2x_3$	0.8602
Buttery	$35.62x_1 + 46.21x_2 + 77.20x_3 + 65.35x_1x_2 + 163.45x_1x_3 + 28.44x_2x_3 – 100.02x_1x_2x_3$	0.8793
Sweet	$113.98x_1 + 26.14x_2 + 43.78x_3 + 44.59x_1x_2 + 47.03x_1x_3 + 32.77x_2x_3 + 278.79x_1x_2x_3$	0.7599
Softness	$-8.46x_1 + 4.42x_2 – 38.34x_3 + 29.03x_1x_2 + 186.16x_1x_3 + 113.93x_2x_3 – 213.45x_1x_2x_3$	0.7462
Graininess	$102.24x_1 + 80.01x_2 + 25.55x_3 + 141.04x_1x_3 + 88.46x_2x_3$	0.8318
Adhesiveness of mass	$78.08x_1 + 89.96x_2 + 81.94x_3 + 38.93x_1x_2 + 55.38x_1x_3 + 41.88x_2x_3 – 74.61x_1x_2x_3$	0.8993
Toothpack	$81.63x_1 + 100.51x_2 + 100.17x_3 + 29.28x_1x_2 + 37.48x_1x_3 – 8.02x_2x_3 – 51.75x_1x_2x_3$	0.8134

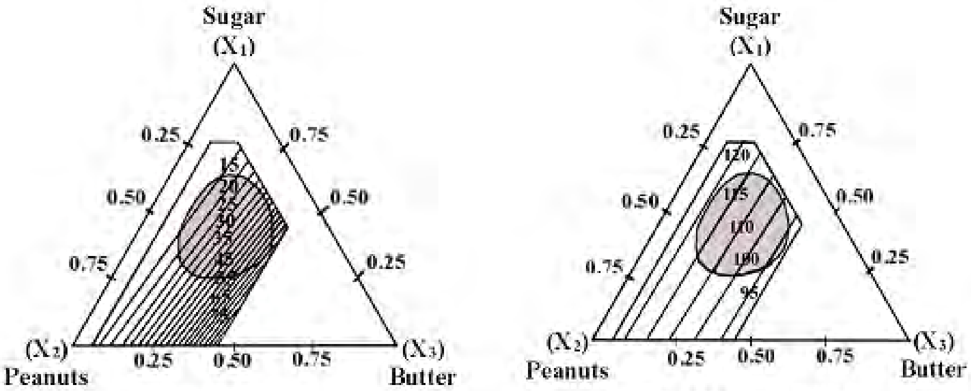
All models significant at $p < 0.05$.

[a] Descriptive ratings based on 150 mm line scales.

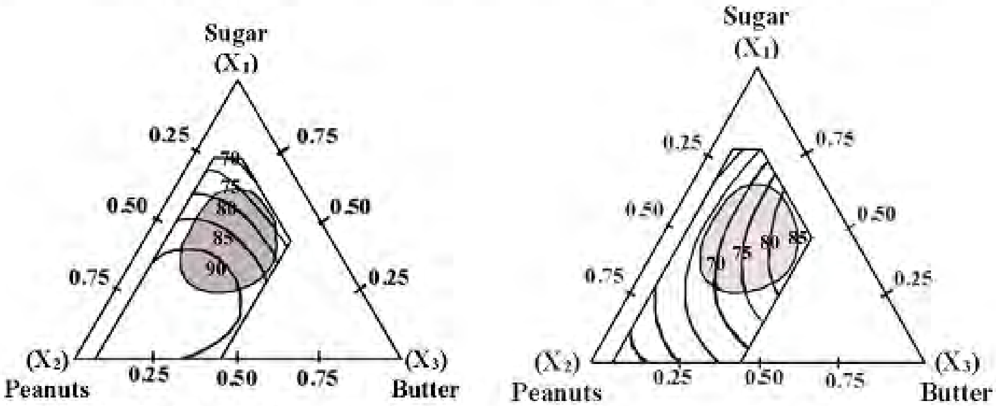
[b] Where x_1, x_2 and x_3 are proportions of the components sugar, peanut and butter used in the mixture to formulate peanut polvoron.



(a) COMPACTNESS (b) CREAM COLOR

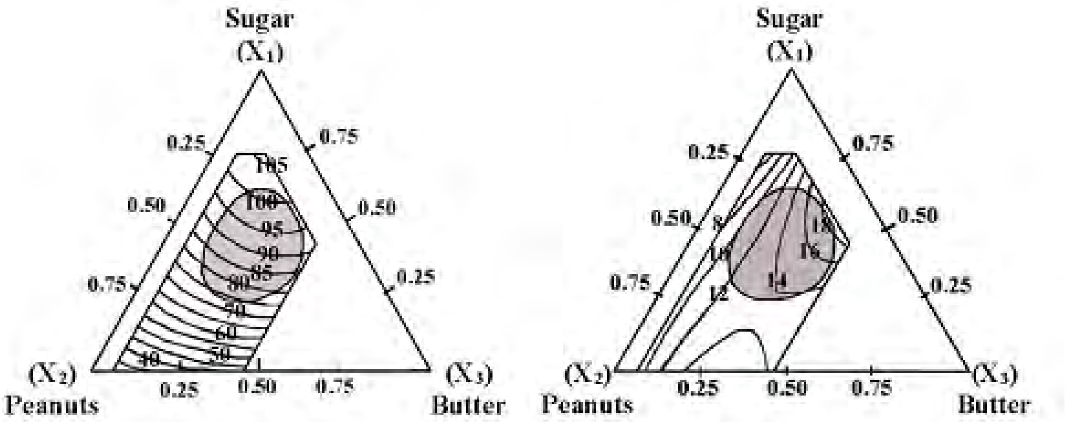


(c) DRYNESS (d) COARSENESS



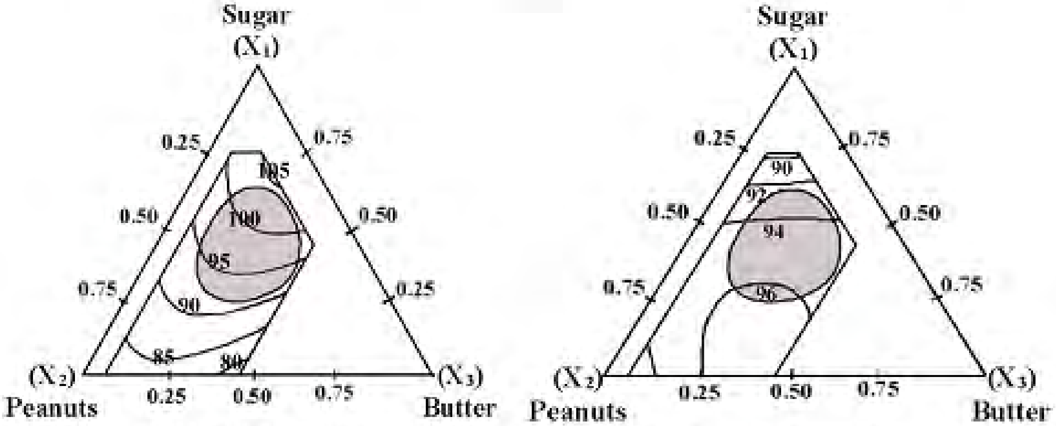
(e) ROASTED PEANUTTY AROMA (f) BUTTERY AROMA

Figure 3.3 Contour plots for blends containing sugar (X_1), peanut fines (X_2), and butter (X_3) designating the optimum regions for compactness (a), cream color (b), dryness (c), coarseness (d), roasted peanutty aroma (e), buttery aroma (f), sweet taste (g), softness (h), graininess (l), adhesiveness of mass (j), and toothpacking (k).



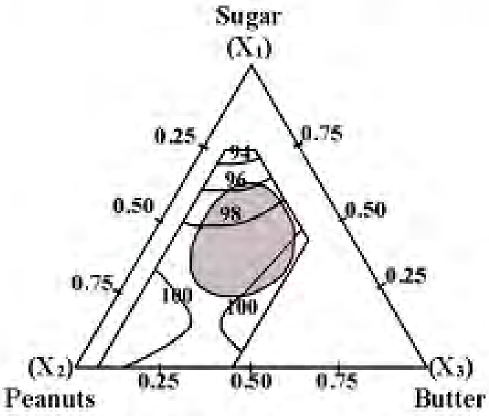
(g) SWEET TASTE

(h) SOFTNESS



(i) GRAININESS

(j) ADHESIVENESS OF MASS



(k) TOOTH PACKING

Fig. 3.3 continued

Verification

The observed and predicted values for appearance, color, flavor and texture acceptance and overall acceptance are presented in Table 3.7. The t-tests indicated that the observed values for the selected formulation (Formulation 1) were not significantly different from the predicted values at ∝ = 0.05.

Table 3.7 Predicted and observed values for consumer acceptance of selected formulations of peanut polvoron for verification of the optimum region (San Juan *et al*., 2006)

Sensory Attribute	Peanut Polvoron containing 40% sugar, 36% peanut, and 24% butter			Peanut Polvoron containing 0% sugar, 95% peanut, and 5% butter		
	Observed	Predicted	t-value	Observed	Predicted	t-value
Overall	6.19	6.41	3.48E-09NS	3.81	3.69	0.0289NS
Color	6.23	6.47	0.0002NS	5.46	5.13	0.0970NS
Appearance	6.08	6.43	6.76E-05NS	5.46	5.10	0.0071NS
Flavor	5.96	6.49	1.92E-09NS	3.08	3.49	0.0060NS
Texture	5.58	6.35	1.11E-07NS	3.50	3.92	0.0009NS

NS= Observed ratings were not significantly different ($p \leq 0.05$) from predicted ratings.

Results of Technology Transfer

The technology of an improved peanut polvoron was transferred to a second collaborator, The Nutcracker Homemade Products, Inc. after the owner/president of the first collaborating company passed away and the children were no longer interested in pursuing the business started by their parents. The owner of another company, The Nutcracker Homemade Products, Inc. readily accepted the proposal of FDC Peanut CRSP Investigators for the technology transfer of a peanut polvoron. The technology was finally transferred on March 22, 2007 with the company owner present. In return, the industry collaborator promised to provide data on sales performance, production volume and socio-economic benefits gained from the production and marketing of peanut polvoron using the technology transferred by FDC PCRSP investigators and will be reported in Monograph 9 Part 2.

CONCLUSIONS

Development of a peanut polvoron was conducted using a mixture design, consisting of varying levels of three comnponents: sugar, peanut fines, and butter. A consumer acceptance test was conducted and predictive models were developed for acceptance of color, flavor, sweetness, texture, and overall acceptance. The sensory profile of various peanut polvoron formulations was evaluated using descriptive analysis tests and predictive models were developed for compactness, cream color, dryness, coarseness, creamy, roasted peanutty, and buttery aroma, sweet and salty tastes, softness, graininess, adhesiveness of mass and toothpacking. Predictive models were used to generate contour plots to identify optimum regions in the areas of overlap. Texture was the limiting sensory attribute in the manufacture of peanut polvoron. Optimum formulations could be obtained in blends containing 22-36% peanut fines, 10-38% butter,

To transfer the technology for the improved peanut polvoron formulation,the Nutcracker Homemade Products, Inc. was approached by FDC on a possible collaboration and was accepted by the company. A formulation of peanut polvoron that was considered as the most acceptable formulation by the consumers obtained from the optimization study was transferred to the collaborator.

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CHAPTER 4

CONSUMER ACCEPTANCE, SENSORY PROFILING, TECHNOLOGY TRANSFER, AND SHELF LIFE OF PEANUT BRITTLE FOR THE MANILA MARKET

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ABSTRACT

The high impact ingredients affecting texture of peanut brittle which were identified in the literature to be glucose syrup, sugar, peanuts and baking soda were verified as to their effect on texture and other sensory characteristics of the product (Food Development Center, 2005a). Findings showed that only glucose syrup, sugar, and peanuts could be used to optimize the ingredients for this product. These ingredients were used to determine the constrained region bounded by the levels of each component that could form peanut brittle. Peanut brittle products in two replicates were prepared from 12 formulations within the constrained region to determine the best formulation, using response surface methodology (RSM).

Using RSM, consumer and descriptive tests were conducted to determine the best peanut brittle formulation that would meet the criteria for an acceptable peanut brittle as follows: (a) with a brittle texture on the first and crunchy on subsequent bites, (b) no bitter taste, and (c) with roasted and caramel aroma. A consumer panel (n=120) evaluated the peanut brittle samples using a balanced incomplete block design. A minimum rating of 6.0 was set as the acceptable rating for each attribute. In the descriptive tests, the sensory attributes evaluated were hardness, fracturability, color, surface shine, buttery aroma, roasted peanutty aroma, caramel aroma, sweet taste, salty taste, and bitter taste using a 150 mm line scale. Data from the consumer and descriptive tests were analyzed using Statistical Analysis System (SAS Institute, Inc., 2001). Prediction equations and contour plots were generated for each sensory attribute, and the acceptable formulations were obtained by superimposing the acceptable regions for each attribute.

Superimposing all acceptable areas in the contour plots for texture, color, appearance, flavor, and overall acceptance showed that all formulations in the constrained region were acceptable to the consumer panel with 6.5 hedonic rating as the minimum acceptance rating given. This means that an acceptable peanut brittle can be produced using any of the formulations within the constrained region. The twelve formulations also produced products with higher acceptance ratings for texture than the commercial sample.

Based on above findings, the products from the 12 formulations were better than the collaborator's product. The acceptable formulations maybe a combination of glucose syrup, sugar, and peanuts within the following ranges: 15 to 90% glucose syrup, 0 to 65% sugar, and 10 to 55% peanuts. The amounts of the other ingredients in the formulation that must be used in fixed amounts were as follows: 16.0% water, 6.0% butter, 3.5% sesame seeds, 1.5% baking soda, 0.6% industrial salt, and 0.15% vanilla powder.

Prediction equations were obtained from the statistical analysis of data for consumer and descriptive testing to show the relation of percentages of the three ingredients in the formulation and acceptability. These equations are useful as tools for changing the levels of ingredients when necessary as when optimizing cost, without sacrificing product acceptability.

An improved process for peanut brittle developed at the Food Development Center (FDC, 2005b) was transferred to Monastery Farms (San Jose, Malaybalay City, Bukidnon) with the assistance of plant personnel of the collaborator using the ingredients and equipment available in the processing plant. The improved process involved optimization of ingredients and introduction of dry blanching to sort aflatoxin infected nuts.

The modifications introduced during the technology transfer were the following: (a) Introduction of a new dry blanching step at 149°C for 8 minutes for a 20-Kg batch of raw peanuts. This facilitated removal of the skin and sorting of aflatoxin infected nuts; (b) Sorting of nuts following dry blanching, before final roasting; (c) Control of time and temperature of roasting and cooking of peanuts and other ingredients for the preparation of peanut brittle. Roasting parameters were 6 to 7 minutes at 149°C for a 20-Kg batch of sorted peanuts to obtain a moderate to strong roasted peanutty aroma, and a medium to dark brown color of peanuts. Cooking temperature for a 4-Kg batch of peanuts and other ingredients was 165 to 170°C to obtain a brittle product with golden brown color and no burnt flavor; (d) Roasting of sesame seeds in a "carajay" for 25 to 30 minutes at low heat which produced a moderate to strong roasted sesame aroma; and (e) Cooling of the cooked mixture to 85 to 90°C prior to cutting, which significantly improved the shape of the cut pieces.

The FDC formulation for peanut brittle which targetted improved texture was also modified to achieve the preferred sweet and salty tastes, roasted peanutty and sesame aroma in the product as requested by the collaborator. The new formulation, achieved by trial and error of the FDC formulation which was previously derived using response surface methodology, is as follows: 14.0% glucose syrup, 37.0% refined sugar, 34.0% roasted peanuts, 7.5% water, 4.0% butter, 1.5% roasted sesame seeds, 1.0% baking soda, 0.35% industrial salt, and 0.65% vanilla concentrate. Detailed description of the standardized process are contained in the "Manual of the Standardized Process for the Preparation of Monk's Peanut Brittle" (Appendix I). The manual includes product formulation, schematic diagram of the process, process description, finished product specifications, estimated cost of ingredients for the preparation of peanut brittle, and requirements for the control of quality of peanut brittle during preparation.

Peanut brittle prepared using the new formulation obtained from the standardized process and packed in its traditional packaging of cellophane as primary packaging and polypropylene jar as secondary packaging had a shelf life of 158 days or 5.3 months at ambient storage. The product was no longer acceptable primarily due to change in its texture/crunchiness and flavor/taste. The shelf life of the product from the new formulation was two months longer than the shelf life of the existing process of the collaborator.

INTRODUCTION

Evaluation of the different peanut products from Cagayan de Oro, Philippines showed that peanut brittle has the potential of strengthening its marketability through improvement of quality. The presence of bitter taste, slightly hard texture, and non-uniformity of size were the problems identified for this product. The bitter taste was attributed to the dark colored kernels in some peanut brittle slices that may have been overlooked during the cooking process or to aflatoxin infected kernels. The aflatoxin infected kernels can be separated from the good kernels through proper sorting of the blanched peanuts, while the overcooked kernels can be prevented through proper control of the cooking process. The texture of the peanut brittle on the other hand, can be improved through modification of the ingredients and the process. Above information indicates that the quality of peanut brittle could be improved provided the problems identified for the product is corrected.

A basic peanut brittle formulation consisted of the ingredients sugar, glucose syrup, water, salt, peanuts, butter, vanilla, and baking soda. Preliminary experiments showed that after using the above ingredients in a peanut brittle formulation, sugar, glucose syrup, and baking soda have major effects on texture of this product (Food Development Center, 2005a). These ingredients contributed to the porosity of the product through the reaction of acid from glucose syrup and sugar, and from the carbon dioxide released by baking soda. Other findings showed that baking soda cannot be used at levels higher than 1.5% due to development of bitter and salty tastes in the product. A previous study (Food Development Center, 2005c) resulted in six (6) formulations for peanut brittle that have the ability to form peanut brittle. The six formulations formed the boundaries of the constrained region or the region outside of which peanut brittle will not form, and within which peanut brittle will be formed.

Improvement of the product taste and texture was achieved in this study. However, the process for this improved product needs to be standardized using the collaborator’s facilities, ingredients and manpower to ensure consistent product quality. The production system, likewise, should optimize use of time and labor.

Monk’s improved peanut brittle is a product where ingredients and processing parameters were changed in relation to the original product. The shelf life of the improved product therefore is not expected to be the same. Although a large change in shelf life is not expected considering the modifications made, this has to be reconfirmed as the information is essential to preparing the marketing plan for the improved product and to evaluating the overall benefits of the improvement made.

OBJECTIVES

This study aims to: (1) determine the effect of levels of ingredients in formulations within the constrained region on texture and other sensory characteristics using response surface methodology, (2) standardize the peanut brittle process using the collaborator's facilities, ingredients and manpower to ensure consistent product quality, and (3) determine the shelf life of the improved peanut brittle.

METHODS

CONSUMER ACCEPTANCE AND SENSORY PROFILING OF PEANUT BRITTLE

Establishment of Industry Collaboration

The collaborator for the study, the Monastery Farms of Malaybalay, Bukidnon, was identified based on an existing peanut brittle product in the Cagayan de Oro market, locally called piñato. Through its representatives, who attended a seminar conducted by FDC Peanut CRSP investigators in Cagayan de Oro in August 2003, the collaborator agreed to FDC's proposal to assist them in improving the texture and flavor of their product. Based on the Memorandum of Agreement, shown in Appendix F, the collaborator agreed to shoulder half of the cost of peanuts used in the product development, full cost of raw materials and ingredients during the transfer of the technology to the plant; make equipment and plant facilities available, provide manpower support during the transfer of technology; provide local transportation, accommodation and meals of two FDC personnel during the transfer of technology.

Location of where research was conducted

The consumer tests were conducted at the Multipurpose Hall of the Food Terminal Inc., FTI Complex, Taguig City, while the descriptive tests and statistical analyses were conducted at the Food Development Center, FTI Complex, Taguig City.

Identification of Formulations of Peanut Brittle Within the Constrained Region

Formulations of peanut brittle within the constrained region (Fig. 4.1) were identified in order to determine the effect of different levels of ingredients on acceptability of texture and other sensory characteristics. The constrained region was developed from a previous study (Food Development Center, 2005c). From Fig. 4.1, the formulations within the constrained region were identified as follows.

Determination of Minimum Number of Formulations

The minimum number of formulations to be used in the optimization studies was determined using the formula by Scheffe' (1963): $n = 2^q - 1$, where n is the number of formulations using q number of components, and q is the number of components being studied, i.e., 3 which were glucose syrup, sugar, and peanuts. Substitution of the number of components to the equation showed that a minimum of 7 formulations should be identified within the constrained region. The formulations in the extreme vertices and in the midpoints between vertices of the constrained region are usually included in the selection of formulations for the minimum number of formulations (Myers and Montgomery, 2002).

Identification of Additional Formulations Within the Constrained Region

Additional formulations were also chosen to support a second-order polynomial that would determine interactions of other levels of ingredients. In this case, 5 more points or formulations located between vertices, at the center of the constrained region or center point, and in a midpoint between a vertex and the center point were added. The twelve (12) formulations identified within the constrained region are shown in Fig. 4.2.

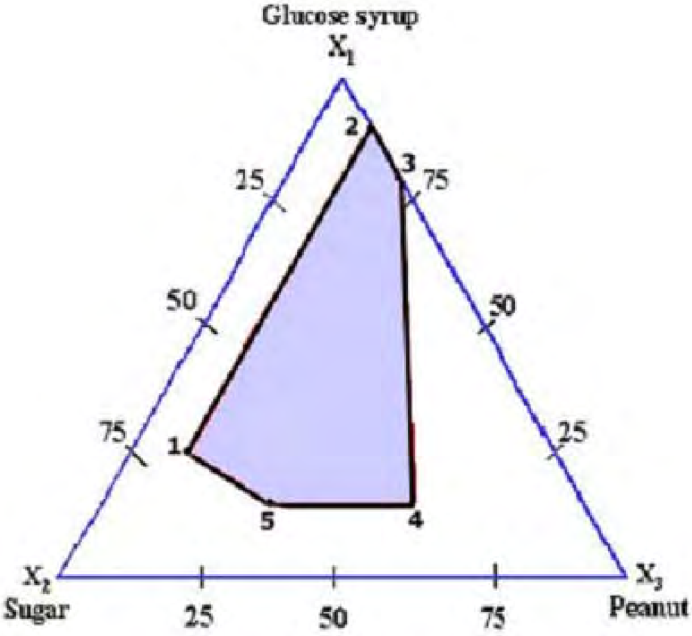


Fig. 6.1 (4.1 ined region in the simplex coordinate system for peanut brittle defined by the following restrictions: $0.15 \leq X_1 \leq 0.90$, $0 \leq X_2 \leq 0.65$, $0.10 \leq X_3 \leq 0.55$, for glucose syrup, sugar and peanuts, respectively.

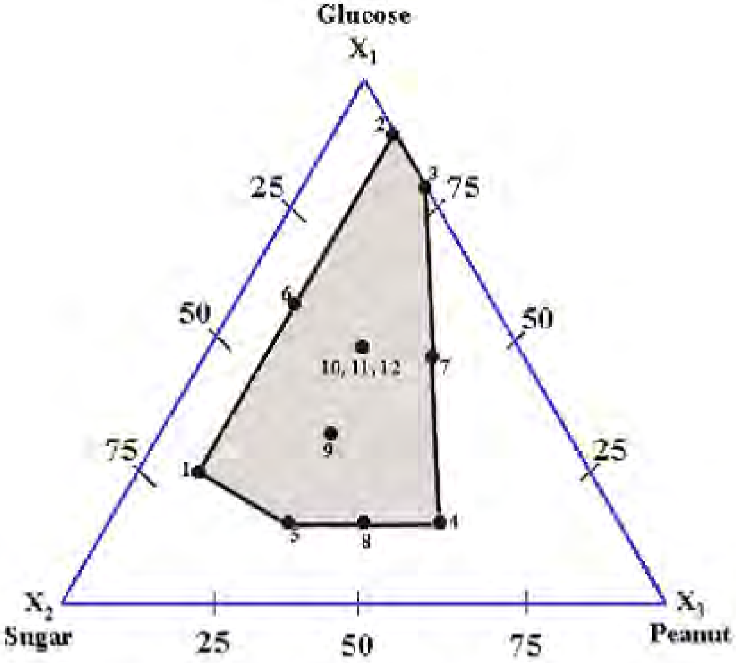


Fig. 6.2 Coı 4.2 ɛd region in the simplex coordinate system for peanut brittle showing the 12 formulations identified within the constrained region.

Preparation of Peanut Brittle Samples for Evaluation

Peanut brittle products were prepared using different levels of glucose syrup, sugar, and peanuts from the 12 formulations within the constrained region. The procedure for preparing peanut brittle is in Appendix A. The formulation was prepared in duplicate, totaling to 24 mixtures for evaluation. Figure 4.2 shows the location of the 12 formulations of peanut brittle in the constrained region.

A commercial sample, referred to in the study as the sample of the collaborator, was received at FDC on January 19, 2005 via JRS Express. The samples were wrapped individually in a specially made cellophane wrapper labeled Monks'. The product was packed in transparent semi-rigid plastic containers which were labeled Monks' Piñato (Peanut Brittle Bar) with Best Before date of March 16, 2005. The samples were stored at 4°C until time of use.

A day before evaluation, the commercial samples were removed from its original wrapper and wrapped in the same manner as the peanut brittle from the 12 formulations. Both the commercial and the prepared 24 samples of peanut brittle were wrapped in unlabeled cellophane wrappers purchased from Tropical Hut, Food Terminal Inc. (FTI Complex, Taguig City).

Sensory Evaluation

Consumer Test of Peanut Brittle

A consumer test of peanut brittle was conducted to determine acceptable levels of glucose syrup, sugar, and peanuts in the peanut brittle formulation. The following steps were carried out:

Development of the ballot. The ballot used for the consumer test is shown in Appendix C. A 9-point Hedonic scale was used in the evaluation of the peanut brittle samples. The attributes include overall liking and liking for texture, color, appearance, and flavor where 1= dislike extremely, 5= neither like nor dislike, and 9= like extremely.

Preparation of demographic questionnaire. A demographic questionnaire (Appendix B) was prepared to obtain background information of the consumers and to determine who would qualify as panelists for the consumer test. The questionnaire includes the following data: name, office address, occupation, gender, age, civil status, and questions whether the prospective consumer has food allergies, is a consumer of peanut brittle and frequency of eating the product.

Venue. Venue for the Central Location Test (CLT) (Meilgaard *et al*., 1988) was conducted at the canteen of the Food Terminal Inc. (FTI Complex, Taguig City) after a series of coordination was made with the Administration Section of the FTI.

Determination of number of panelists for the consumer test. One hundred twenty consumers were required to evaluate 24 samples of peanut brittle prepared in two replicates from the 12 formulations. The number of consumers (n=120) needed was determined based on a balanced incomplete block design because it was unreasonable to expect the panelists to evaluate and provide reliable data on all the samples (Meilgaard *et al*., 1988). In this design, a panelist evaluated only six of the 24 samples which were randomly selected. Thirty (30) responses were required for each peanut brittle sample, for a total of 720 responses for the 24 samples. Since only six samples will be evaluated by a panelist, a total of 120 panelists were required.

Selection of panelists. Separate tables were set up at the FTI canteen which were used by the consumers to fill-out demographic questionnaires prior to the test. Consumers who satisfied the following criteria were selected as panelists for the consumer test: (1) had no food allergies, (2) were between the ages of 18 and 70, and (3) were consumers of peanut brittle.

Sample evaluation. Two pieces of peanut brittle samples, wrapped in cellophane, were presented to each of the 120 panelists for evaluation of its sensory characteristics. The samples were coded with three digit numbers and assigned randomly to each panelist. Each panelist evaluated 6 samples which were randomly selected from the 24 peanut brittle samples. A control sample from the collaborator, referred to in the study as the commercial sample, was also coded and evaluated by each panelist for a total of 7 samples per participant.

The samples were evaluated in the order designated on the ballot. The order designated for the evaluation of the 7 peanut brittle samples was randomized for each panelist such that the order of presentation was different for each panelist. The panelists were instructed to evaluate 4 samples, take a 1-minute break and evaluate 3 more samples. The panelists were also instructed to drink water after every sample and not to make comments during evaluation to prevent influencing other participants. The ballot in Appendix C was used by the panelists in evaluating the samples.

Descriptive Test of Peanut Brittle

A descriptive test of peanut brittle was conducted to define the sensory properties of peanut brittle that were acceptable to consumers from the consumer test. The following steps were carried out:

Selection of panelists. The pre-screening questionnaire used for the selection of panelists is presented in Appendix D. Panelists were selected from a pool of trained FDC panelists and screened based on the following criteria: (1) not allergic to peanut products, (2) a consumer of peanut brittle, (3) does not have dentures or braces, (4) in healthy condition, (5) non-smoker, and (6) willing to participate. The detailed procedure for the selection of panelists is presented in a report on "Guidelines for the Quantitative Descriptive Analysis (QDA) as Applied to Peanut Brittle" (Food Development Center, 2005d). Twelve (12) panelists were selected and were as follows: Amelita Natividad, Liza Tenorio, Rachel Rocafort, Grace Dolor, Elizabeth Perlas, Myrna Mangilit, Ma. Lourdes Santiago, Nora Pascual, Luzviminda Maala, Carmelita Alkuino, Vivian Matienzo, Fe Urnieta.

Training of panelists. A 150-mm unstructured line scale with anchors at 12.5 mm from each end (Meilgaard *et al*., 1988) was used in rating the intensity of the sensory attributes of the 24 peanut brittle products. The panel consisted of 8 to 12 panelists. All sensory attributes of the product and their intensities such as texture (hardness and fracturability on the first bite and first chew), appearance (color, surface shine), aroma (roasted peanutty, buttery, sesame, vanilla, caramel), and taste (sweet, bitter, salty) were evaluated. Ballots were generated by the panelists using reference samples and descriptors that represented attributes likely to be encountered in the product.

The panelists indicated the intensity of each attribute by placing a vertical line on the unstructured line scale. Quantification was accomplished by measuring the distance from zero to the vertical line. The ballot used for the descriptive test is shown in Appendix E. The detailed procedure for training of panelists is presented in a report on "Guidelines for the Quantitative Descriptive Analysis (QDA) as Applied to Peanut Brittle" (Food Development Center, 2005d).

Evaluation of samples. The twenty-four samples (12 formulations x 2 replicates) of peanut brittle were evaluated by 8 to 12 panelists using Quantitative Descriptive Analysis (Resurreccion, 1998). Evaluations were conducted at the FDC sensory laboratory in partitioned booths illuminated by fluorescent lighting. The panelists evaluated 4 samples per session for 14 non-consecutive sessions. The samples, coded with three digit random numbers, were randomly selected using a complete random block design. The samples, references, cups for expectoration, plastic cups with water for rinsing the mouth, unsalted crackers, ballots, pens, and napkins were provided in trays lined with white paper. The panelists were instructed to evaluate the samples for texture, appearance, aromatics and taste. During each session, panelists were provided with references to standardize evaluation ratings and to avoid drifting (Meilgaard *et.al*., 1988).

Panelists were further instructed to evaluate the peanut brittle samples in the order designated in the ballot and to rate each sample based on the intensity of the attribute as perceived in the sample. The details of evaluating peanut brittle samples are presented in a report on "Guidelines for the Quantitative Descriptive Analysis (QDA) as Applied to Peanut Brittle" (Food Development Center**,** 2005d).

Data Analyses

Data obtained from the consumer and descriptive tests were analyzed using the Statistical Analysis System (SAS Institute Inc., 2001).

Analysis of Data Using the Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT)

The analysis of variance of data from the consumer and descriptive tests was determined using the General Linear Models (GLM) procedure to determine the significance of the effect of the levels of glucose syrup, sugar, and peanuts on the sensory attributes of the peanut brittle products, while Duncan's Multiple Range Test (DMRT) was used to determine significance of mean differences (Tables 4.1 and 4.2).

Acceptable Formulations of Peanut Brittle

Regression analysis (Proc Reg; SAS, 2001) was used to fit the full second order polynomial by Scheffe' to the data of each sensory attribute evaluated, which generated the prediction equations. A prediction equation shows the relationship of the levels of the ingredients and the minimum rating of 6.0 for acceptance in the consumer test, or the relationship of the levels of ingredients and intensity of the attribute perceived in a peanut brittle sample in the descriptive test. A total of five (5) prediction equations were generated for the consumer test and fourteen (14) for the descriptive test. The prediction equations for the consumer and descriptive tests are presented in Tables 4.3 and 4.4.

The regions or formulations of peanut brittle covered by the minimum acceptance rating of 6.0 for each sensory attribute were determined from the contour plots and superimposed to obtain the region of overlap as shown in Fig. 4.3. The region of overlap represents the formulations that were acceptable (hedonic rating of 6.0 or above) to the consumers. From this region, the range of percentages of glucose syrup, sugar and peanuts that were considered acceptable were determined.

Model Verification

Model verification was performed on two formulations (Formulation Nos. 9 and 12) predicted to result in acceptable products through a consumer test. The two formulations were chosen because they ranked first and third among the 12 formulations that received high ratings in the consumer test. The formulations were prepared in two replicates for a total of 4 samples. Thirty panelists from FTI evaluated the samples. These participants were chosen from the 120 panelists who previously evaluated 24 peanut brittle products. Each panelist evaluated all four samples using the ballot shown in Appendix E. The data were analyzed using the t-statistics to determine if a significant difference exists between the observed and predicted values of the two peanut brittle samples for each sensory attribute (Table 4.5). The ratings obtained by the two formulations from the model verification were also compared with the ratings obtained by the commercial sample from the first consumer test using 24 samples of the product.

TECHNOLOGY TRANSFER OF PEANUT BRITTLE PROCESS TO COLLABOTATOR AND STANDARDIZATION OF PEANUT BRITTLE PROCESS IN COLLABORATOR'S PLANT (as per Memorandum of Agreement, Appendix F)

Evaluation of Equipment and Ingredients Used by the Collaborator for Suitability to Peanut Brittle Preparation

The equipment and ingredients used by the collaborator in preparing peanut brittle were evaluated for suitability to peanut brittle production. Specifically, these were evaluated to determine capability to produce product with optimum quality. Suitability of equipment to optimize use of time and labor during production was also analyzed. The results are presented in Tables 4.6 and 4.7, respectively.

Identification of Potential Problems in Carrying-Out the Standardization Process Based on the Process and Equipment Used by the Collaborator

The plant personnel were interviewed prior to the standardization of the process to identify potential problems that would result in an unsafe consumption of the product or unacceptable sensory quality from that established by FDC.

Identification of Plant Personnel Who Participated in the Standardization of the Process

The plant personnel involved in the production of peanut brittle were identified as well as their work assignments during the identification of equipment and ingredients used by the collaborator. The results are listed in Table 4.8.

Testing of the FDC Peanut Brittle Process Using the Collaborator's Equipment

Two (2) FDC personnel, namely Jenny Manalo and Edith San Juan, demonstrated the FDC procedure for the preparation of peanut brittle to the plant personnel of Monastery Farms using their equipment and ingredients. The peanut brittle process of FDC is described in Appendix G.

Preparation of Peanuts

The FDC steps for the preparation of roasted peanuts were dry blanching at 140°C, immediate cooling to 45°C, deskinning, sorting for aflatoxin infected peanuts, roasting to desired color and flavor at 140°C, chopping of peanuts, and sifting of chopped peanuts. The steps, however, were only discussed with the plant personnel since the temperature used by the collaborator was at 149°C. The dry blanching and roasting steps were later standardized at 149°C using the Probat coffee roaster.

Preparation of Ingredients

The ingredients were prepared as follows: (1) sesame seeds was roasted over a medium fire for 15 to 20 minutes, and immediately cooled to 45°C, (2) butter was softened at room temperature, and (3) ingredients were weighed based on FDC formulation.

Preparation of Peanut Brittle

The peanut brittle was prepared by mixing of ingredients, cooking, molding of cooked peanut brittle mixture, cooling of cooked mixture to 85 to 90°C, cutting, cooling of peanut brittle pieces at ambient condition before packing, packing, and storing.

Modification of the Peanut Brittle Process

The following steps of the FDC process were modified or standardized:

Dry Blanching of Peanuts

The dry blanching step for peanuts was standardized using the Probat coffee roaster which is operated at 149°C (Appendix H**).** The basis for determining the blanching time at 149°C for a 20-Kg batch of raw peanuts was the ease in deskinning of peanuts. The results are shown in Table 4.9. The step was established as follows:

Dry blanching at 149°C.(1) The Probat coffee roaster was pre-heated to 200°F (or 93°C) for about 10 minutes; (2) Twenty (20) Kg of raw peanuts per batch was fed into the receiver of the roaster; (3) The temperature of the roaster was increased to 300°F (or 149°C) during blanching; (4) Peanut samples were withdrawn every minute for 9 minutes to test for ease in deskinning of peanuts. Evaluation for ease in deskinning of peanuts was done manually by rubbing the blanched peanuts against the surface of the “bilao” or winnowing tray.

Deskinning of peanuts. (1) Approximately 1 to 2 Kg of dry blanched peanuts was placed in a winnowing tray; (2) Peanuts was deskinned by manually rubbing off the skin against the winnowing tray by hands with rubber gloves (Appendix H); (3) The peanut skin was separated from the peanuts by a process locally called “pagtatahip” or winnowing (Appendix H).

Roasting of Peanuts

The step on roasting of peanuts was standardized using the Probat coffee roaster at 149°C for 20-Kg batches of sorted dry blanched peanuts by determining the roasting time. The endpoint of roasting was based on the development of a dark roasted peanut color and flavor. Peanut samples were withdrawn every minute to determine color and flavor. The results are presented in Table 4.10.

Roasting of Sesame Seeds

Two hundred (200) grams of sesame seeds was roasted in the carajay or “kawa” over a low fire using the inner flame of the stove. The endpoint of roasting was based on the development of a moderate to strong roasted sesame aroma and a medium brown color. Roasted sesame seed samples were withdrawn every five minutes to determine aroma and color. The results are presented in Table 4.11.

Cooking of Peanut Brittle Mixture

The step on cooking of peanut brittle was standardized by cooking 4-Kg batches of peanut brittle mixtures in the carajay (Appendix H). The mixtures were cooked at temperatures of 165°C to 172°C. The cooked mixtures were evaluated for color. The results are presented in Table 4.12.

Cooling of Cooked Peanut Brittle Mixture Prior to Cutting

The cooked mixture was immediately molded and flattened in a pre-formed plastic formica with grids (Appendix H). The mixture was cut using a stainless steel knife with a blade of about 12 inches when the temperature was 140, 120, 110, 90, 85, and 80°C. The cut peanut brittle at each cutting temperature was observed for softness of the mixture and evenness of the cut portions. The results are shown in Table 4.13.

The modifications made on the process, which are summarized in Table 4.14, were incorporated in the procedure for preparing peanut brittle

Modification of Ingredients in the Formulation

The FDC formulation for peanut brittle was modified at the plant by trial and error after evaluation of the product based on the preferred sweetness and saltiness as requested by the collaborator, and equipment used in the plant. One batch of peanut brittle, consisting of a 4-Kg mixture, was prepared using the FDC formulation and evaluated by the plant personnel involved in the peanut brittle manufacture by tasting.

The peanut brittle prepared by the plant personnel was evaluated after each preparation to determine if the product conforms to the Finished Product Specifications established by FDC which is described in Section IV of the Manual of the Standardized Process for the Preparation of Monk's Peanut Brittle (FDC, 2006b) shown in Appendix I. During the standardization process, the FDC formulation was modified three times (Table 4.15) after evaluation of the prepared peanut brittle based on the aroma (peanut and sesame aroma) and taste (sweetness and saltiness) preferred by the collaborator.

Training of Industry Personnel on the Standardized Process

The plant personnel were trained on the standardized process for peanut brittle after learning the procedures and the critical quality control points for each step. The modified procedure and the requirements for control of quality in the manufacture of peanut brittle are presented in Appendix I entitled “Manual of the Standardized Process for the Preparation of

Monk's Peanut Brittle”. A photo documentation of plant facilities, plant site, FDC teaching the process, and industry personnel carrying out the process are shown in Appendix H.

SHELF LIFE STUDY OF MONK’S PEANUT BRITTLE

Storage of the Product at Ambient Conditions

The optimized peanut brittle with a total net weight of 270 g per jar, was wrapped in 60 mm x 80 mm (width x length) cellophane with an average thickness of 0.014mm, and in polypropylene jars with a screw cap and a diameter of 100 mm and height of 90 mm. Each jar, containing 50 pieces of peanut brittle or approximately 5 g per piece was labeled with the product name, date samples were received, date of storage, and storage temperature, and stored at ambient temperature in a shelf life storage room. Control samples were stored in an incubator at 0-4^{o}C.

Schedule of Product Testing During Storage

Samples of the product were withdrawn from storage every 15 days for a total of 6 evaluations up to 90 days of storage. Consumer acceptance tests were conducted every sampling period. Descriptive analysis was conducted when the product was rated below 5 by the consumer panel. Moisture content was determined initially and at end of storage.

Product Test Methods Used

Packaging Condition

Presence of defects such as improper sealing, punctures of the polypropylene jars were evaluated visually (USFDA, 2001).

Sensory Evaluation Through a Consumer Test

The method used was a Consumer Test using a 9-point hedonic scale (Meilgaard *et al*., 1988). Thirty (30) consumers who were employees from the Food Terminal Inc. (FTI) were recruited to participate in the test. The criteria for the selection of the consumer panel were as follows: (1) had no food allergies, (2) were between the ages of 18 and 70, and (3) were consumers of peanut brittle. The consumer test was conducted in an open room, the Multipurpose Hall of the Food Terminal Inc. (FTI Complex, Taguig City).

Two pieces of peanut brittle samples, wrapped in cellophane, were presented to each of the 30 panelists for evaluation of its acceptability. The samples were coded with three digit numbers and assigned randomly to each panelist. Each panelist evaluated 2 samples at a time, a control sample and a sample stored at ambient conditions.

The samples were evaluated in the order designated on the ballot. The ballot in Appendix C was used by the panelists in evaluating the samples.

Sensory Evaluation by Descriptive Analysis

Descriptive analysis using unstructured line scales, 150 mm was conducted when the peanut brittle samples were rated as unacceptable by the consumer panel, or had ratings below 5. The procedure for conducting a descriptive test is similar to the procedure used in the sensory profiling of peanut brittle.

Procedure for Establishing the End of Shelf Life

The shelf life of a food product is defined as the period at which it will retain an acceptable level of eating quality from a safety and sensory point of view (Labuza, 2002). The end of shelf life of the product was established when the average rating was less than 5 by 30 consumers which corresponds to "dislike slightly". Descriptive analysis describes the properties of the reference and the product at end of shelf life.

RESULTS

CONSUMER ACCEPTANCE AND SENSORY PROFILING OF PEANUT BRITTLE

Formulations Identified Within the Constrained Region

According to Myers and Montgomery (2002), a mixture space is a simplex such that all design points must be at the vertices, on the edge or faces or in the interior of the simplex. A simplex is a uniformly spaced set of points on the triangle, as in this study.

Using the formula by Scheffe' (1963), a minimum of 7 formulations were identified in the constrained region. Five of these were taken from the 5 extreme vertices of the constrained region (Formulation Nos. 1, 2, 3, 4, and 5), and the other two formulations were taken from the 2 edge centroids (Formulation Nos. 6 and 7).

Five more formulations were selected to support a second-order polynomial. The polynomial, consisting of the variables glucose syrup, sugar and peanuts, determines the interaction of these ingredients in the response surfaces when sensory data are processed to determine acceptable formulations. A second-order polynomial consists of interactions of two or more variables or components in the mixture. One formulation was located between Formulation Nos. 4 and 5 (Formulation No. 8), and another at the center of the constrained region (Formulation No. 10). Another midpoint (Formulation No. 9) was also added. The overall centroid (Formulation No. 10) was replicated as Formulation Nos. 11 and 12 to determine if the response was reproducible.

Evaluation of Peanut Brittle from Formulations within the Constrained Region vs. Commercial Sample

Consumer Test

Mean consumer acceptance ratings for the attributes tested for peanut brittle are shown in Table 4.1. All peanut brittle samples had ratings of above 6.0 for the attributes overall liking and liking for texture, color, appearance, and flavor. These indicated that all of the samples were acceptable to the consumers.

Peanut brittle samples prepared from 80% glucose syrup, 0% sugar, and 20% peanuts (Formulation No. 3) had the lowest acceptance ratings for all attributes from among the 12 formulations except for color, and when compared with the commercial sample.

Table 4.1 Mean consumer ratings of peanut brittle from 12 formulations within the constrained region and of the commercial sample [a]

Formulation No.	Level of use (%) of ingredient							
	Glucose syrup (x_1)	Sugar (x_2)	Peanuts (x_3)	Overall liking	Color	Appearance	Flavor	Texture
1	25	65	10	7.02a	7.07abc	7.00a	6.85bc	7.05ab
2	90	0	10	6.98a	7.07abc	6.98a	7.02ab	7.27a
3	80	0	20	6.38b	6.69bc	6.75a	6.33c	6.62b
4	15	30	55	6.78ab	6.62c	6.95a	6.68bc	6.82ab
5	15	55	30	7.00a	7.15ab	7.13a	7.00ab	7.13ab
6	57.5	32.5	10	6.95a	7.00abc	6.98a	6.88bc	7.37a
7	47.5	15	37.5	6.98a	6.88abc	6.90a	6.95ab	6.98ab
8	15	43	42	6.95a	7.08abc	6.93a	6.95ab	7.02ab
9	34	38	28	7.10a	7.28a	7.10a	7.53a	7.32a
10	48	26	26	6.90a	6.85abc	7.00a	6.88bc	6.98ab
11	48	26	26	7.03a	7.08abc	6.95a	7.03ab	7.05ab
12	48	26	26	7.08a	7.13abc	7.00a	7.00ab	7.15ab
Commercial sample [b]	-	-	-	6.74	7.25	7.14	6.52	6.92

[a] Ratings are based on a 9-point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, and 9= like extremely. Mean values in the same column not followed by the same letter are significantly different ($p < 0.05$).

[b] Commercial sample used was a product of the collaborator.

There was no significant difference for texture, color, appearance, and flavor of the 12 peanut brittle products. However, a high texture rating was obtained in the product with 57.5% glucose syrup, 32.5% sugar, and 10% peanuts (Formulation No. 6). The ratings for flavor and color were highest in the product with 34% glucose syrup, 38% sugar, and 28% peanuts (Formulation No. 9), while rating for appearance was highest in the product containing 30% peanuts (Formulation No. 5).

Of the 12 peanut brittle products, 10 products had ratings higher than the ratings of the commercial sample for texture, overall liking, and flavor. These were products of Formulation Nos. 1, 2, 5, 6, 7, 8, 9, 10, 11, and 12. However, in terms of color, the commercial sample had higher mean acceptance ratings than the 11 peanut brittle products except for product from Formulation No. 9. Appearance of the commercial sample had the highest mean rating compared with the 12 products.

Among the 12 formulations of peanut brittle, Formulation No. 9 had high mean ratings in all sensory attributes. The mean consumer ratings obtained for Formulation No. 9 was compared with the mean ratings of the commercial sample. t-test showed that a significant difference existed for overall liking, and liking for color, appearance and texture except for flavor. This means that Formulation No. 9 had better sensory characteristics than the commercial sample except for flavor. The values obtained from the t-test were as follows:

Sensory attribute	t-value
a. Overall liking	0.1632
b. Liking for:	
Color	0.7366
Appearance	0.9430
Texture	0.1896
Flavor	0.0003
	(not significantly different at $p < 0.05$)

Descriptive Test

Table 4.2 shows the mean intensity ratings for the different sensory attributes of peanut brittle. Of the 12 peanut brittle formulations tested, two formulations (Formulation Nos. 2 and 4) had products which were significantly different from the other formulations for hardness in the first chew. Formulation No. 5 was also significantly different from the other formulations for hardness in the first bite. However, when the products of the 12 formulations were compared with the commercial sample, the latter was harder to bite and chew.

The commercial sample was brittle and hard in texture than the products from the 12 formulations as shown by its higher ratings for fracturability and hardness. This implied that the 12 formulations had products which required a lesser force to be broken into pieces than the commercial sample.

The roasted peanutty aroma in formulations containing more peanuts was more pronounced as in Formulation No. 4. Formulations with less peanuts had a weaker intensity of this attribute as in Formulation Nos. 1, 2, and 3. The commercial sample also had a lower intensity of this attribute.

Formulations with more sugar had products with higher ratings for caramel aroma and sweet taste as in Formulation No. 1.

Table 4.2 Mean ratings for the sensory attributes of peanut brittle using different levels of glucose syrup, sugar, and peanuts

Formulation No.	Level of use (%) of ingredient			Mean sensory ratings						
	Glucose syrup (x_1)	Sugar (x_2)	Peanuts (x_3)	Hardness (First bite)	Fracturability (First bite)	Hardness (First chew)	Fracturability (First chew)	Color	Surface Shine	Peanutty aroma
1	25	65	10	102.40ab	74.76a	98.88a	69.44a	127.31a	70.33b	33.58e
2	90	0	10	95.56e	65.94c	85.14d	62.00c	96.94c	35.71f	35.07e
3	80	0	20	99.72bcd	70.95b	91.22c	66.65b	99.78c	48.08d	36.85e
4	15	30	55	86.58f	64.71c	82.13e	60.00c	98.80c	41.43e	63.15a
5	15	55	30	99.60bcd	71.19b	92.06c	65.39b	106.07b	55.07c	50.23bc
6	57.5	32.5	10	103.44a	74.47a	96.76ab	70.11a	124.53a	72.92b	41.54d
7	47.5	15	37.5	97.28de	69.19b	90.14c	65.74b	99.53c	48.07d	51.69b
8	15	43	42	98.90cd	69.87b	94.78b	68.76a	125.89a	93.21a	47.85c
9	34	38	28	99.74bcd	70.21b	91.63c	65.06b	106.42b	54.29c	48.93bc
10	48	26	26	100.70abc	70.60b	91.85c	66.10b	100.74c	50.14cd	50.80bc
11	48	26	26	99.32bcd	70.65b	91.50c	65.20b	100.37c	50.23cd	48.67bc
12	48	26	26	99.85bcd	69.80b	91.45c	65.30b	100.55c	50.18cd	49.62bc
Commercial sample [b]	-	-	-	110	80	100	75	130	100	35

[a] Sensory ratings are based on 150 mm line scale with anchors 12.5 mm from each end for the following attributes: hardness (12.5= soft, 137.5= hard), fracturability (12.5= crumbly, 137.5= brittle), color (12.5= off-white, 137.5= brown), surface shine (12.5= dull, 137.5 glossy), roasted peanutty aroma (12.5= perceptible, 137.5= strong), buttery aroma (12.5= perceptible, 137.5= strong), sesame aroma (12.5= perceptible, 137.5= strong), vanilla aroma (12.5= perceptible, 137.5= strong), caramel aroma (12.5= perceptible, 137.5= strong), sweet taste (12.5= perceptible, 137.5= strong), salty taste (12.5= perceptible, 137.5= strong), and bitter taste (12.5= perceptible, 137.5= strong).
Mean values in the same column not followed by the same letter are significantly different ($p < 0.05$).

[b] Commercial sample used was a product of the collaborator.

Table 4.2 ***continued . . .***

Formulation No.	**Level of use (%) of ingredient**			**Mean sensory ratings**						
	Glucose syrup (x_1)	**Sugar (x_2)**	**Peanuts (x_3)**	**Buttery aroma**	**Sesame aroma**	**Vanilla aroma**	**Caramel aroma**	**Sweet taste**	**Salty taste**	**Bitter taste**
1	25	65	10	65.16ab	5.07d	24.62a	93.59a	125.21a	35.11ab	4.75c
2	90	0	10	60.31d	4.82d	19.75f	80.36e	84.54f	34.88ab	10.14a
3	80	0	20	63.44bc	6.78c	22.65de	84.44cd	97.53e	34.27ab	6.53b
4	15	30	55	62.00cd	6.93c	22.14e	79.83e	97.75e	35.00ab	5.00c
5	15	55	30	64.28ab	8.56b	23.12bcde	87.50c	122.42ab	34.11b	5.00c
6	57.5	32.5	10	64.28ab	7.00c	23.65abcd	90.47b	122.10ab	35.73ab	4.86c
7	47.5	15	37.5	64.05ab	9.05ab	24.12abc	82.19de	115.40cd	34.60ab	4.76c
8	15	43	42	64.73ab	6.92c	22.70cde	84.88cd	113.58d	35.93a	4.75c
9	34	38	28	65.28ab	8.67b	24.62a	84.68cd	118.00bcd	34.15b	5.35c
10	48	26	26	64.55ab	9.28ab	24.50ab	85.20cd	120.42abc	34.20ab	4.80c
11	48	26	26	64.40ab	9.62a	24.94a	84.68cd	121.40ab	34.43ab	4.83c
12	48	26	26	65.65a	9.56a	24.88a	85.20cd	120.90abc	35.13ab	4.85c
Commercial sample	-	-	-	10	110	10	50	90	42	15

Formulations containing high amounts of glucose syrup but without sugar had the lowest intensity rating for caramel aroma and sweet taste in Formulation No. 2. This means that when sugar is absent in the formulation, glucose syrup cannot contribute to the sweetness of the product even when added at high concentrations.

A formulation had a higher rating for bitter taste when the formulation had high levels of glucose syrup but without sugar as in Formulation Nos. 2 and 3, which were significantly different than the other formulations for bitter taste.

Formulations with more sugar as in Formulation Nos. 1, 6 and 8 had products which were darker in color than in formulations with less sugar. Thus, these formulations were significantly different from the other formulations in color.

No significant difference existed in the buttery aroma of the products.

Formulations containing lower or higher than 26 to 37.5% peanuts were significantly different from the other formulations in sesame aroma. Thus, Formulation Nos. 1, 2, 3, 4, 6, and 8 were significantly different in sesame aroma from Formulation Nos. 5, 7, 9, 10, 11, and 12.

Formulations containing 90% glucose syrup and 10% peanuts as in Formulation No. 2 had products with the lowest intensity of vanilla aroma and thus was significantly different in vanilla aroma than the other formulations.

Formulations with almost the same levels of peanuts and sugar as in Formulation No. 8 had the highest rating for surface shine.

Modeling of Sensory Attributes of Peanut Brittle

Consumer Test

The prediction equations generated for significant sensory attributes are shown in Table 4.3. Contour plots generated for the different sensory attributes showing the regions of minimum product acceptability (rating of 6) for each sensory attribute, and the regions of overlap are shown in Fig. 4.3.

Table 4.3 Prediction equations or Scheffe's second-order polynomial of sensory attributes generated from the consumer test

Attribute	Prediction equation
Overall Liking	$7.39x_1 + 7.88x_2 + 7.90x_3 – 3.89x_1x_2 – 5.84x_2x_3 – 6.02x_1x_3 + 28.22x_1x_2x_3$
Liking for:	
Texture	$7.74x_1 + 6.86x_2 + 7.00x_3 – 0.33x_1x_2 – 0.20x_2x_3 – 5.28x_1x_3 + 13.17x_1x_2x_3$
Color	$7.31x_1 + 7.45x_2 + 5.29x_3 – 2.64x_1x_2 + 1.86x_2x_3 – 0.89x_1x_3 + 14.10x_1x_2x_3$
Appearance	$7.17x_1 + 7.36x_2 + 7.12x_3 – 1.46x_1x_2 – 0.99x_2x_3 – 2.35x_1x_3 + 7.29x_1x_2x_3$
Flavor	$7.62x_1 + 7.81x_2 + 7.10x_3 – 6.01x_1x_2 – 5.03x_2x_3 – 6.82x_1x_3 + 42.88x_1x_2x_3$

Formulations with more glucose syrup and sugar had higher acceptance rating for texture, but had lower acceptance rating in formulations with more peanuts as in Formulation Nos. 4 and 7, and in formulations with less peanuts as in Formulation No. 3.

Contour plots for color, appearance, flavor, and overall liking indicate that formulations containing more sugar had higher acceptance ratings than formulations with less sugar. Results also indicate that sugar had a great influence on acceptance of peanut brittle.

Superimposing all acceptable areas in the contour plots for texture, color, appearance, flavor and overall liking showed that all formulations in the constrained region were acceptable to the consumers with 6.5 as the minimum acceptance rating given for flavor. This means that an acceptable peanut brittle can be produced using any of the formulations within the constrained region.

Descriptive Test

The prediction equations obtained from the statistical analysis are shown in Table 4.4 and the contour plots generated are presented in Fig. 4.4. The plots showed that intensity ratings for hardness and fracturability in the first bite and first chew decreased in formulations with more peanuts. The intensity of the roasted peanutty aroma increased in formulations with more peanuts. Contour plot for color indicated that the product became darker when the product had more sugar. Higher levels of sugar resulted in products with higher intensity of caramel aroma and salty taste. There were no significant differences in the surface shine, sesame aroma, vanilla aroma, buttery aroma, sweet taste, and bitter taste of the different peanut brittle formulations as shown by the contour plots.

Table 4.4 Prediction equations or Scheffe's second-order polynomial of sensory attributes generated from the descriptive test

Attribute	**Prediction equation**
Hardness (first bite)	$87.29x_1 + 83.07x_2 + 15.58x_3 - 84.32x_1x_2 + 169.16x_1x_3 + 197.74x_2x_3 - 383.47x_1x_2x_3$
Fracturability (first bite)	$58.77x_1 + 61.80x_2 + 29.59x_3 + 82.71x_1x_2 + 112.11x_1x_3 + 112.66x_2x_3 - 416.76x_1x_2x_3$
Hardness (first chew)	$74.68x_1 + 80.40x_2 + 26.08x_3 + 110.58x_1x_2 + 166.18x_1x_3 + 176.75x_2x_3 - 563.86x_1x_2x_3$
Fracturability (first chew)	$54.27x_1 + 49.34x_2 + 19.23x_3 + 99.91x_1x_2 + 122.61x_1x_3 + 155.14x_2x_3 - 510.18x_1x_2x_3$
Surface shine	$7.51x_1 - 40.26x_2 - 124.33x_3 + 475.95x_1x_2 + 434.39.91x_1x_3 + 796.24x_2x_3 - 2364.67x_1x_2x_3$
Color	$86.68x_1 + 78.73x_2 + 52.40x_3 + 284.76x_1x_2 + 134.91x_1x_3 + 306.30x_2x_3 - 1431.70x_1x_2x_3$

Table 4.4 *continued . . . .*

Attribute	**Prediction equation**
Sesame aroma	$1.89x_1 – 1.73x_2 – 11.18x_3 + 15.31x_1x_2 + 47.27x_1x_3 + 46.75x_2x_3 + 24.14x_1x_2x_3$
Roasted peanutty Aroma	$34.68x_1 + 16.81x_2 + 93.17x_3 + 26.15x_1x_2 – 58.65x_1x_3 – 23.66x_2x_3 + 296.12x_1x_2x_3$
Vanilla aroma	$17.08x_1 + 23.51x_2 + 14.83x_3 + 14.46x_1x_2 + 35.04x_1x_3 + 3.63x_2x_3 + 0.55x_1x_2x_3$
Buttery aroma	$56.75x_1 + 60.47x_2 + 44.12x_3 + 25.10x_1x_2 + 55.22x_1x_3 + 45.48x_2x_3 – 82.53x_1x_2x_3$
Caramel aroma	$75.15x_1 + 86.32x_2 + 52.24x_3 + 75.97x_1x_2 + 85.17x_1x_3 + 80.82x_2x_3 – 398.44x_1x_2x_3$
Sweet taste	$61.04x_1 + 88.78x_2 – 20.67x_3 + 215.18x_1x_2 + 341.77x_1x_3 + 293.21x_2x_3 – 500.71x_1x_2x_3$
Salty taste	$35.11x_1 + 31.85x_2 + 37.84x_3 + 13.95x_1x_2 – 7.00x_1x_3 + 6.06x_2x_3 – 52.30x_1x_2x_3$
Bitter taste	$14.31x_1 + 11.78x_2 + 13.22x_3 – 41.22x_1x_2 – 46.60x_1x_3 – 36.72x_2x_3 + 157.95x_1x_2x_3$

Model Verification

Two peanut brittle formulations which were within the region of acceptable formulations (hedonic rating of 6 or higher) were verified for acceptance. The results of t-statistics performed on the consumer test are shown in Table 4.5. The observed and the predicted values of the 2 peanut brittle formulations were evaluated for each sensory attribute. Calculated t-statistics indicated that the observed and predicted values were not significantly different from each other. The predicted value of a sensory attribute is the mean rating given by all panelists in the consumer test using a big group of consumers. The observed value of a sensory attribute is the mean rating given by the consumer panel in the verification test of the acceptable formulations. When no significant difference exists between the two values, the formulations that were predicted to be in the region of acceptable formulations were actually acceptable to the consumers as determined in this study. Formulation Nos. 9 and 12 were used in the model verification since these were two of the formulations that had ratings of 7.0 and higher in all sensory attributes in the consumer test. The acceptance ratings obtained for all sensory attributes by Formulation Nos. 9 and 12 in the verification test were higher than the acceptance ratings for the commercial sample in the consumer test. This implied that products produced from the region with acceptable formulations would most likely be acceptable than the commercial sample since the acceptance ratings obtained by peanut brittle samples prepared from the 12 formulations were higher and were described as “like moderately” in all attributes.

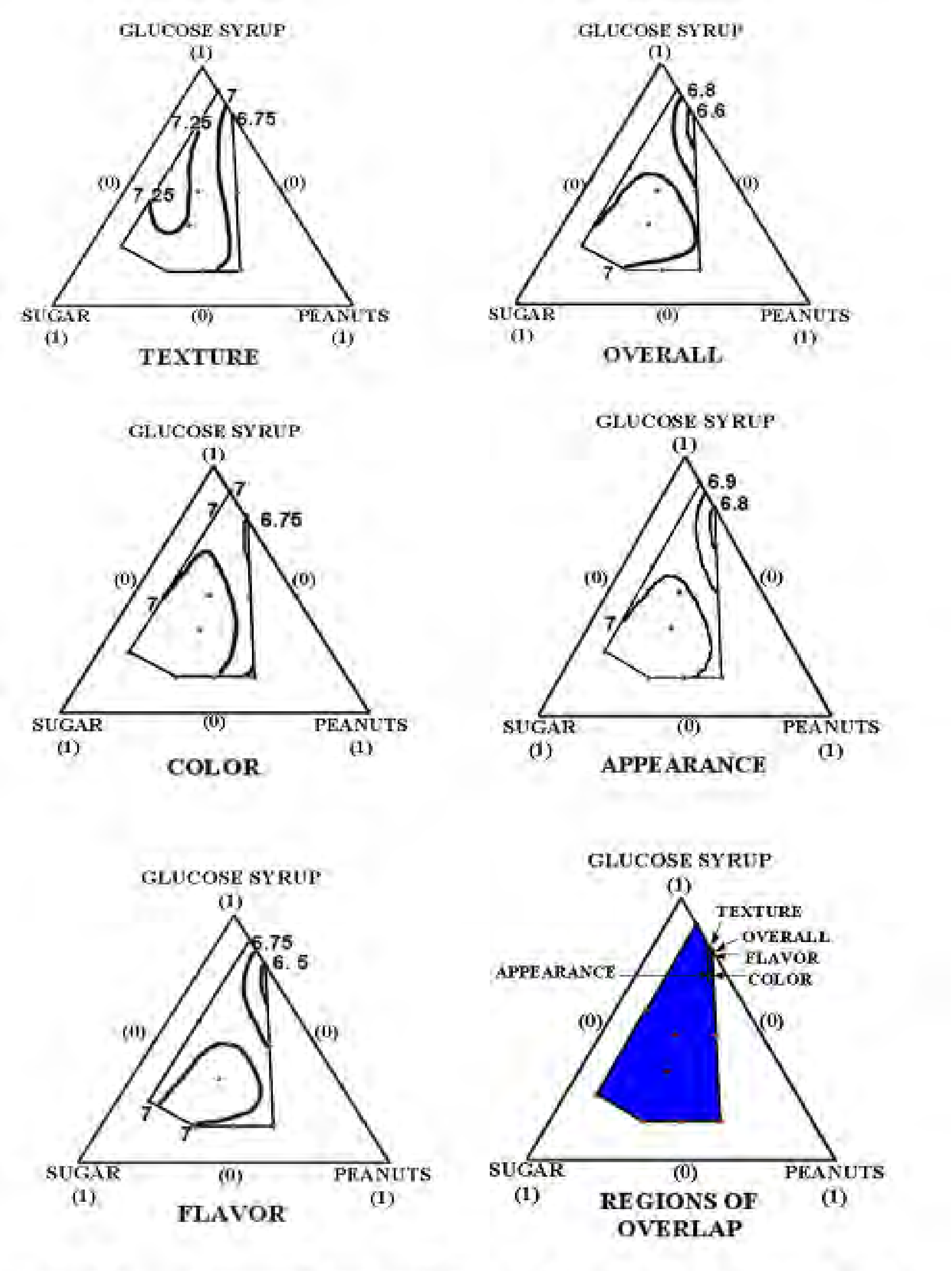
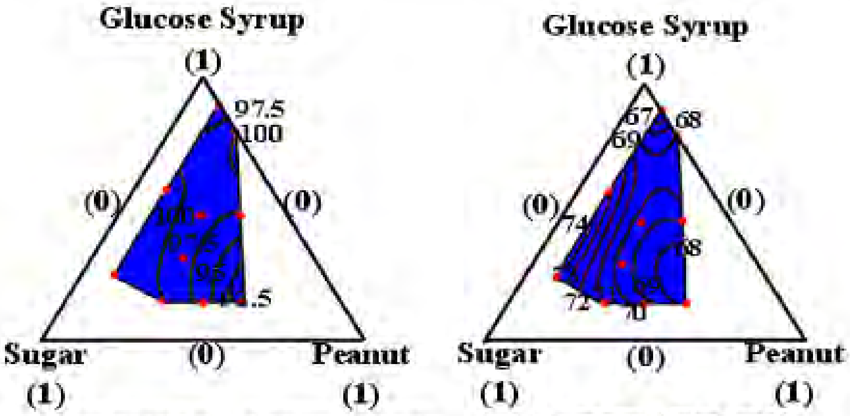
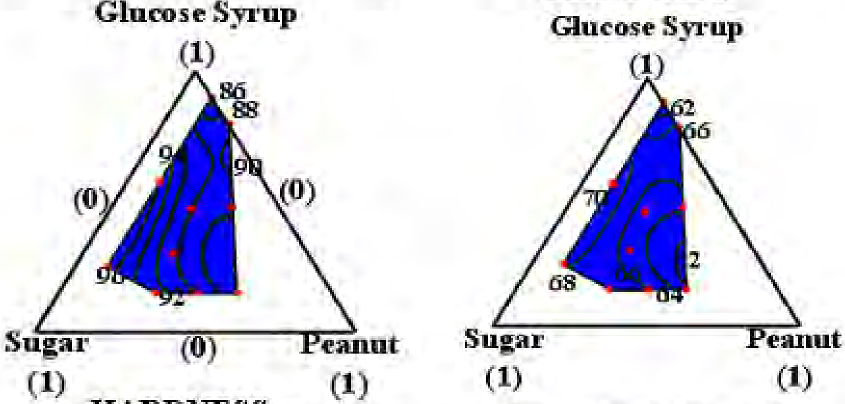


Fig. 4.3 Response surface plots for texture, overall liking, color, appearance, flavor and the regions of overlap with acceptance ratings of 6 and greater when glucose syrup, sugar and peanuts were varied in peanut brittle formulations.



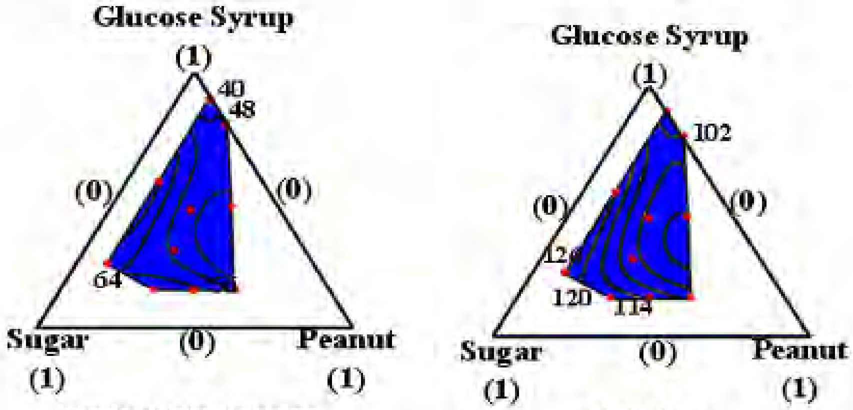
HARDNESS – FIRST BITE

FRACTURABILITY – FIRST BITE



HARDNESS – FIRST CHEW

FRACTURABILITY – FIRST CHEW



SURFACE SHINE

COLOR

Fig 4.4 Effect of glucose syrup, sugar and peanuts on sensory properties of peanut brittle: hardness and fracturability on the first bite, hardness and fracturability on the first chew, surface shine, color, sesame aroma, roasted peanutty aroma, vanilla aroma, buttery aroma, caramel aroma, sweet taste, salty taste and bitter taste, and the regions of overlap.

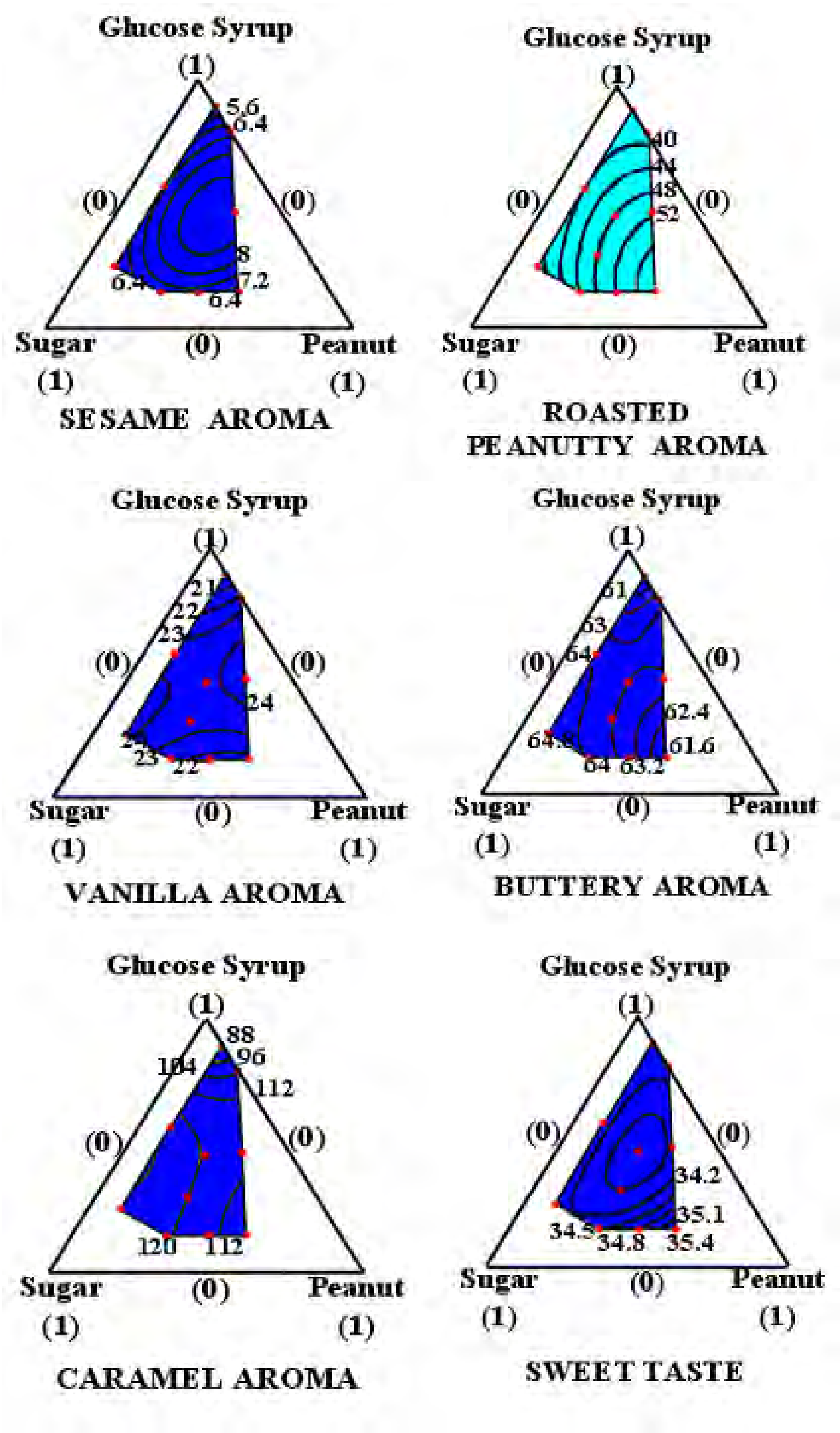
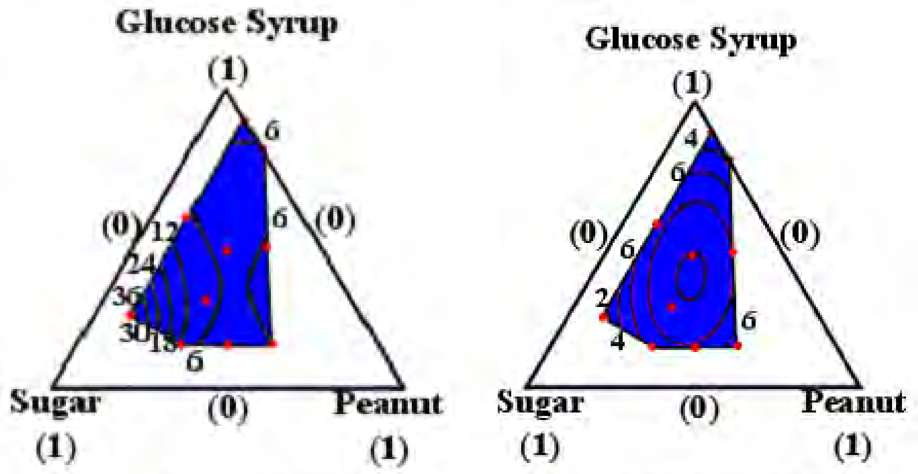
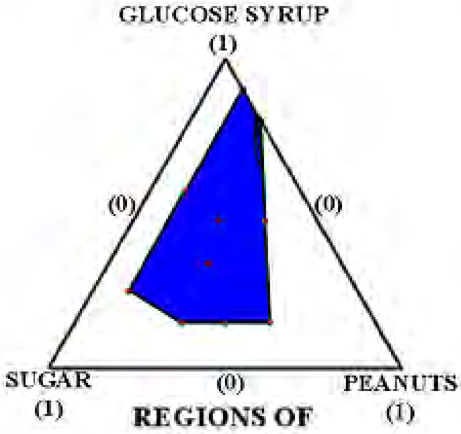


Fig.* 4.4 *continued



SALTY TASTE **BITTER TASTE**



REGIONS OF OVERLAP

Fig.* 4.4 *continued

Table 4.5 Observed and predicted values of two peanut brittle formulations from the region predicted to have acceptable formulations

Sensory attribute	Treatment 1 [a]			Treatment 1 [b]		
	Observed	Predicted	t- value	Observed	Predicted	t-value
Overall acceptance	7.38ns	7.04	-0.59	7.18ns	6.96	-0.63
Acceptance for:						
Texture	7.30ns	7.12	1.52	7.23ns	7.19	1.45
Color	7.32ns	7.08	0.59	7.24ns	7.09	0.53
Appearance	7.30ns	7.42	0.13	7.18ns	6.98	0.10
Flavor	7.38ns	7.13	0.07	7.22ns	6.95	0.06

[a] Peanut brittle containing 34% glucose, 38% sugar and 28% peanuts (Formulation No. 9).

[b] Peanut brittle containing 48% glucose, 26% sugar and 26% peanuts (Formulation No. 12)..

ns Not significantly different at $p < 0.05$

TECHNOLOGY TRANSFER OF PEANUT BRITTLE PROCESS TO COLLABORATOR AND STANDARDIZATION OF PEANUT BRITTLE PROCESS IN COLLABORATOR'S PLANT

Evaluation of Equipment and Ingredients Used by Collaborator for Suitability to Peanut Brittle Preparation

Tables 4.6 and 4.7 present the equipment and ingredients used by the collaborator for the preparation of Monk's peanut brittle (piñato). Most of the equipment were evaluated to be suitable for peanut brittle production except for the pan-type weighing scale and the stainless steel rolling pin. The pan-type weighing scale may not produce a consistent product quality due to inaccurate weight measurements of ingredients below 50 grams, while the use of the stainless steel rolling pin to reduce peanut size is a slow process and thus could affect productivity.

Table 4.6 Evaluation for suitability of equipment used by Monastery Farms for the preparation of peanut brittle

Equipment / processing implement	Description	Evaluation
1. Heavy duty weighing scale	Has a capacity of 100 kg with 1-Kg graduation	Suitable for weighing exact weights of raw peanuts on a kilogram basis only. The equipment is usually used for weighing sacks of peanuts and sugar.
2. Battery operated digital weighing scale	Has a capacity of 2 Kg with 0.01-gram graduation	Suitable for weighing small amounts of ingredients due to the 0.01g graduation

Table 4.6 *continued . . . .*

Equipment / processing implement	Description	Evaluation
3. Pan-type weighing scale	Otex brand, has a capacity of 10 Kg with 50-gram graduation	Not accurate for weighing peanuts, sugar, water and other ingredients if the weight required is between 0 to 50 grams
4. Roaster	Probat brand coffee roaster, German-made, has a capacity of about 100 kg with paddle to evenly mix peanuts during roasting	Pre-heating of roaster to 200°F is about 10 to 15 minutes; suitable for roasting 20 Kg of sorted blanched peanuts at 300°F (or 149°C) for 6 to 7 minutes
5. Stainless steel tables for sorting	Each table with dimension of about 1m x 1.5 m (w x l) has a hole of about 6-inch in diameter at one side of the table where good quality peanuts are passed through and collected underneath the table with pails	Suitable for sorting of peanuts
6. "Bilao" or winnowing tray	Oval-shaped mat-like implement used to separate the peanut skin from the peanuts by manually rubbing the dry blanched peanuts against the surface of the winnowing tray	The implement is capable of separating the peanut skin from the peanuts provided that peanuts are properly blanched, i.e. peanut was dry blanched in the roaster for not less than 8 minutes at 300°F.
7. Stainless steel rolling pin	A rolling pin made of stainless steel used to reduce the size of roasted peanuts to about 0.2 to 0.4 cm by rolling	Manually operated; capable of reducing the size of roasted peanuts into the desired size; however output production is minimal due to the slow process of manually reducing the peanut size
8. Black tarpauline	Made of tarpauline material used as mat in grinding peanuts	Can be easily cleaned and dried
9. Heavy duty gas stoves	Made of cast iron with a burner of about 10 inches in diameter. The burner has 2 layers of flame, the outer and inner layers. The outer flame produces a higher temperature than the inner flame during cooking	The flame of the gas stove can be easily controlled with a knob

Table 4.6 *continued . . . .*

Equipment / processing implement	**Description**	**Evaluation**
10. Carajay or "kawa"	Approximately 24 inches in diameter and 6 inches deep in the middle; made of cast iron	The cooking vessel is deep enough to accommodate a 4-Kg mixture of peanut brittle per cooking batch
11. Stainless steel knives	Approximately 12 inches long with sharpened edge	The knife is sharp enough to cut the peanut brittle into desired sizes
12. Peanut brittle molders	Made of plastic formica with adjustable slits to serve as guide in cutting; the bottom part of the molder is made of plastic chopping board	Adjustable to the desired size, cleanable
13. Wall fan	Approximately 14 inches in diameter used for cooling the peanut brittle pieces after cutting	Capable of cooling the peanut brittle pieces in about 2 minutes

Table 4.7 Ingredients used by Monastery Farms in the preparation of peanut brittle

Name of Ingredient	**Description**
1. Roasted peanuts	Raw peanuts (Florrunner type peanuts, small), purchased from the farmers in Bukidnon and roasted in a Probat coffee roaster for about 12 minutes at 300°F (149°C)
2. Refined sugar	Obtained from a supplier in Bukidnon
3. Water	Plain tap water
4. Baking soda	Obtained from a supplier in Bukidnon
5. Butter	Anchor brand, unsalted, obtained from a supplier in Bukidnon
6. Industrial salt	Refined, white salt obtained from a supplier in Bukidnon
7. Sesame seeds	Obtained from a supplier in Bukidnon
8. Vanilla concentrate	Liquid, Neco Brand

Identification of Potential Problems in Carrying Out the Standardization Process Based on the Process and Equipment Used by the Collaborator

The processing steps used by the collaborator in the preparation of Monk's peanut brittle were as follows: (1) roasting of peanuts for 10 to 12 minutes at 300°F (or 149°C), (2) sorting for mold-infected and damaged peanuts, (3) reducing of peanut size to about 0.2 to 0.4 mm, (4) softening of butter, (5) weighing of ingredients, (6) cooking, (7) molding, (8) cutting, (10) cooling to room temperature, (11) packing of cooled peanut brittle pieces in polypropylene (PP) jars, (12) wrapping in cellophane and packing in PP jars, and (13) storing at ambient conditions.

In the above process, the following were observed as possible sources of safety and quality problems of the product:

Aflatoxin in peanuts due to improperly sorted peanuts. The practice of Monastery Farms in preparing roasted peanuts is a one-time process of roasting of raw peanuts for 10 to 12 minutes at 300°F (or 149°C) until the desired dark roasted peanuts or a dark brown color in peanuts is achieved. With this procedure, no dry blanching was done. Sorting was carried out after cooling the roasted peanuts to room temperature. Using the above procedure, sorting for aflatoxin infected kernels may not be carried out properly because of the dark color of the kernels obtained after roasting. It is necessary that the kernels are light in color before sorting to be able to segregate infected and damaged kernels which oftentimes are also dark colored. To correct this, FDC suggested that a dry blanching step be introduced in the procedure. The blanching time was determined using the Probat coffee roaster set at 149°C for a 20-Kg batch of raw peanuts. Evaluation showed that 20 Kg of raw peanuts must be dry blanched at 300°F (or 149°C) for not less than 8 minutes to be able to deskin peanuts easily by the use of a winnowing tray, results are shown in Table 4.9. The peanuts were sorted for damaged or infected kernels following the dry blanching step.

Inconsistent sensory quality of product due to inaccurate weight measurement of ingredients through the use of a weighing scale with low sensitivity. Inaccurate weights of ingredients will likely result in inconsistent quality of the product. The weighing scale used to measure the weight of roasted peanuts, sugar and water is an Otex brand pan-type weighing scale which has a sensitivity of 50 grams. In cases wherein the weight required is between 0 to 50 grams, an approximation of the weight required is done by plant workers. This observation was raised, and the collaborator agreed to buy a digital top loading balance with a 0.01 gram sensitivity.

Inconsistent product flavor and texture due to incorrect temperature of mixture during cooking to its hard crack stage. The collaborator does not use a thermometer to monitor product temperature during cooking. Cooking is stopped when sugar is completely melted and has caramelized to a golden brown color. This could be a hit and miss practice and may result in inconsistencies in sensory quality such as development of a burnt aroma when the hard crack stage of sugar is exceeded or when the temperature of the mixture exceeded 170°C, and lack of brittle texture in the product when the required temperature of 165 to 170°C is not reached during cooking. To correct this practice, the collaborator agreed to FDC's suggestion to buy a digital thermometer with metalized probe capable of reading the required cooking temperature, and to turn off the stove when the required temperature is reached.

Mishapened peanut brittle pieces due to high temperature of the cooked peanut brittle mixture during cutting. As practiced by the collaborator, the peanut brittle mixture which has a product temperature of 165 to 170°C after cooking, is cut immediately after molding. The temperature of the mixture after molding is at least 140°C and at this temperature the mixture is still very soft resulting in uneven and deformed peanut brittle pieces after cutting. It was recommended that the temperature of the mixture should be 85 to 90°C before cutting, which is achievable with a 4-Kg mixture per batch of cooking. The temperature, however, should not be lower than the recommended temperature because a lower temperature will cause hardening of the mixture and result in breakage of the product while cutting.

Identification of Plant Personnel who Participated in the Standardization Process

The list of Monastery Farm personnel involved in the preparation of peanut brittle and their respective work assignments is shown in Table 4.8. According to the collaborator, their work force is enough for their daily production of at least 4 batches of peanut brittle, with each batch consisting of 4 Kg of peanut brittle mixture.

Table 4.8 List of plant personnel involved in the preparation of peanut brittle

Work assignment	Name of Personnel	
Roasting	Eleno Mila,	Rex Avila
Sorting	Milania Cerna,	Felisa Carvajal
	Melanie Badolis,	Epina Matchon
	Marivic Aliga,	Adelina Avila
Cooking	Boy Nabadilla	
Cutting	Eddie Mangeran	
Wrapping	Inday Gocun	

Modification of the Peanut Brittle Process

Dry Blanching of Peanuts

Blanching of peanuts was standardized to determine the blanching time using the Probat coffee roaster at 149°C for a 20-Kg batch of raw peanuts. Results showed that blanching should not be less than 8 minutes to be able to deskin peanuts easily (Table 4.9). Blanching peanuts for less than 8 minutes could be deskinned between fingers but was hard to deskin when rubbed against the winnowing tray.

Table 4.9 Effect of blanching time (in minutes) on ease in deskinning peanuts using the Probat coffee roaster at 300°F (or 149°C)

Time of blanching (in minutes)	Evaluation
1	No peeling off
2	Some peeling off when rubbed between fingers
3	Some peeling off when rubbed between fingers
4	Completely peeled off when rubbed between fingers but difficult to peel off when manually rubbed against the surface of the "bilao", a native container, or winnowing tray by hands
5	Completely peeled off when rubbed between fingers but difficult to peel off when manually rubbed against the surface of the winnowing tray by hands
6	Completely peeled off when rubbed between fingers but difficult to peel off when manually rubbed against the surface of the winnowing tray by hands
7	Slightly easy to peel off when manually rubbed against the surface of the winnowing tray by hands
8	Easily peeled off when manually rubbed against the surface of the winnowing tray by hands
9	Easily peeled off when manually rubbed against the surface of the winnowing tray by hands

Roasting of Peanuts

The step on roasting of peanuts was standardized to determine the roasting time of 20 Kg of sorted blanched peanuts at 149°C. Results showed that blanched peanuts must be roasted for 6 to 7 minutes (Table 4.10) to obtain a moderate to strong roasted peanutty aroma and a medium to dark brown color which is acceptable to the collaborator.

Roasting of Sesame Seeds

Roasting of sesame seeds was standardized to determine time of roasting 200 grams of sesame seeds in a carajay over a low fire, using the inner flame of the stove in order to obtain a moderate to strong roasted sesame aroma and a medium brown color. Results showed that 25 to 30 minutes of roasting was needed to achieve the required sensory quality in sesame seeds (Table 4.11). The collaborator wanted a strong sesame aroma in the product.

Table 4.10 Effect of roasting time (in minutes) on aroma and color of peanuts using the Probat coffee roaster at 300°F (or 149°C)

Time of roasting (in minutes)	Evaluation
1	Weak roasted peanutty aroma, light brown color
2	Weak roasted peanutty aroma, light brown color
3	Slight roasted peanutty aroma, light to medium brown color
4	Moderate roasted peanutty aroma, medium brown color
5	Moderate roasted peanutty aroma, medium brown color
6	Moderate to strong roasted peanutty aroma, medium brown color
7	Moderate to strong roasted peanutty aroma, medium to dark brown color
8	Strong roasted peanutty aroma, dark brown color, with perceptible burnt aroma
9	Slight burnt peanutty aroma, dark brown color

Table 4.11 Effect of roasting time (in minutes) on aroma and color of 200-gram batches of sesame seeds using a carajay over a low fire

Time of roasting (in minutes)	Evaluation
5	Weak roasted sesame aroma, light cream color
10	Weak roasted sesame aroma, light cream color
15	Slight roasted sesame aroma, light brown color
20	Slight to moderate roasted sesame aroma, medium brown color
25	Moderate to strong roasted sesame aroma, medium brown color
30	Moderate to strong roasted sesame aroma, medium brown color
35	Slight burnt sesame aroma, medium to dark brown color

Cooking of Peanut Brittle

The cooking step was standardized by comparing the color and flavor of the peanut brittle mixtures after cooking at different temperatures. Peanut brittle mixtures cooked to a temperature of 165 to 170°C will definitely have a brittle texture. Results showed that mixtures cooked between 165 to 170°C had a golden brown color and no burnt flavor, while mixtures cooked at 172°C had a dark brown color with burned portions and therefore had a burnt flavor (Table 4.12). The sugar at this temperature had undergone extensive caramelization producing the burnt flavor or bitter taste in the product. The results encouraged the collaborator to buy a thermometer for cooking of the mixture.

Table 4.12 Effect of cooking temperature (°C) on color and flavor of 4-Kg mixtures of peanut brittle

Cooking temperature (°C)	Evaluation
165	Golden brown color, no burnt flavor
167	Golden brown color, no burnt flavor
170	Golden brown color, no burnt flavor
172	Dark brown color with burned portions, with burnt flavor

Cooling of Cooked Peanut Brittle Mixture Prior to Cutting

The cooling procedure was standardized to demonstrate the importance of temperature of the cooked mixture during cutting, the results are presented in Table 4.13. Results showed that most of the peanut brittle pieces cut at temperatures higher than 90°C had noticeable dome-shaped top portion as compared to peanut brittle cut at a temperature of 85 to 90°C. The dome shaped top portion was due to cutting of the mixture while still soft, at temperatures between 100 to 140°C, causing the product to stick to the cutter during cutting. Cutting of the mixture at temperatures lower than 85°C resulted in more broken pieces because the mixture had started to harden, and the sugar at this temperature resists cutting.

Table 4.13 Effect of product temperature on evenness of cut of peanut brittle

Product temperature (°C)	Evaluation
140	Mixture was very soft; with dome-shaped top portion when cut
120	Mixture was very soft; with dome-shaped top portion when cut
110	Mixture was very soft; with dome-shaped top portion when cut
100	Mixture was slightly soft; with dome-shaped top portion when cut
90	Mixture was soft but retains its shape when cut; more even cut portions
85	Mixture is soft but retains its shape when cut; more even cut portions
80	Mixture starts to harden; more broken pieces after cutting

A summary of the modifications made on the FDC process for peanut brittle is shown in Table 4.14 with the corresponding recommendations

Table 4.14 Summary of modifications made on the FDC process for peanut brittle

Parameters	Recommendations
1. Dry blanching	Pre-heating of the Probat coffee roaster to 200°F (or 93°C), and dry blanching of 20 Kg of raw peanuts for 8 minutes at 300°F (or 149°C) in the Probat coffee roaster.
2. Sorting of dry blanched peanuts before final roasting	Sorting for aflatoxin infected peanuts after dry blanching prior to final roasting of 20 Kg of peanuts at 300°F (or 149°C) in the Probat coffee roaster for 6 to 7 minutes.
3. Roasting of sesame seeds	Roasting of two hundred (200) grams of sesame seeds per batch in a carajay over low fire for 25 to 30 minutes or until a moderate to strong roasted sesame aroma with a medium brown color is obtained.
4. Cooking of peanut brittle mixture	Cooking of a 4-Kg mixture of peanut brittle in the cooking pan at 165 to 170°C, is the temperature at the hard crack stage of sugars. The color of the mixture at this temperature after cooking is golden brown.
5. Cooling of the cooked mixture prior to cooking	Immediate flattening of the cooked peanut brittle mixture in the molder and cooling to 85 to 90°C before cutting to reduce amount of mishapened and broken peanut brittle pieces.

Modification of the FDC Formulation

Table 4.15 shows the modifications made on the FDC formulation. Prior to modification of the formulation, the plant personnel commented that the peanut brittle prepared from the FDC formulation was too sweet and slightly salty, and had an “asgad” or irritating aftertaste in the throat. The collaborator preferred a moderate roasted peanutty aroma in the product and suggested that the amount of roasted peanuts be increased. The formulation was modified three times.

Table 4.15 Modifications made on the FDC formulation for peanut brittle

Ingredient	FDC Formulation	Modification 1	Modification 2	Modification 3
Glucose syrup	27.45	14.00	14.00	14.00
Refined sugar	24.56	31.28	37.00	37.00
Roasted peanuts	20.24	28.97	34.00	34.00
Water	16.00	16.00	8.00	7.50
Butter	6.00	4.00	4.00	4.00
Sesame seeds	3.5	3.50	1.50	1.50
Baking soda	1.5	1.50	1.00	1.00
Industrial salt	0.60	0.60	0.35	0.35
Vanilla	0.15*	0.15*	0.15*	0.65**
TOTAL	100.00	100.00	100.00	100.00

* Vanilla powder was used.

** Vanilla liquid (or concentrate) was used.

Modification 1

The amount of glucose syrup was reduced mainly due to the “asgad” or irritating aftertaste in the throat, and secondly due to cost. The amount of butter was likewise reduced to lessen saltiness of the product. The amount of peanuts was increased to improve the roasted peanutty aroma while the amount of sugar was increased to improve the sweetness of the product. Evaluation of product from this modification showed that the peanut brittle was acceptable except that it had a lesser intensity of the roasted peanutty aroma and with slight saltiness in the product.

Modification 2

The amounts of refined sugar and roasted peanuts were increased while water was decreased. The two former ingredients were increased in order to improve the roasted peanutty aroma and sweetness of the product. Water, used mainly to dissolve the sugar and to evenly mix it with glucose syrup, was reduced to be able to increase the amount of sugar and peanuts. The product from this modification was acceptable to the plant personnel in terms of texture, roasted peanutty aroma and sweetness. However, they commented that they prefer to use the vanilla concentrate, which they are currently using, than the vanilla powder.

Modification 3

The changes made were the increase in the amount of vanilla concentrate to 0.65% and reduction in the amount of water to 7.5%. After evaluation, the product was acceptable in aroma, taste and texture to the plant personnel.

Training of Industry Personnel on the Standardized Process

A hands-on training of the industry personnel was conducted by FDC using the standardized process and modified formulation for peanut brittle. A total of 11 plant personnel were trained.

SHELF LIFE OF MONK'S PEANUT BRITTLE

Shelf Life of Monk's Peanut Brittle The mean ratings for acceptability of the product during storage at ambient conditions is shown in Table 4.16. The number of responses for ratings 6 and above, 5, and 4 and below for the acceptability of fine peanut bar during storage is shown in Table 4.17 After 155 days or 5.2 months, the mean ratings for liking for texture/crunchiness, flavor/taste as well as overall liking was considered as "neither like nor dislike" by the consumer panel except for color and appearance of the product which were still considered as "like slightly" with mean ratings of 5.9 and 6.0, respectively. The control samples after 155 days of storage were considered as "like moderately" by the consumer panel.

The peanut brittle at the end of its shelf life had a hardness and fracturability ratings lower than the control sample (Table 4.18). This means that the product tends to soften during storage. This is the main reason of its unacceptability. The aromatics, such as roasted peanutty, buttery, sesame, vanilla and caramel aroma decreased in intensity. No rancid flavor and odor was detected in the sample. The shelf life plot of Monk's peanut brittle stored at ambient conditions is shown in Fig. 4.5. The plot shows that a rating of 4.9 could be obtained after approximately 179 days of storage for texture/crunchiness, 190 days for flavor/taste, and 180 days for overall liking.

Table 4.16 Acceptability of peanut brittle packed in its traditional packaging material during storage at ambient conditions

Storage temperature (°C)	Storage time (days)	Mean ratings [a]				
		Liking for texture/ crunchiness	Overall liking	Liking for color	Liking for appearance	Liking for flavor/taste
4 (control)	0 (initial)	7.4	7.2	7.1	7.1	7.3
	15	7.3	7.1	7.1	7.1	7.4
	30	6.8	7.0	7.0	6.9	7.1
	45	7.3	7.5	7.3	7.4	7.4
	63	7.0	7.0	6.7	6.8	7.0
	90	7.4	7.4	7.3	7.3	7.5
	123	7.1	7.1	7.3	7.3	7.2
	147	7.4	7.3	7.4	7.4	7.6
	155	7.3	6.9	7.0	6.6	7.2
	158	6.9	7.0	7.1	7.1	7.2
28-32 (ambient)	0 (initial)	7.4	7.2	7.1	7.1	7.3
	15	7.0	7.0	7.1	7.1	7.0
	30	6.3	6.4	6.8	6.4	6.7
	45	7.3	7.3	7.4	7.3	7.5
	63	6.6	6.6	6.6	6.6	6.7
	90	6.3	6.4	6.7	6.6	6.4
	123	5.9	6.2	6.6	6.6	6.6
	147	6.3	6.4	6.5	6.8	6.5
	155	5.1	5.3	6.0	5.9	5.4
	158	4.0	4.1	4.7	4.5	4.2

[a] The sample was evaluated by 30 consumers. A 9-point hedonic scale was used for rating acceptability where 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

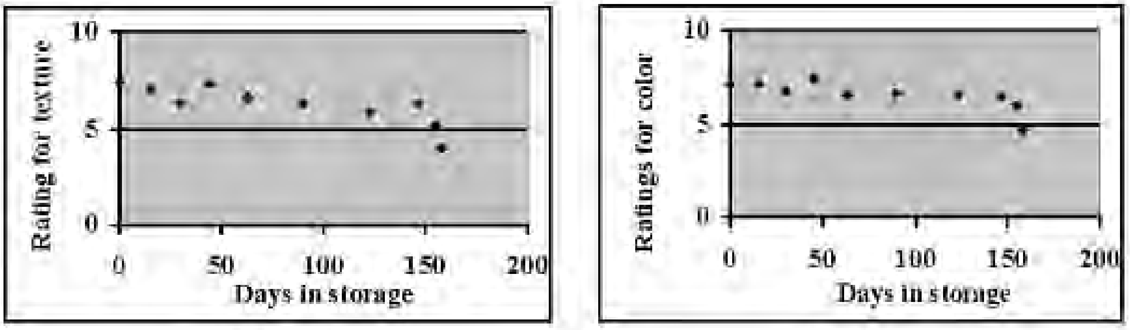
Table 4.17 Number of responses for ratings 6 and above, 5, and 4 and below for the acceptability of Monk's peanut brittle packed in its traditional packaging material during storage at ambient conditions

Storage temperature (°C)	Storage time (days)	Rating	Number of Responses				
			Texture/ crunchiness	Overall liking	Color	Appearance	Flavor/ taste
4 (control)	0 (initial)	6 and above	29	28	28	29	30
		5	1	1	1	0	0
		4 and below	0	1	1	1	0
	15	6 and above	29	28	28	29	30
		5	1	1	1	0	0
		4 and below	0	1	1	1	0
	30	6 and above	26	26	27	26	26
		5	1	1	2	1	1
		4 and below	3	3	1	3	3
	45	6 and above	29	29	29	29	28
		5	0	1	1	1	1
		4 and below	1	0	0	0	1
	63	6 and above	27	27	25	28	26
		5	2	2	4	1	3
		4 and below	1	1	1	1	1
	90	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	123	6 and above	27	27	29	28	29
		5	2	0	0	1	0
		4 and below	1	3	1	1	1
	147	6 and above	28	28	29	28	29
		5	1	0	1	1	1
		4 and below	1	2	0	1	0
	155	6 and above	30	28	29	27	30
		5	0	1	0	1	0
		4 and below	0	1	1	3	0

[a] A 9-point hedonic scale was used for acceptability ratings (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely)

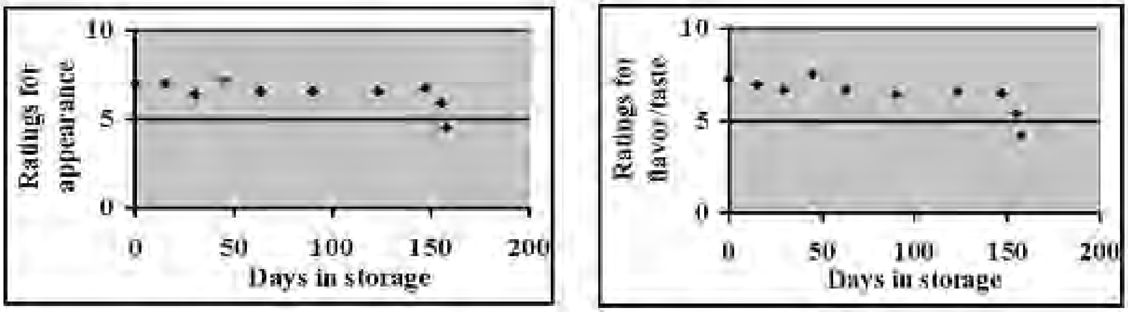
Table 4.17 *continued...*

Storage temperature (°C)	Storage time (days)	Rating	Number of Responses				
			Texture/ crunchiness	Overall liking	Color	Appearance	Flavor/ taste
	158	6 and above	28	28	29	29	29
		5	0	1	1	0	0
		4 and below	2	1	0	1	1
28-32 (ambient)	15	6 and above	25	26	26	27	25
		5	3	2	1	2	2
		4 and below	2	2	3	1	3
	30	6 and above	24	25	25	24	27
		5	0	1	3	5	0
		4 and below	6	4	2	1	3
	45	6 and above	29	29	29	28	28
		5	0	0	1	0	2
		4 and below	1	1	0	2	0
	63	6 and above	27	27	27	27	27
		5	0	0	1	1	1
		4 and below	3	3	2	2	2
	90	6 and above	23	23	26	26	23
		5	2	2	1	1	3
		4 and below	5	5	3	3	4
	123	6 and above	20	22	24	26	26
		5	2	1	1	0	0
		4 and below	8	7	5	4	4
	147	6 and above	23	25	26	28	24
		5	3	2	2	1	4
		4 and below	4	3	2	1	2
	155	6 and above	17	17	23	22	19
		5	1	2	1	3	1
		4 and below	2	11	6	5	0
	158	6 and above	8	11	15	15	10
		5	3	1	1	1	3
		4 and below	19	18	14	14	17



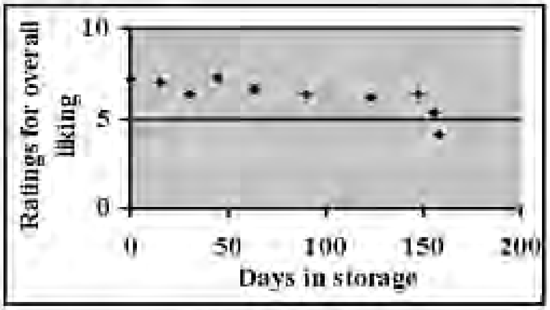
TEXTURE/
CRUNCHINESS

COLOR



APPEARANCE

FLAVOR/
TASTE



OVERALL
LIKING

Fig. 4.5 Shelf life plot of peanut brittle packed in its traditional packaging materials and stored at ambient conditions.

Table 4.18 Sensory characteristics of peanut brittle packed in its traditional packaging material at end of shelf life at 30°C

Sensory attribute	Ratings
1. Texture	
Hardness on first bite	94
Fracturability on first bite	63
Hardness on first chew	87
Fracturability on first chew	58
2. Appearance	
Color	94
Surface shine	78
3. Aromatics	
Roasted peanutty aroma	50
Buttery aroma	58
Sesame aroma	15
Vanilla aroma	18
Caramel aroma	95
Rancid aroma	0
4. Tastes	
Sweet taste	99
Salty taste	26
Bitter taste	4

CONSTRAINTS IN THE ADOPTION OF THE TECHNOLOGY FOR PEANUT BRITTLE BY MONASTERY FARMS

Reasons for Non-Adoption of the Technology for Peanut Brittle by Monastery Farms

1. Collaborator is fearful about changing a product quality profile that is already accepted by their market in Cagayan de Oro

According to the collaborator, they are uncertain if their consumers, especially in Northern Mindanao who are familiar with the quality of their product, will accept the change in quality to be introduced by FDC's formulation, even if it is claimed to be better. This fear was not overcome by our suggestion that the new product be marketed only to a newer consumer population, i.e. that in Metro Manila.

The collaborator's reaction suggests that a critical requirement for technology adoption is the provision of evidence that an improvement in product quality leads to an improvement in product acceptance and this is also best done in the place where the product is primarily sold in this case, in Northern Mindanao. In the future, we recommend that the verification of consumer acceptance of the improved formulation be carried out in the area where a product is primarily marketed.

2. Collaborator is resistant to adopting new ways of doing things when the traditional way already gives him a marketable product

The use of a thermometer to establish the end point of cooking is not of interest to the collaborator because they are able to establish such an end point without a thermometer. Their product is darker and has a bitter taste because their end point produces a longer cooking time but product color and taste is consistent in spite of the fact that a thermometer is not used.

The above indicates that the transfer of technology to an established industry should when possible, consider the use of traditional ways of doing things to produce the d product. In case of the above, the end point of cooking should be established by the method traditionally used by the processor, i.e. through the color and taste of the mixture undergoing cooking. This color and taste should be calibrated against the end point established using a thermometer so that there can be an objective way to check/verify if the technology transferred is working.

3. Collaborator was not interested in using glucose syrup due to added cost

The importance of using glucose syrup in improving the texture of the product was explained to the collaborator. According to the collaborator, its use will only add to production cost.

The total cost of ingredients in the new formulation with glucose syrup is cheaper by PhP 10.00 (PhP=Philippine peso) as compared to the formulation of the collaborator without glucose syrup. The new formulation has lesser percentages of the three major ingredients (peanuts, sugar and glucose syrup) which totals to 85% than the formulation of the collaborator which contains peanuts and sugar for a total of 92%. These ingredients have great effects on the cost because these comprise the bulk of the ingredients.

CONCLUSIONS

CONSUMER ACCPETANCE AND SENSORY PROFILING OF PEANUT BRITTLE

The best formulation of peanut brittle can be determined using response surface methodology (RSM). The effect of variations in levels of glucose syrup, sugar, and peanuts on the sensory attributes of 12 peanut brittle formulations was represented by the contour plots. Superimposing all acceptable areas in the contour plots for texture, color, appearance, flavor and overall acceptance showed that all formulations in the constrained region were acceptable to the consumer panel with 6.5 as the minimum acceptance rating given. This means that an acceptable peanut brittle can be produced using any of the formulations within the constrained region. The formulations had products with higher acceptance ratings for texture than the commercial sample.

The roasted peanutty aroma of peanut brittle in 11 of the 12 formulations was higher in intensity than in the commercial sample. The 12 formulations had products with high intensity ratings for caramel aroma and sweet taste than the commercial sample. Above findings indicate that the products from the 12 formulations were better than the collaborator’s product.

The acceptable formulations could consist of any combination of glucose syrup, sugar and peanuts within these ranges: 15 to 90% glucose syrup, 0 to 65% sugar, and 10 to 55% peanuts. The amounts of the other ingredients in the formulation that must be used in fixed amounts were as follows: 16.0% water, 6.0% butter, 3.5% sesame seeds, 1.5%baking soda, 0.6% industrial salt, and 0.15% vanilla powder.

The prediction equations can be used as a tool for changing the levels of ingredients when necessary as when optimizing cost, without sacrificing product acceptability. The prediction equations for each sensory attribute obtained from the statistical analysis could be manipulated to produce acceptable peanut brittle products provided that the levels of glucose syrup, sugar and peanuts were within the established ranges of these ingredients. This is done by substituting the variables with the levels of glucose syrup, sugar and peanuts, and then computing to estimate for the acceptance rating of the chosen formulation.

TECHNOLOGY TRANSFER OF PEANUT BRITTLE PROCESS TO COLLABORATOR AND STANDARDIZATION OF PEANUT BRITTLE PROCESS IN COLLABORATOR'S PLANT

The process for peanut brittle was successfully standardized at Monastery Farms using the equipment and ingredients available in the processing plant. The process and formulation were modified to produce a safe peanut brittle product with consistent sensory quality, the characteristics of which are described in the Finished Product Specifications in Appendix G..

The modifications introduced during the technology transfer stage involved the control of time and temperature of roasting and cooking, and standardization of the weight of peanuts in the dry blanching and roasting steps. The following steps were standardized: (a) Introduction of a new dry blanching step at 149°C for 8 minutes. This facilitated removal of the skin and sorting of aflatoxin infected nuts; (b) Sorting of nuts following dry blanching before final roasting at 149°C for 6 to 7 minutes; (c) Control of time and temperature of roasting and cooking of peanuts and other ingredients for the preparation of peanut brittle; (d) Roasting of sesame seeds in a “carajay” for 25 to 30 minutes at low heat to produce a moderate to strong roasted sesame aroma; (e) Cooling of the cooked mixture to 85 to 90°C prior to cutting, which significantly improved the shape of the cut pieces.

The peanut brittle formulation of FDC obtained from the optimization study was also modified based on the preferred sweet and salty tastes and roasted peanutty and sesame aroma in the product as requested by the collaborator. The new peanut brittle formulation based on the standardized process consists of 14.0% glucose syrup, 37.0% refined sugar, 34.0% roasted peanuts, 7.5% water, 4.0% butter, 1.5% roasted sesame seeds, 1.0% baking soda, 0.35% industrial salt, and 0.65% vanilla concentrate.

A total of 11 plant personnel were trained on the standardized process. The quality control points were emphasized by explaining the importance of the standardized steps.

SHELF LIFE STUDY OF MONK’S PEANUT BRITTLE

After 158 days or 5.3 months of storage at ambient conditions, the peanut brittle samples packed in its traditional packaging of cellophane as primary packaging and polypropylene jar as secondary packaging, was no longer acceptable primarily due to change in its texture/crunchiness and flavor/taste.

The new formulation of peanut brittle packed in its traditional packaging material had a shelf life that exceeded the shelf life of the peanut brittle produced by the collaborator using their formulation by 2 months. Thus, the new formulation is thus recommended for use by the collaborator.

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APPENDIX A

PROCEDURE FOR THE PREPARATION OF PEANUT BRITTLE

PROCEDURE FOR THE PREPARATION OF PEANUT BRITTLE

1. Roasting of Sesame Seeds

1.1 Place 200 grams of sesame seeds in a 12” frying pan.
1.2 Set fire to medium. Stir continuously to prevent over roasting.
1.3 Roast sesame seeds for 10 minutes or until color turns to golden brown to brown.

2. Sifting of baking soda

Sift baking soda in a fine stainless steel wire mesh to remove clumps. Do this twice.

3. Weighing and mixing of other ingredients

3.1 Weigh glucose directly into the cooking pan. Since glucose is highly viscous, weighing in a container and transferring in the pan may result in inaccurate weight.
3.2 Mix sugar and water with glucose.
3.3 Mix sesame seeds and peanuts.
3.4 Mix softened butter, vanilla, and salt.
3.5 Place baking soda in a clean, dry salt/pepper dispenser.

4. Cooking

4.1 Place the pan with glucose, sugar and water over a medium fire. Occasionally stir the mixture.
4.2 When the temperature of the mixture reaches 165- 170°C, reduce to low heat and stir in the butter with vanilla and salt. Dispense half of the baking soda in the mixture with continuous mixing. Pour the peanut and sesame mixture and distribute evenly by mixing, while dispensing the remaining baking soda.
4.3 Mix the mixture until it reaches the desired color of golden brown.
4.4 Immediately remove mixture from heat and place in the cutter. *Caution: Mixture is very hot.*

5. Cooling and cutting of peanut brittle

5.1 Place the mixture in a cutter and flatten using a rolling pin.
5.2 When mixture cools to 85-90°C, the mixture is ready for cutting. This is characterized by the following: a) it does not stick too much in the cutter, b) resistance is felt during cutting, and c) the product does not deform when cut.
5.3 Cut the peanut brittle by following the grids in the cutter. To prevent sticking of the pieces of peanut brittle, avoid placing it side by side. If the peanut brittle is not totally cut, cut the peanut brittle pieces completely using a knife.
5.4 Cool the peanut brittle pieces.

6. Packing

6.1 Individually wrap the peanut brittle pieces in a polyethylene plastic.
6.2 Pack in plastic containers with a net weight of 270 grams.
6.3 Seal containers using transparent tape.

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE CONSUMER TEST OF PEANUT BRITTLE

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE CONSUMER TEST OF PEANUT BRITTLE

Panelist # ________

NAME: ____

OFFICE ADDESS: _____________________________________ TEL.NUMBER: ___________

POSITION/ OCCUPATION: ______________________________

GENDER: ____ Male _____ Female

AGE: _______ CIVIL STATUS: _____ Single _____ Married

DO YOU HAVE FOOD ALLERGIES? _____ Yes _____ No

DO YOU EAT PEANUT BRITTLE? _____ Yes _____ No

IF YES, HO OFTEN?
_____ Rarely ______ Three times a month
_____ Less than once a month______ Once a week
_____ Once a month ______ 2-3 times a week
_____ Twice a month ______ Daily

Thank you very much!

APPENDIX C

BALLOT FOR THE CONSUMER TEST OF PEANUT BRITTLE

BALLOT FOR THE CONSUMER TEST OF PEANUT BRITTLE

CENTRAL LOCATION TEST: February 1, 2005

Panelist # __________ Sample # _________

Instruction: Please answer the following questions by putting a check mark in the square that best reflects your feelings about this sample.
Please bite half of the sample and answer the first 2 questions; then look at the sample and answer questions 3 and 4; lastly, eat the rest of the sample and answer question 5.

1. OVERALL, how would you rate this 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 would you rate the COLOR of this 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 would you rate the APPEARANCE of this 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 would you rate the FLAVOR/TASTE of this 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 would you rate the TEXTURE/ CRUNCHINESS 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
☐	☐	☐	☐	☐	☐	☐	☐	☐

Thank you !

APPENDIX D

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE DESCRIPTIVE TEST OF PEANUT BRITTLE

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE DESCRIPTIVE TEST OF PEANUT BRITTLE

Instruction: Kindly complete this questionnaire and return the duly accomplished form.

Name ____
Address ____
Occupation ____
Office ____
Telephone Number ____
Birthday ____
Gender Male ___________ Female ________
Civil Status Single __________ Married ________

SURVEY QUESTIONS
1. Are you allergic to peanuts and peanut products? Yes __________ No __________
2. Do you eat peanut brittle? Yes ________ No ________
3. If yes, how often?
   Less than once a month _________ Once a month ________
   Once a month _________ 2-3 times a week ________
   Twice a month _________ Daily ________
4. Please describe the product.
   ____
   ____
   ____
5. Do you have dentures/ braces? Yes ________ No ________

HEALTH
Please indicate if you have the following:
1. Colds Yes _______ No _______
2. Cough Yes _______ No _______
3. Diabetes Yes _______ No _______
4. Arthritis Yes _______ No _______

OTHERS
1. Do you smoke? Yes ______ No _______
2. Are you willing to participate in discussions if ever selected? Yes _______ No _______

Signature of Potential Panelists: ______________________________

THANK YOU !

APPENDIX E

BALLOT FOR THE DESCRIPTIVE TEST OF PEANUT BRITTLE

BALLOT FOR THE DESCRIPTIVE TEST OF PEANUT BRITTLE

NAME:______________________ CODE:_____________

Date:________________________

Instruction: Please put a vertical mark through the line scale to indicate the amount of each attribute (the scale is from 0 to 150mm)

Texture

First Bite: Hardness (is the force to bite through the incisors)

Soft Hard

First Bite: Bite through a pre-determined size of sample with incisors
Reference/ Intensity Rating: Planter's Peanuts= 95; Carrots= 110; Warm-up= 100;
Monk's Peanut Brittle= 110

First Bite: Fracturability (is the force with which the sample breaks)

Crumbly Brittle

First Bite: Bite through a pre-determined size of sample with incisors
Reference/ Intensity Rating: Graham crackers= 40; Corn chips= 55; Chichacorn= 65;
Warm-up= 70; Monk's Peanut Brittle= 80

First Chew: Hardness (force to bite through with molars)

Soft Hard

First Chew: Bite through a pre-determined size of sample with molars
Reference/ Intensity Rating: Planter's Peanuts= 90; Carrots= 100; Warm-up= 90;
Monk's Peanut Brittle= 100

First Chew: Fracturability (force with which the sample breaks)

Crumbly Brittle

First Chew: Bite through a pre-determined size of sample with molars
Reference/ Intensity Rating: Graham crackers= 35; Corn chips= 45; Chichacorn= 60;
Warm-up= 65; Monk's Peanut Brittle= 75

Appearance

Color

Off-white Brown

Off-white- the color associated with plain popcorn
Brown- the color associated with powdered cocoa
Reference/ Intensity Rating: Washed sugar= 20; Lady's Choice Peanut Butter = 30; Graham= 90; Ludy's Peanut Butter= 130; Warm up= 100; Monk's Peanut brittle= 130; Cocoa Powder= 150

Surface Shine

Dull Glossy

Glossy- not dull
Reference/ Intensity Rating: Lady's Choice Peanut Butter = 40; Ludy's Peanut Butter = 120; Anchor butter =150; Warm-up=50;Monk's Peanut Brittle= 100

Aromatics

Roasted Peanutty Aroma (aroma associated with medium roasted peanuts)

Perceptible Strong

Reference/ Intensity Rating: Raw Peanut- 0; Planter's Peanut = 70; Warm-up = 50; Monk's Peanut Brittle = 35

Buttery Aroma (aroma associated with unsalted butter)

Perceptible Strong

Reference/ Intensity Rating: Butterball= 110; Anchor butter= 150; Warm-up= 65; Monk's Peanut Brittle= 10

Sesame Aroma (aroma associated with sesame seeds)

Perceptible Strong

Reference/ Intensity Rating: Raw Sesame= 0; Roasted Sesame Seeds= 25; Sesame oil= 150; Warm-up= 10; Monk's Peanut Brittle= 110

Vanilla Aroma (aroma associated with vanilla)

Perceptible Strong

Reference/ Intensity Rating; 5% Vanilla= 35; Warm-up= 25; : Monk's Peanut Brittle= 10

Caramel aroma **(aroma associated with caramelized sugar)**

Perceptible Strong

Reference/Intensity Rating: 2% sucrose solution = 20; 5% sucrose solution = 50;
10% sucrose solution = 100; 16% sucrose solution = 150;
Warm up= 85; Monk's Peanut Brittle= 50

Tastes

Sweet Taste (taste stimulated by sucrose)

Perceptible Strong

References/Intensity Rating: 2% sucrose solution= 20; 5% sucrose solution = 50;
10% sucrose solution = 100; 16% sucrose solution = 150;
Warm-up =120; Monk's Peanut Brittle= 90

Salty Taste (taste stimulated by sodium chloride)

Perceptible Strong

Reference/Intensity Rating: 0.2% sodium chloride solution = 25;
0.35% sodium chloride solution = 50;
0.5% sodium chloride solution = 100;
Warm-up= 35; Monk's Peanut Brittle= 42

Bitter Taste (taste stimulated by caffeine)

Perceptible Strong

Reference/ Intensity Rating: 0.05% caffeine solution= 20; 0.08% caffeine solution= 50;
0.15% caffeine solution= 100; Warm- up=5;
Monk's Peanut Brittle= 15

APPENDIX F

MEMORANDUM OF AGREEMENT WITH MONASTERY FARMS

FOOD DEVELOPMENT CENTER
FTI Complex, Taguig, Metro Manila

Phone : 838-4014 to16;
Telefax: 838-4692; 838-4016;
E-mail : infofdc@pacific.net.ph

NFA

IDM'2004
FDC No. 04-04-011

Rec'd
April 7'04
[illegible] April 6

April 6, 2004

FOR : **The Administrator**

THRU : **The Deputy Administrator for Operations**
The Asst. Administrator for Industry Development

FROM : **The Food Development Center**

SUBJECT : **MEMORANDUM OF AGREEMENTS (MOA) WITH CAFFINORMIN AND NFA-FDC**

This is to inform you that we initiated a cooperative program with the Chamber of Agriculture, Fisheries and Food Industries of Northern Mindanao, Inc. (CAFFINORMIN) to expand the utilization and markets for peanut products. Through CAFFINORMIN, we will provide technical assistance for product improvement to Monastery Farms.

This is also to request you to sign the enclosed Memorandum of Agreements that will govern NFA-FDC's collaboration with CAFFINORMIN. In these documents, FDC will provide technology and training for product improvement and a proposal for the establishment of a Peanut Service Station for upgrading postharvest handling methods. Funding for all activities will be provided by the Peanut Collaborative Research Support Program (PCRSP) of the University of Georgia through Professor Anna Resurreccion. For 2004 activities, US$41,758.00 has been provided to FDC and thru NFA-FDC to the University of the Philippines and Leyte State University. The money is held in trust at NFA.

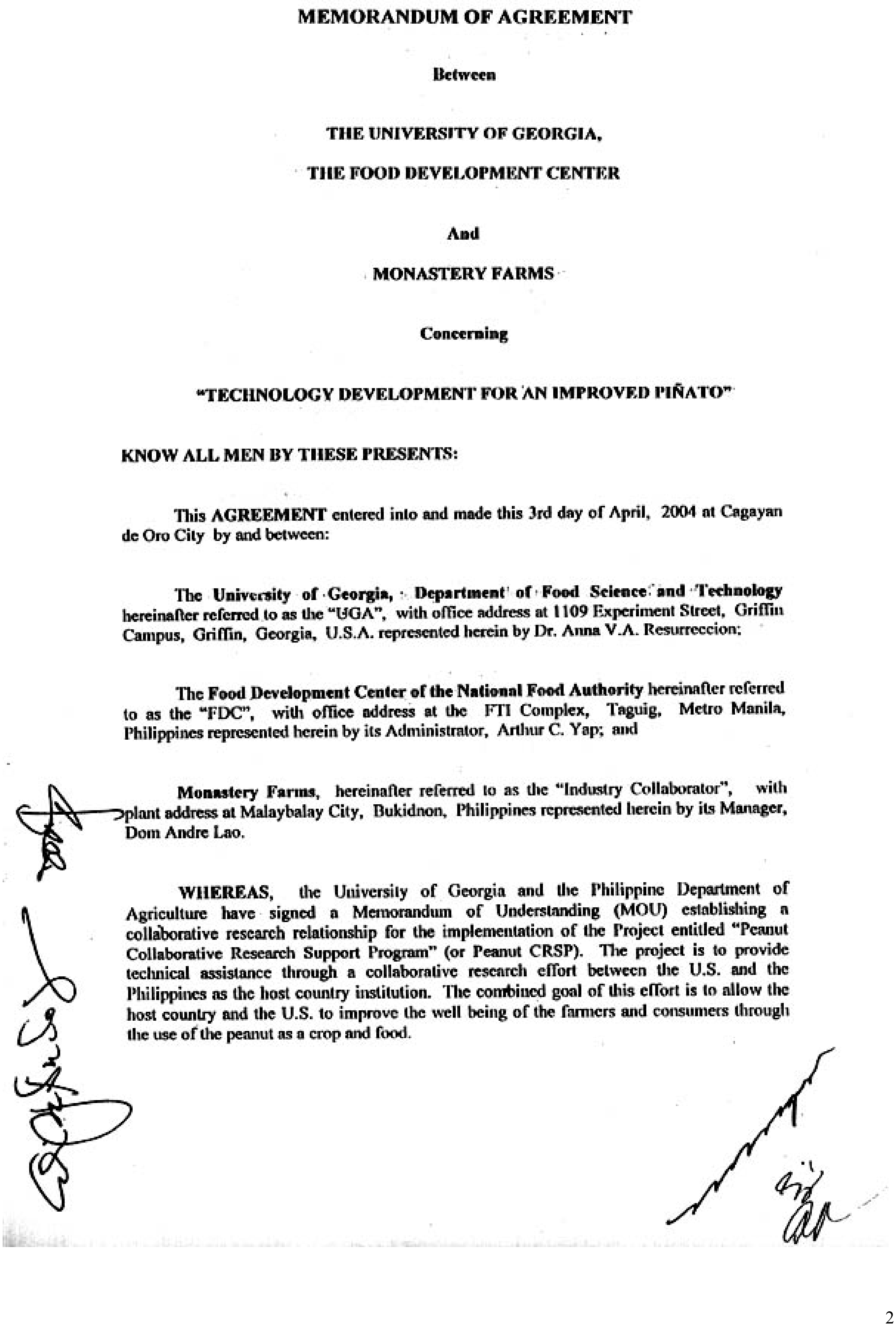
Our collaboration with the University of Georgia is governed by an umbrella MOU signed by the Secretary of Agriculture and by the Administrator of NFA in 1997.

The choice of CAFFINORMIN is the result of a search by FDC for a reliable cooperative that will collaborate in the implementation of our commitments to PCRSP. This activity represents our first venture with a cooperative.

A symbolic signing of the enclosed MOA's was held at Cagayan de Oro City last April 3, 2004 at the request of CAFFINORMIN to coincide with the holding of the First National Root Crop Congress. NFA was represented by the Assistant Administrator for Industry Development and the Regional Director of Region X, and FDC by the undersigned.

Thank you for your attention and I anticipate your favorable action on this program by signing the enclosed MOA's.

ALICIA O. LUSTRE
Director



MEMORANDUM OF AGREEMENT

Between

THE UNIVERSITY OF GEORGIA,

THE FOOD DEVELOPMENT CENTER

And

MONASTERY FARMS

Concerning

"TECHNOLOGY DEVELOPMENT FOR AN IMPROVED PIÑATO"

KNOW ALL MEN BY THESE PRESENTS:

This **AGREEMENT** entered into and made this 3rd day of April, 2004 at Cagayan de Oro City by and between:

The **University of Georgia, Department of Food Science and Technology** hereinafter referred to as the "UGA", with office address at 1109 Experiment Street, Griffin Campus, Griffin, Georgia, U.S.A. represented herein by Dr. Anna V.A. Resurreccion;

The **Food Development Center of the National Food Authority** hereinafter referred to as the "FDC", with office address at the FTI Complex, Taguig, Metro Manila, Philippines represented herein by its Administrator, Arthur C. Yap; and

Monastery Farms, hereinafter referred to as the "Industry Collaborator", with plant address at Malaybalay City, Bukidnon, Philippines represented herein by its Manager, Dom Andre Lao.

WHEREAS, the University of Georgia and the Philippine Department of Agriculture have signed a Memorandum of Understanding (MOU) establishing a collaborative research relationship for the implementation of the Project entitled "Peanut Collaborative Research Support Program" (or Peanut CRSP). The project is to provide technical assistance through a collaborative research effort between the U.S. and the Philippines as the host country institution. The combined goal of this effort is to allow the host country and the U.S. to improve the well being of the farmers and consumers through the use of the peanut as a crop and food.

WHEREAS, the University of Georgia and the Food Development Center of the National Food Authority have entered into a sub-grant agreement under the above MOU to implement a proposal research on "Development of Peanut Postharvest Handling and Processing Technologies". The goal of the proposed research is to stimulate economic growth through expansion of markets for high quality products from peanuts.

WHEREAS, the UGA and FDC had implemented a project to achieve the above goal through a "Technology Development for an Improved Piñato". The project was implemented in collaboration with the Industry Collaborator to ensure short-medium-term technology transfer.

WHEREAS, all the parties had cooperated with one another for the effective implementation of the aforesaid project and had provided the following support :

<u>FDC – Peanut CRSP Philippines</u>

1. Manpower for product and process development, equipment design and fabrication and fees for sensory evaluation and other tests.
2. Half or 50% of the cost of peanuts used in product and process development.
3. Air tickets and manpower cost of two personnel who will transfer the improved product as well as related technologies as control of aflatoxin, GMP and HACCP to the company.

<u>Monastery Farms</u>

1. Half or 50% of the cost of peanuts used in product and process development.
2. Full cost of raw materials and ingredients during the transfer of the technology to the plant.
3. Availability of equipment and plant facilities and of manpower support during the transfer of technology.
4. Local transportation, accommodation and meals of two FDC personnel who will transfer the improved process as well as related technologies to the plant.

WHEREAS, the UGA and FDC are developing a technology for the quality improvement of piñato and will transfer the said technology to the Industry Collaborator;

NOW, THEREFORE, in consideration of the above premises and their mutual covenants herein setforth, the parties have agreed as follows:

1. **THAT** the **FDC** shall develop a new process for an improved piñato product that will be crunchy and not hard, and with no bitter taste. It shall not obtain any information from the Industry Collaborator on its technology but will develop a process based on its own expertise.

2. **That** the **FDC** shall develop a cutter for the Industry Collaborator to achieve uniform sizes of piñato.

3. **That** the **Industry Collaborator** shall have exclusive use of the FDC process for a period of two years after launching of the product.

4. **THAT** the **FDC** shall provide technical manpower support during the two-year period.

5. **THAT** the **Industry Collaborator** shall agree to market the improved product within two years of completion of the technology development and provide FDC with the results of any increase in sales and volume, market outreach and other parameters.

6. **THAT** the **Industry Collaborator** shall agree to the dissemination of the technology developed by FDC to all relevant industries through a training course to be conducted by FDC two years after launching of the product.

IN WITNESS HEREOF, the parties hereunder set their hands on the date and place first above written.

UNIVERSITY OF GEORGIA

DR. ANNA V.A. RESURRECCION
Professor

FOOD DEVELOPMENT CENTER
NATIONAL FOOD AUTHORITY

ATTY. ARTHUR C. YAP
Administrator

CHAMBER OF AGRICULTURE, FISHERIES AND FOOD INDUSTRIES OF NORTHERN MINDANAO, INC.

ENGR. EDWIN B. ANDOT
President

MONASTERY FARMS

DOMA ANDRE LAO
Manager

SIGNED IN THE PRESENCE OF

MR. MIGUEL WYCOCO
Regional Director, NFA Region X

DR. ALICIA O LUSTRE
Director, NFA-FDC

ACKNOWLEDGEMENT

REPUBLIC OF THE PHILIPPINES) S.S.
QUEZON CITY

BEFORE ME, a Notary Public for and in ____________________ this ______________ day of ______________ 2004 personally appeared:

	- Residence Certificate -		
NAME	**No.**	**Date of Issue**	**Place of Issue**
Atty. Arthur C. Yap			
Dr. Anna V.A. Resurreccion			
Dom Andre Lao			

known to me as the same persons who executed the foregoing Agreement and acknowledged to me that the same is their free and voluntary act and deed that of the principals represented by them.

I further acknowledge that this instrument, including the foregoing Agreement and this page on which this acknowledgement is written, consists of 4 pages, all signed by the parties and their witnesses and sealed with my notarial seal.

WITNESS MY HAND AND SEAL on the date and the place first above written.

Doc. No. _____
Page No. _____
Book No. _____
Series of _____

ANNEX 1

PROPOSAL FOR R&D COLLABORATION
TO MONASTERY FARMS, MALAYBALAY, BUKIDNON

A. Rational

The Monastery Farms, Malaybalay City, Bukidnon responded to the invitation of Peanut-CRSP Philippines to collaborate in improving its peanut brittle (piñato) as a model product for development for small industry associations. An initial evaluation of piñato showed that the presence of bitter taste and slightly hard texture, and non-uniformity of size were the problems identified for this product. An initial analysis of the problem indicates that the bitter taste may be due to the dark colored kernels in some piñato slices that got burned during the cooking process or to the aflatoxin infected kernels. The aflatoxin infected kernels can be separated from the good kernels through proper sorting of the blanched peanuts. The bitter taste, due to burned kernels, can also be prevented through proper control of the cooking process. The texture of the piñato can be improved through modification of ingredients and process.

B. Objectives

1. To improve the aroma and texture of piñato.
2. To attain a uniform size of piñato.
2. To transfer the technology of improved piñato to collaborator.
3. To conduct market testing of piñato.

C. Expected Outputs

1. Aroma and texture of piñato improved.
2. Uniform size of piñato attained.
3. Technology of improved piñato transferred to collaborator.
4. Market testing of improved piñato conducted.

D. Duration: Three months from approval of project

E. Activities and Cost Sharing Scheme

Activities:

1. Improvement of piñato at the laboratories and Pilot Plant of the Food Development Center.
2. Transfer of developed technology of improved piñato to collaborator.
3. Conduct of market testing of improved piñato.

Cost Sharing Scheme:

FDC – Peanut CRSP Philippines

1. Manpower for product and process development, equipment design and fabrication and fees for sensory evaluation and other tests.
2. Half or 50% of the cost of peanuts used in product and process development.
3. Air tickets and manpower cost of two personnel who will transfer the improved product as well as related technologies as control of aflatoxin, GMP and HACCP to the company.

Monastery Farms

1. Half or 50% of the cost of peanuts used in product and process development.
2. Full cost of raw materials and ingredients during the transfer of the technology to the plant.
3. Availability of equipment and plant facilities and of manpower support during the transfer of technology.
4. Local transportation, accommodation and meals of two FDC personnel who will transfer the improved process as well as related technologies to the plant.

F. Terms for Collaboration

1. Monastery Farms to have exclusive use of the process for a period of two years.
2. FDC to provide technical manpower support during the two-year period.
3. Monastery Farms to provide production and sales volume for the measurement of Project Impact for a period of two years after completion of technology development.
4. Monastery Farms to agree to disseminate the technology developed for an improved piñato through a training workshop to be conducted by FDC on the third year after completion of the technology development.

Proposed by: **The Food Development Center**

DR. ALICIA O. LUSTRE
Director

Conforme:

DOM ANDRE LAO
Monastery Farms
Malaybalay, Bukidnon

4/1

APPENDIX G

PROCEDURE FOR THE PREPARATION OF PEANUT BRITTLE DEVELOPED BY FDC FOR MONASTERY FARMS

PROCEDURE FOR THE PREPARATION OF PEANUT BRITTLE DEVELOPED BY FDC FOR MONASTERY FARMS (FDC, 2005b)

A. Preparation of Ingredients

1. Preparation of roasted peanuts

1.1 Dry blanching at 140°C

a. Preheat peanut roaster to 140°C.
b. Dry blanch 20 Kg of peanuts at 140°C for about 20 minutes or until the skin can be peeled off easily between fingers.

1.2 Immediate cooling to 45°C

After dry blanching, spread the peanuts on top of stainless steel working tables. Immediately cool the peanuts with the aid of electric fans and mix occasionally to facilitate cooling. Cooling ends if peanuts can be handled by the hands. The temperature of peanuts at this point is approximately 45°C

1.3 Deskinning

Remove the skin of the peanuts taking care not to crush the peanuts. Deskinning may be done manually by hand or with the use of a peanut blancher or any similar equipment that can remove the skin of peanuts. Use an electric fan to facilitate the removal of the skin from the peanut kernels.

1.4 Sorting for aflatoxin infected peanuts

a. Transfer the de-skinned peanuts to a well-lighted room and spread on top of stainless steel working tables.

b. Sort out mold-contaminated and damaged peanuts from the good peanuts. Also remove skin adhering in peanuts that were not properly de-skinned to facilitate sorting of aflatoxin-contaminated kernels. The descriptions of the defects in peanuts are the following:

<u>Mouldy kernels</u> are defined as kernels with mould filaments visible to the naked eye (Codex Alimentarius Commission, 1994a).

<u>Decayed kernels</u> are defined as those showing visibly significant decomposition (Codex Alimentarius Commission, 1994a).

<u>Rancid kernels</u> are defined as kernels which have undergone oxidation of lipids and should not exceed 5 meq active oxygen/Kg lipid, or the production of free fatty acid should not exceed 1.0% resulting in the production of disagreeable flavors (Codex Alimentarius Commission, 1994a).

1.5 Roasting of peanuts

a. Roast peanuts at 140°C until the color is light to medium brown, the texture is crunchy and a roasted peanutty aroma is present.
b. Transfer the peanuts on top of stainless steel working tables and immediately cool to 45°C with the aid of electric fans. Mix occasionally to facilitate cooling.
c. Transfer roasted peanuts into a big container with plastic lining.
d. Store roasted peanuts as indicated in section 2.2 until intended use.

1.6 Chopping of peanuts

Chop roasted peanuts to a size range of 0.2 to 0.4 cm. Chopping may be done manually using a sharp knife or with the use of equipment such as silent cutter or blender.

1.7 Sifting of chopped peanuts

Sift chopped peanuts in a fine stainless steel wire mesh (Sieve # 18, Tsutsui, Tokyo, Japan) to remove off-sized chopped peanuts. The sifted peanuts should be less than 0.4 cm in size, otherwise the peanuts should be cut further into the desired size.

2. Preparation of roasted sesame seeds

2.1 Roasting at medium heat

a. Place 200 grams of sesame seeds in a 12" frying pan.
b. Set fire to medium. Stir continuously to prevent over roasting.
c. Roast sesame seeds for 15 to 20 minutes or until the color turns to golden brown to brown.

2.2 Immediate cooling to 45°C

a. Cool immediately by spreading the sesame seeds on a tray at room temperature.
b. Set aside until intended use.

3. Softening of butter

Place butter in a clean container with cover. Leave butter to soften at room temperature.

4. Weighing

4.1 Weigh the dry ingredients using a calibrated, dry, and clean weighing scale in clean and dry containers such as bowls, plastic or glass containers and spatula.

4.2 Weigh glucose syrup directly into the frying pan intended for cooking the mixture. Glucose syrup is highly viscous and weighing in a container and transferring this to a pan may glucose syrup to adhere to the container resulting in inaccurate weight.

4.3 For a 4-Kg mixture of peanut brittle, the amount required for each ingredient is as follows:

Ingredients used in the formulation	% of ingredient in the formulation	Amount required in grams
Glucose syrup	27.45	1,098.0
Washed sugar	24.56	982.4
Roasted peanuts	20.24	809.6
Water	16.00	640.0
Butter	6.00	240.0
Roasted sesame seeds	3.50	140.0
Baking soda	1.50	60.0
Industrial salt	0.60	24.0
Vanilla powder	0.15	6.0
Total	**100.00**	**4,000.0**

B. Preparation of Peanut Brittle

1. Mixing of ingredients

1.1 Mix roasted sesame seeds and roasted peanuts in a clean, dry plastic container.
1.2 Mix glucose syrup, water and washed sugar in the pan.
1.3 Mix softened butter, vanilla concentrate and salt in a clean, dry plastic container.

2. Cooking

2.1 Place the pan with glucose syrup, sugar and water over medium fire and stir the mixture every about five (5) minutes.
2.2 When the temperature of the mixture reaches 165°C, reduce to low heat.
2.3 Add the mixture of butter, vanilla and salt to the mixture of sugar and glucose. Continuously mix the mixture.
2.4 Dispense half of the baking soda using a salt and pepper dispenser to the mixture and continuously mix the mixture.
2.5 Add the roasted peanuts and sesame seeds in the mixture. Continuously mix the mixture.
2.6 Dispense half of the remaining baking soda in the mixture. Continuously mix the mixture.
2.7 Extend the cooking time of the mixture using low flame for about 1 minute or until the desired color is attained.

3. Molding of cooked peanut brittle mixture

Immediately flatten the cooked peanut brittle mixture on the stainless steel cutting table with the use of a rolling pin.

4. Cooling of the mixture to 85-90^{o}C

Cool the peanut brittle mixture to 85-90^{o}C before cutting. A higher temperature will result in uneven and deformed cut pieces, while a lower temperature will cause the hardening of mixture and will result in breakage of the peanut brittle during cutting.

5. Cutting

Immediately cut the cooled peanut brittle mixture to the desired size of 4cm x 0.5cm x 1.5cm when the temperature of the mixture reaches 85-90^{o}C.

6. Cooling of peanut brittle pieces at ambient conditions

Separate the cut peanut brittle pieces on the stainless steel table after cutting and cool to ambient temperature to prevent sticking of the cut pieces.

7. Packing

7.1 Individually twist wrap each piece of the cooled peanut brittle in a cellophane wrapper.
7.2 Pack approximately 50 pieces of wrapped peanut brittle or equivalent to a net weight of 270 grams in polypropylene jars.
7.3 Seal jars with screw-type lids and place a transparent tape around the lid for added protection.

8. Storing

Store the product at room temperature.

APPENDIX H

PHOTOS TAKEN DURING THE STANDARDIZATION OF PROCESS FOR PEANUT BRITTLE AT MONASTERY FARMS

Fig. 1 Dry blanching and roasting of peanuts are performed in a Probat coffee roaster at 149°C.

Fig. 2 Cooling of peanuts using the paddle of the roaster and air from the roaster that sucks out heat from peanuts.

Fig. 3 Stainless steel drums used for holding of dry blanched peanuts.

Fig. 4 Manual de-skinning of blanched peanuts using “bilao” or winnowing tray.

Fig. 5 Peanut is separated from the peanut skin by a process called "pagtatahip" or winnowing.

Fig. 6 Sorting out of aflatoxin infected kernels.

Fig. 7 Reducing of peanut size using a stainless steel rolling pin.

Fig. 8 Weighing of glucose syrup directly on the cooking pan due to its thick consistency.

Fig. 9 Cooking of peanut brittle.

Fig. 10 Molding and flattening of hot peanut brittle mixture in a pre-formed molder made of plastic formica with grids.

Fig. 11 Cutting of peanut brittle mixture.

Fig. 12 Cooling of peanut brittle by separately spreading the pieces on the table with the aid of an electric fan.

Fig. 13 Packing of peanut brittle in cellophane as its primary packaging and in polypropylene jars as its secondary packaging.

APPENDIX I

MANUAL OF THE STANDARDIZED PROCESS FOR THE PREPARATION OF MONK'S PEANUT BRITTLE

MANUAL OF THE STANDARDIZED PROCESS FOR THE PREPARATION OF MONK'S PEANUT BRITTLE

Prepared by:

The Food Development Center
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For:

The Monastery Farms
Malaybalay City, Bukidnon

Date: August 18, 2006

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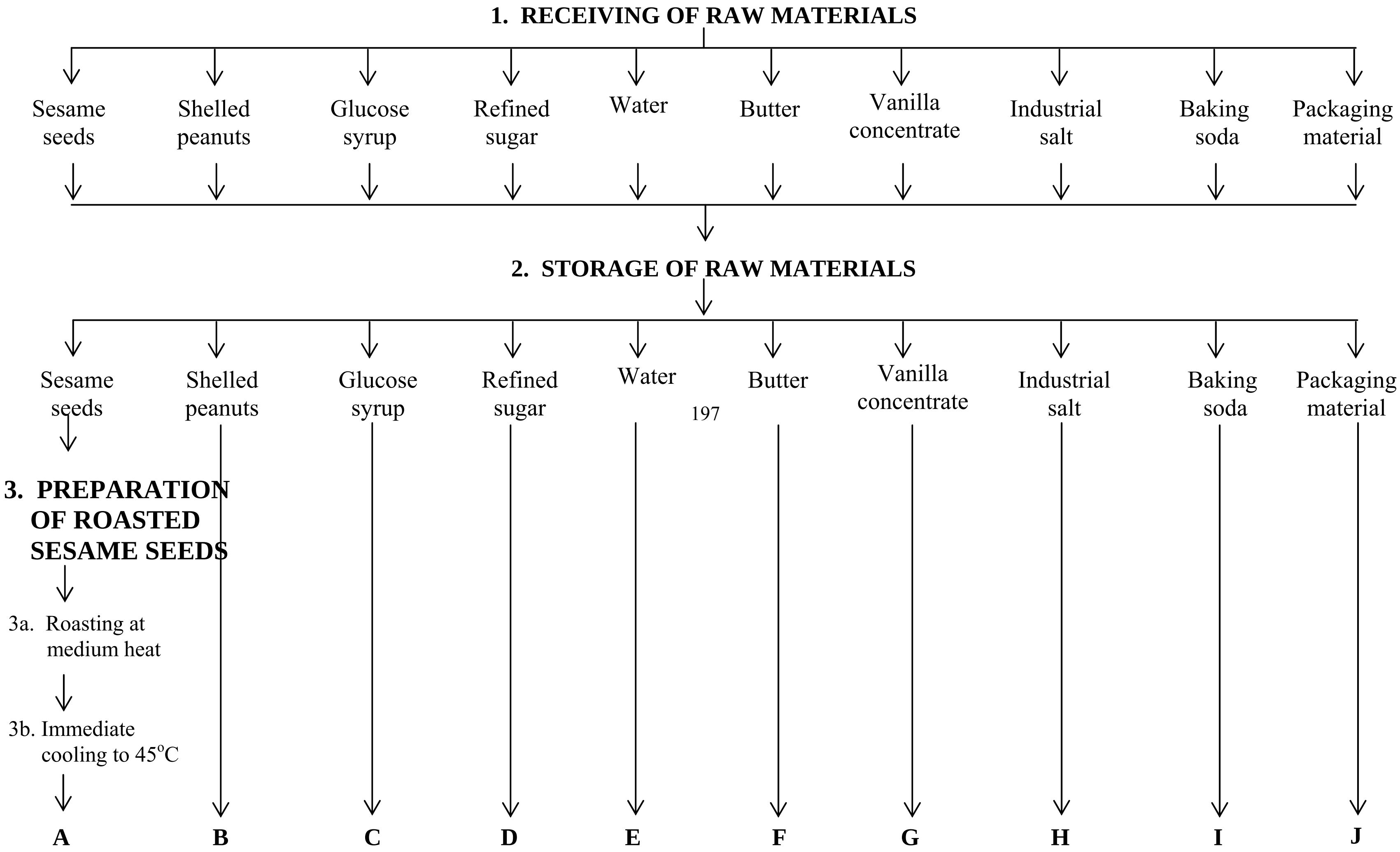
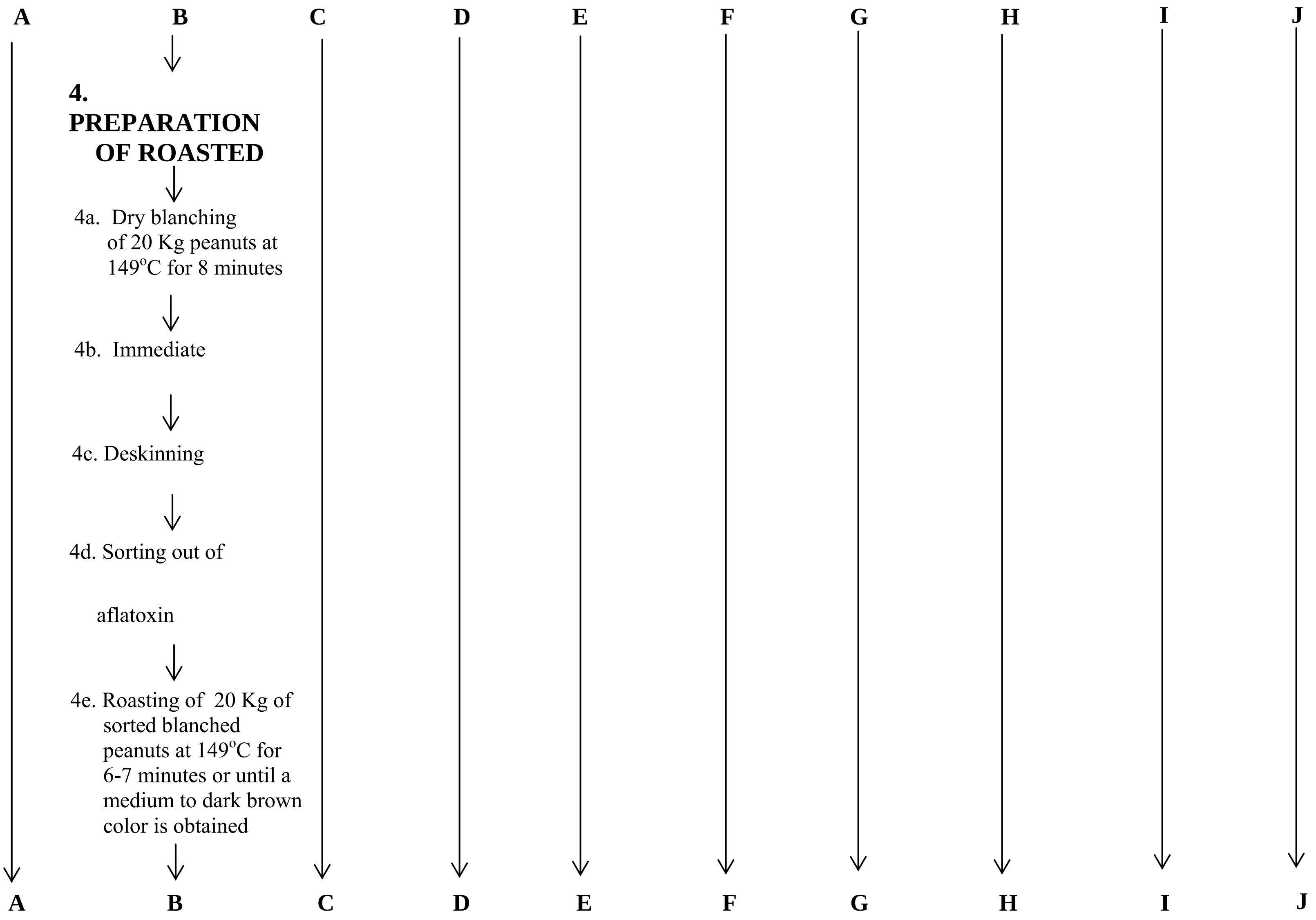
I. PEANUT BRITTLE (PIÑATO) FORMULATION

Ingredient	**% in Formulation**
Glucose syrup	14.00
Refined sugar	37.00
Roasted Peanuts	34.00
Water	7.50
Butter	4.00
Sesame seeds	1.50
Baking soda	1.00
Industrial salt	0.35
Vanilla powder	0.65
TOTAL	100.00

II. FLOW DIAGRAM FOR THE PROCESSING OF PEANUT BRITTLE




A
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4. PREPARATION OF ROASTED
4a. Dry blanching of 20 Kg peanuts at 149°C for 8 minutes
4b. Immediate
4c. Deskinning
4d. Sorting out of
aflatoxin
4e. Roasting of 20 Kg of sorted blanched peanuts at 149°C for 6-7 minutes or until a medium to dark brown color is obtained
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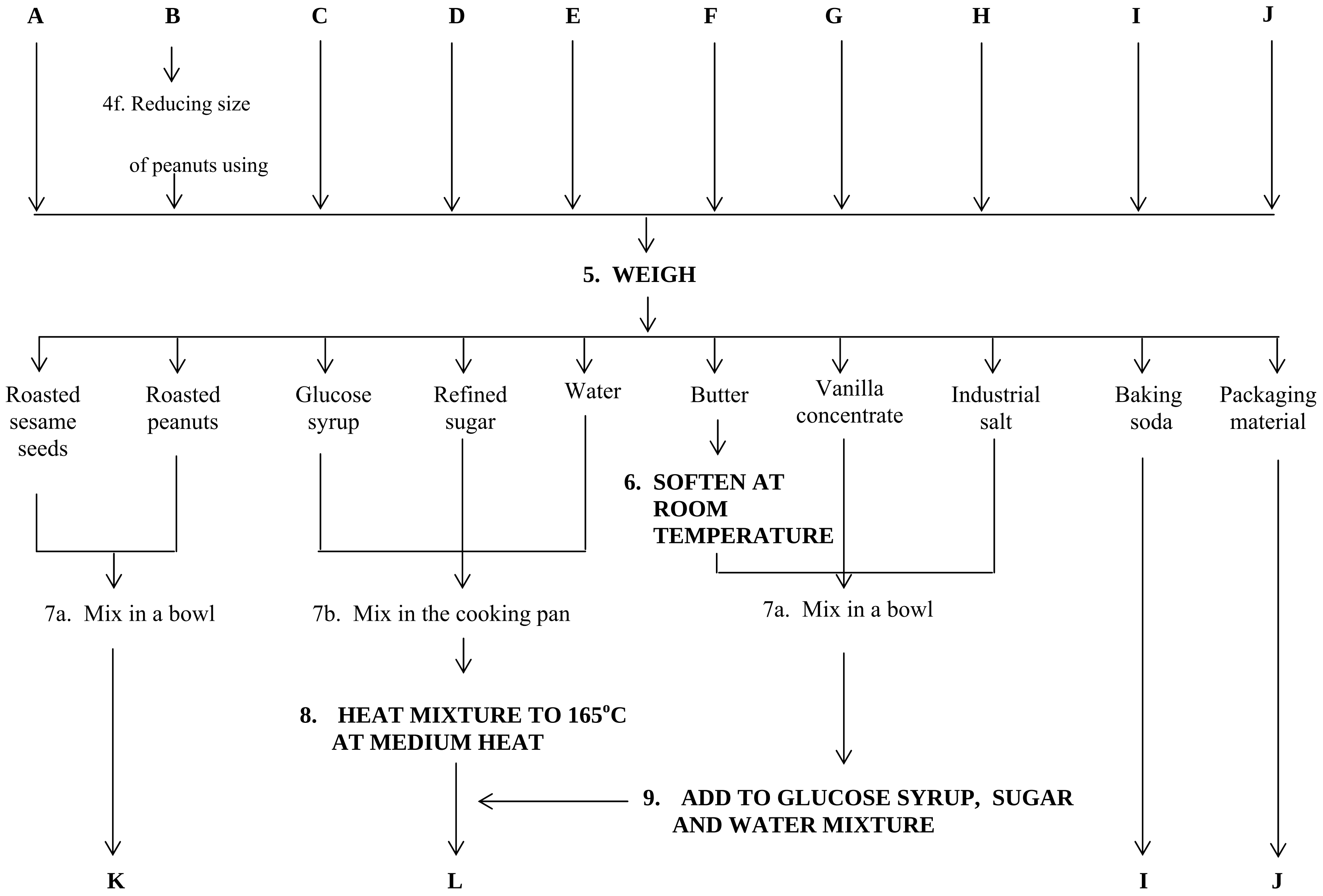
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G
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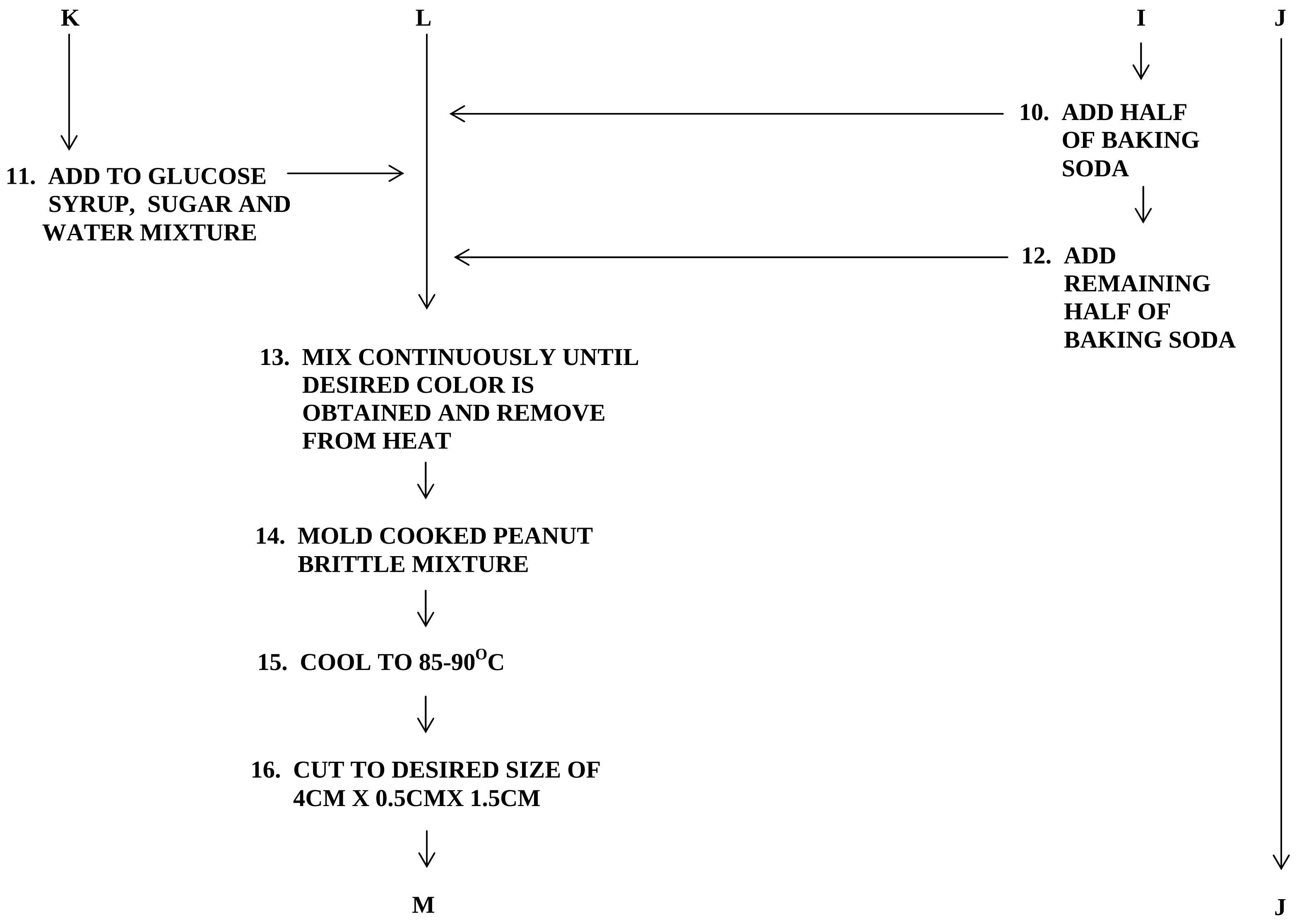
J
4f. Reducing size
of peanuts using
5. WEIGH
Roasted sesame seeds
Roasted peanuts
Glucose syrup
Refined sugar
Water
Butter
Vanilla concentrate
Industrial salt
Baking soda
Packaging material
6. SOFTEN AT ROOM TEMPERATURE
7a. Mix in a bowl
7b. Mix in the cooking pan
7a. Mix in a bowl
8. HEAT MIXTURE TO 165°C AT MEDIUM HEAT
9. ADD TO GLUCOSE SYRUP, SUGAR AND WATER MIXTURE
K
L
I
J



10. ADD HALF OF BAKING SODA

11. ADD TO GLUCOSE SYRUP, SUGAR AND WATER MIXTURE

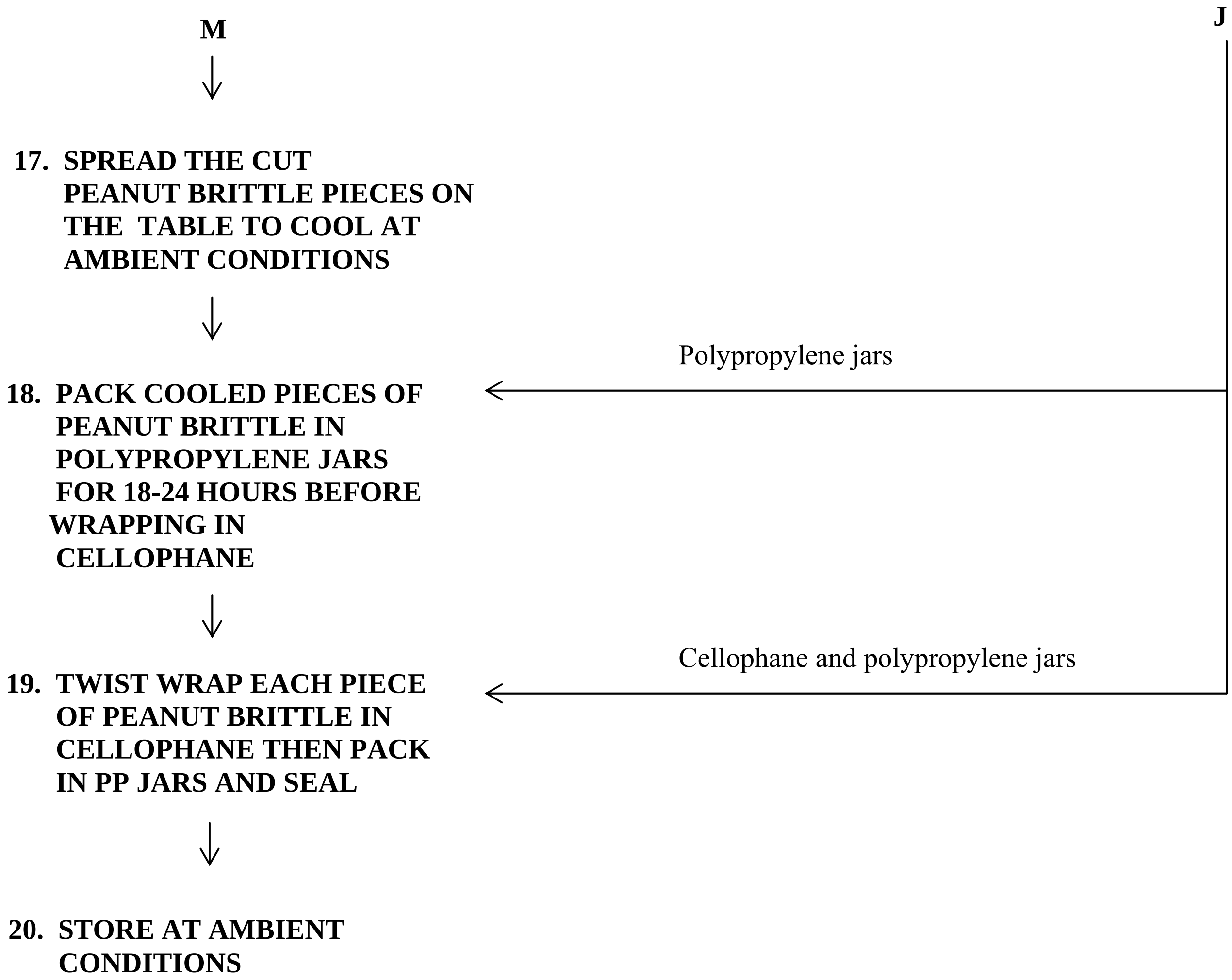
12. ADD REMAINING HALF OF BAKING SODA

13. MIX CONTINUOUSLY UNTIL DESIRED COLOR IS OBTAINED AND REMOVE FROM HEAT

14. MOLD COOKED PEANUT BRITTLE MIXTURE

15. COOL TO 85-90^{O}C

16. CUT TO DESIRED SIZE OF 4CM X 0.5CMX 1.5CM



17. **SPREAD THE CUT PEANUT BRITTLE PIECES ON THE TABLE TO COOL AT AMBIENT CONDITIONS**

18. **PACK COOLED PIECES OF PEANUT BRITTLE IN POLYPROPYLENE JARS FOR 18-24 HOURS BEFORE WRAPPING IN CELLOPHANE**

19. **TWIST WRAP EACH PIECE OF PEANUT BRITTLE IN CELLOPHANE THEN PACK IN PP JARS AND SEAL**

20. **STORE AT AMBIENT CONDITIONS**

III. PROCESS DESCRIPTION

A. Receiving of Raw Materials

Inspect raw materials and ingredients on arrival to make sure that these conform to the raw material specifications below.

Segregate defective raw materials/ingredients and record results of inspection. Only lots which pass the quality specifications should be used for processing.

1. Sesame seeds

1.1 Free from off-odor and off-flavor, i.e. rancid, stored
1.2 Free from filth as impurities of animal origin, including dead insects

2. Shelled peanuts

2.1 Raw shelled, medium sized Florunner type peanuts (*Arachis hypogea* L.) grown locally were purchased from the suppliers of the collaborator in Malaybalay, Bukidnon
2.2 Free from abnormal flavours, odours, living insects and mites (Codex Alimentarius Commission, 1994a)
2.3 Maximum moisture content of 9.0% (Codex Alimentarius Commission, 1994a).
2.4 Mouldy, rancid or decayed kernels should not be more than 0.2% mass/mass (Codex Alimentarius Commission, 1994a).

Mouldy kernels are defined as kernels with mould filaments visible to the naked eye (Codex Alimentarius Commission, 1994a).

Decayed kernels are defined as those showing visibly significant decomposition (Codex Alimentarius Commission, 1994a).

Rancid kernels are defined as kernels which have undergone oxidation of lipids and should not exceed 5 meq active oxygen/Kg lipid, or the production of free fatty acid should not exceed 1.0% resulting in the production of disagreeable flavors (Codex Alimentarius Commission, 1994a).

2.5 Aflatoxin content: 15 ppb maximum level (Codex Alimentarius Commission, 1994a)

3. Glucose syrup

3.1 Clear, thick and viscous liquid
3.2 Total soluble solids should not be less than 70°Bx (Codex Alimentarius Commission, 1994b)

4. Refined sugar

4.1 Free flowing
4.2 Free from dirt, metal fragments and any foreign matter
4.3 No objectionable taste or odor in dry or in 10% sugar solution (Philippine National Standards, 1993)

5. Water

5.1 Odorless, colorless, and free from any kind of flavor and taint
5.2 Potable which conforms to the following microbiological specifications:

Aerobic Plate Count, cfu. mL	:	<100	(Marshall, 1986)
Coliforms, MPN/100ml	:	0	(World Health Organization, 1985 and Marshall, 1986)
E. coli, MPN/100 ml	:	0	(World Health Organization, 1985 and Marshall, 1986)

5.3 Free residual chlorine of not less than 0.25 to 0.5 ppm (Troller, 1983)

6. Butter

6.1 Free from off-odor and off-flavor, i.e. rancid, stored.
6.2 Clean and free from any foreign matter.
6.3 No signs of fat separation.
6.4 Pale yellowish in color.

7. Vanilla concentrate

7.1 Free from filth such as impurities of animal origin, including dead insects.
7.2 Free from off-odor.

8. Industrial salt

8.1 Food grade
8.2 Fine grained and free flowing
8.3 Free from dirt and any foreign material as sand, hair, insect fragments, stones, and others.

9. Baking soda

9.1 Free flowing
9.2 Free from dirt and any other foreign matter.

10. Packaging materials

The packaging materials shall be any flexible packaging material that is clean and free from foreign material on the surface.

B. Storage of Raw Materials

All containers of ingredients should be labeled and marked with the date of arrival so that the policy of "first in first out" can be followed.

1. Sesame seeds

1.1 Sesame seeds should be stored in a freezer to prevent development of off-odors and off- flavors, especially when there is a big volume of this raw material.

1.2 The sacks, bags or containers of ingredients should not come in contact with the walls of the shelves to avoid dampness.

2. Shelled peanuts

2.1 Store peanuts in clean jute sacks or kraft paper sacks in an environment with a relative humidity of 55 to 65% to prevent mould growth.

2.2 Place sacks of peanuts in pallets and should not come in contact with the walls of the storage room to avoid dampness.

3. Glucose syrup

Glucose syrup should be stored at room temperature in a properly sealed container.

4. Refined sugar

Refined sugar should be kept in a dry, cool and ventilated pace. A damp environment will cause caking of these ingredients.

5. Water

Water is stored in clean and fully enclosed elevated stainless steel water tanks.

6. Butter

Butter should be stored in the refrigerator.

7. Vanilla concentrate

Store vanilla concentrate in clean plastic containers with cover.

8. Industrial salt

8.1 Industrial salt is kept in a dry, cool and ventilated place. A damp environment will cause caking of the ingredient.

8.2 The sacks, bags or containers of industrial salt should not come in contact with the walls of the shelves to avoid dampness.

9. Baking soda

9.1 Baking soda is kept in a dry, cool and ventilated place. A damp environment will cause caking of the ingredient.

9.2 The sacks, bags or containers of baking soda should not come in contact with the walls of the shelves to avoid dampness.

10. Packaging materials

Accepted lots of packaging materials are stored on pallets in the storage warehouse.

C. Preparation of Ingredients

☐

1. Roasted peanuts

1.1 Dry blanching at 300°F (or 149°C)

a. Pre-heat Probat roaster to 200°F or 93°C.
Load 20 Kg of raw peanuts in the receiver of the roaster while roaster is pre-heated.
c. Open the receiver of the Probat roaster upon reaching 200°F (or 93°C) to allow entry of peanuts to the roaster. Increase the temperature of the peanut roaster to 300°F (or 149°C) by adjusting the flame.
d. Dry blanch peanuts for 8 minutes at 300°F (or 149°C).

1.2 Immediate cooling to 45°C

a. Allow peanuts to cool in the roaster for about 5 minutes through a continuous rotation of the paddle of the roaster and air that sucks out the heat from the product. Cooling ends if peanuts can be handled by the hands, or the temperature of peanuts is about 45°C.
b. Transfer cooled peanuts to the sorting table in stainless steel drums.

1.3 Deskinning

a. Place approximately 1 to 2 Kg of dry blanched peanuts in a native container called "bilao" or winnowing tray.
b. Deskin peanuts by manually rubbing off the peels by hands with rubber gloves against the winnowing tray.
c. Separate peanuts from the skin by a process locally called "pagtatahip" or winnowing.

1.4 Sorting out of aflatoxin contaminated peanuts

a. Place peanuts on the stainless steel table.
b. Sort out mold-contaminated and damaged peanuts from the good peanuts and place in separate containers.

1.5 Roasting at 300°F (149°C)

a. Pre-heat Probat roaster to 300°F (or 149°C).
b. Load 20 Kg of sorted blanched peanuts into the roaster.
c. Roast peanuts for 6 to 7 minutes at 300°F (or 149°C) or until a moderate to strong roasted peanutty aroma with a medium to dark brown color is obtained.

d. Cool peanuts in the roaster for about 5 minutes through a continuous rotation of the paddle of the roaster and air that sucks out the heat from the product. Cooling ends when peanuts can be handled by hands, or the temperature of peanuts is about 45°C.

1.6 Immediate cooling to 45°C

a. Allow peanuts to cool in the roaster for about 5 minutes through a continuous rotation of the paddle of the roaster and air that sucks out the heat from the product. Cooling ends if peanuts can be handled by the hands, or the temperature of peanuts is about 45°C.
b. Transfer cooled peanuts in stainless steel drums with cover.

1.7 Reducing of peanut size

a. Spread on top of a stainless steel table a black tarpauline measuring about 1m x 1m.
b. Place approximately 2 kgs of roasted peanuts on the mat.
c. Reduce size of peanuts by rolling a metal rolling pin on the peanuts until the desired size of approximately 0.2 to 0.4 cm is obtained, and place in clean plastic drums with cover.

2. Roasted sesame seeds

2.1 Roasting at medium heat

ã Place 200 grams of sesame seeds in a 12" frying pan.
b. Set fire to medium. Stir continuously to prevent over roasting.
c. Roast sesame seeds for 20 to 25 minutes or until the color turns to medium brown and has a moderate to strong roasted sesame aroma.

2.2 Immediate cooling to 45°C

a. Cool immediately by spreading sesame seeds on a tray at room temperature.
b. Set aside until intended use.

3. Softened butter

Place the butter from the refrigerator in a clean container with cover and leave at room temperature to soften before using.

4. Weighing of ingredients

4.1 Determine the required amount of ingredients based on the peanut brittle formulation shown in section 1. For a four (4) Kg mixture, the required amount of ingredients are as follows:

Ingredients used in the formulation	% of ingredient in the formulation	Amount required in grams
Glucose syrup	14.00	560.0
Refined sugar	37.00	1,480.0
Roasted peanuts	34.00	1,360.0
Water	7.50	300.0
Butter	4.00	160.0
Roasted sesame seeds	1.50	60.0
Baking soda	1.00	40.0
Industrial salt	0.35	14.0
Vanilla concentrate	0.65	26.0
TOTAL	100.00	4,000.0

4.2 Weigh the dry ingredients using a calibrated, dry, and clean weighing scale in clean and dry containers such as bowls, plastic or glass containers.

4.3 Weigh glucose syrup directly into the frying pan intended for cooking the mixture. Glucose syrup is highly viscous and weighing in a container and then transferring this to a pan may result in inaccurate weight of the ingredient.

D. Preparation of Peanut Brittle (Piñato)

1. Mixing of ingredients

1.1 Mix roasted sesame seeds and roasted peanuts in a clean, dry plastic container.
1.2 Mix glucose syrup, water and refined sugar in the pan.
1.3 Mix softened butter, vanilla concentrate and salt in a clean, dry plastic container.

2. Cooking

2.1 Place the pan with glucose syrup, sugar and water over a medium fire. Occasionally stir the mixture every about five (5) minutes.
2.2 When the temperature of the mixture reaches 165°C, reduce to low heat.
2.3 Add the mixture of butter, vanilla and salt to the mixture of sugar and glucose. Continuously mix the mixture.
2.4 Dispense half of the baking soda using a salt and pepper dispenser to the mixture and continuously mix the mixture.
2.5 Add the roasted peanuts and sesame seeds and continuously mix the mixture.
2.6 Dispense half of the remaining baking soda in the mixture. Continuously mix the mixture.
2.7 Extend the cooking time of the mixture until the desired color is attained.

3. Molding or flattening the mixture

Immediately mold and flatten the cooked peanut brittle mixture in a pre-formed plastic formica with grids with the use of a rolling pin.

4. Cooling of mixture to 85-90°C

Cool the flattened peanut brittle mixture to 85-90°C before cutting. A higher temperature will result in uneven and deformed cut pieces while a lower temperature will cause hardening of the mixture and result in breakage during cutting.

5. Cutting of mixture

Immediately cut the cooled peanut brittle mixture to desired size of 4cm x 0.5cm x 1.5cm.

6. Cooling of peanut brittle pieces at ambient condition

Separate the peanut brittle pieces after cutting, and cool to ambient temperature with the use of an electric fan to prevent sticking of the cut pieces.

7. Storing of cooled, unwrapped peanut brittle pieces

Place cooled peanut brittle pieces in polypropylene (PP) jars and seal tightly. Store at room temperature for about 18 to 24 hours prior to wrapping in cellophane. This is done because production of at least four batches of peanut brittle is done on the first day while wrapping in cellophane and packing in PP jars is done on the second day of production.

8. Packing

8.1 Individually twist wrap each piece of the cooled peanut brittle in a cellophane wrapper.
8.2 Pack approximately 50 pieces of wrapped peanut brittle or equivalent to a net weight of 270 grams in polypropylene jars.
8.3 Seal jars with screw-type lids and with the use of a transparent tape.

9. Storing of product at room temperature

Store the product at room temperature.

IV. FINISHED PRODUCT SPECIFICATIONS

A. Sensory Properties

1. Appearance/ Color : More nuts embedded in the candy
Glossy surface
Golden brown in color
Rectangular in shape with a dimension of 4cm x 0.5cm x 1.5cm (length x thickness x width)
2. Taste : Sweet taste
No bitter taste
No salty aftertaste

3. Aroma : Moderate to strong roasted peanutty aroma
Moderate to strong roasted sesame aroma
Caramel aroma
Buttery aroma
4. Texture : Brittle on the first bite and crunchy on subsequent bites

B. Chemical Specifications

Aflatoxin Content : 10 ppb (processed) (Codex Alimentarius Commission, 1994a)

C. Microbiological Specifications

Salmonella : Negative for products consumed without heating or other treatment to destroy microbes (ICMSF, 1986)

D. Packaging Specifications

1. The primary packaging material should not absorb moisture.
2. Should not have any off-odors that would adversely affect the acceptability of the product.

V. ESTIMATED COST OF INGREDIENTS FOR THE PREPARATION OF PEANUT BRITTLE

A. Cost of Ingredients per 1-Kg Mixture

Raw Material	Unit cost	Amount (grams)	Total Cost (P)
Glucose syrup	50.00/ kilo	140.0	7.000
Refined sugar	38.00/ kilo	370.0	14.060
Roasted peanuts*	132.00/ kilo	340.0	44.880
Water	0.25/ gal or 0.065/ g	75.0	4.875
Butter	48.00/ 225 grams	40.0	8.533
Roasted sesame seeds**	130.00/ kilo	15.0	1.950
Baking soda	68.00/ kilo	10.0	0.680
Vanilla concentrate	22.00/ kilo	6.5	0.143
Industrial salt	12.00/ kilo	3.5	0.042
	TOTAL	1,000.0	82.163

* Cost based on cost of shelled peanuts and cost of roasting at FDC
** Cost based on cost of sesame seeds and cost of roasting at FDC

Yield: 600 g of peanut brittle
Recovery: 60%

B. Cost of ingredients per 1 Kg of finished product

$$\frac{\text{Cost of ingredients per 1 Kg mixture of raw materials}}{\text{\% recovery}} = \frac{\text{P 82.163/ Kg}}{60\%} = \text{P 136.94/ Kg}$$

VI. REQUIREMENTS FOR CONTROL OF QUALITY OF PEANUT BRITTLE DURING PREPARATION

Table 6.19 presents the critical supervisory activities during the preparation of Monk's peanut brittle to ensure that product samples are prepared in accordance to the standardized process.

Table 6.19 Critical supervisory activities at each processing step

Processing Step	**Description of Critical Supervisory Activities**
A. Preparation of Ingredients for Peanut Brittle (Piñato)	Visually check for the following:
1. Preparation of Roasted Peanuts	
1a. Dry blanching at 300^{o}F (or 149^{o}C) 1b. Immediate cooling to 45^{o}C 1c. Deskinning 1d. Sorting out of aflatoxin infected peanuts 1e. Roasting at 300^{o}F (or 149^{o}C) 1f. Immediate cooling to 45^{o}C 1g. Reducing of peanut ***size***	● Temperature gauge of the roaster is 300^{o}F (or 149^{o}C), and during the blanching step ● Immediate cooling of dry-blanched peanuts to 45^{o} ● Cleanliness of equipment ● Proper sorting for mold infected peanuts. Sorted blanched peanuts should be free from mold infected peanuts. ● Cleanliness of equipment ● Temperature of the Probat roaster before putting sorted dry-blanched peanuts is 300^{o}F (or 149^{o}C) ● Immediate cooling of roasted peanuts to 45^{o}C ● Cleanliness of packaging material ● Proper labeling and package coding ● Cleanliness of equipment ● Cleanliness of equipment
2. Preparation of Roasted Sesame Seeds	
2a. Roasting	● *Correct weight of sesame seeds is 200 grams using a 12-inch frying pan* ● Heat setting is medium ● Roasting time is 15 to 20 minutes or when color turns to golden brown to brown ● Cleanliness of equipment
2b. Immediate cooling	● Ensure that roasted sesame seeds is immediately spread on a tray to cool at room temperature to prevent further cooking.

Table 6.18*continued* . . . .

Processing Step	**Description of Critical Supervisory Activities**
3. Softening of butter	- Cleanliness of containers
4. Weighing of ingredients	- Correct weight of ingredients - Cleanliness and proper calibration of weighing scales - Glucose syrup is weighed directly in the cooking pan - Cleanliness of bowls and plastic containers for the weighed ingredients
B. Preparation of Peanut Brittle (Piñato)	
1. Mixing of ingredients	- Cleanliness of bowls and plastic containers
2. Cooking	- Proper use of calibrated thermometer. The tip of the thermometer should not touch the frying pan. - Proper heat setting during cooking to medium heat - Correct temperature of 165 to 170°C during cooking, to attain brittleness of texture and to prevent development of a burnt aroma in the product - Proper mixing of ingredients to ensure even distribution in the mixture - Proper heat setting during cooking after reaching 170°C to low heat to attain the desired golden brown color of the mixture
3. Molding or flattening the mixture	- Cleanliness of table, tarpaulin mat , and rolling pin
4. Cooling of mixture to 85-90°C	- Correct temperature of mixture during cooling is 85-90 °C
5. Cutting of mixture	- Clean equipment - Correct temperature of mixture before cutting is 85- 90 C - Product is uniformly cut for a size of 4cm x 1.5cm x 0.5 cm (length x width x thickness)
6. Cooling of peanut brittle pieces at ambient condition	Visually check that peanut brittle is cooled at ambient condition to prevent sticking of peanut brittle pieces
7. Storing of cooled, unwrapped peanut brittle pieces	
8. Packing	- Product is twist wrapped in cellophane and then packed in polypropylene jars - Cleanliness of packaging materials
9. Storage at room temperature	- Clean and dry storage area

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CHAPTER 5

STANDARDIZATION OF PROCESS AND SHELF LIFE OF FINE PEANUT BAR FOR A SMALL COMPANY

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ABSTRACT

The standardized process of the Food Development Center (Appendix A) for fine peanut bar (a type of peanut brittle), a product adapted from Thailand referred to as “Tuub-Taab” (PCRSP, 2003), was standardized at the collaborator’s plant with the assistance of plant personnel of the collaborator using the ingredients and equipment available in the collaborator's processing plant.

The dry blanching and roasting processes were validated as they were the steps most likely to be affected by the type of equipment found in the collaborator’s plant. (a) Dry blanching of peanuts was carried out at 80°C for 4 hours to facilitate removal of the skin and sorting of aflatoxin infected nuts; (b) Roasting of peanuts was carried out at 150°C for 40 minutes for a 1.5-Kg batch using a non-rotating portable turbo oven. The roasting step was accompanied by manual mixing of the peanuts for 30 seconds every three minutes. The dry blanching and roasting steps produced the desired easily deskinned blanched peanuts and roasted peanuts with a medium to dark brown color and with a medium to strong roasted peanutty aroma, respectively.

The final process steps for fine peanut bar were the following: 1) receiving of raw materials; 2) storage of raw materials; 3) preparation of roasted sesame seeds; 4) preparation of roasted peanuts; 5) weighing; 6) spreading half of roasted sesame seeds on table; 7) mixing of water, washed sugar, glucose syrup, vegetable oil and industrial salt in a cooking pan; 8) heating the mixture with occasional stirring every about 5 minutes to 165-170°C; 9) adding in the roasted peanuts; 10) transferring and flattening the mixture in the bed of roasted sesame seeds in step number 6 above; 11) flattening the mixture again with the remaining half of the roasted sesame seeds spread on the top; 12) cutting immediately while hot to 5 cm x 2.5 cm (length x width); 13) cooling at ambient conditions; 14) packing in polypropylene bags; and 15) storage at ambient conditions. Detailed description of the ingredients and standardized process are contained in the “Manual of the Standardized Process for the Preparation of Fine Peanut Bar at the Collaborator’s Plant” (Appendix C). The manual includes product formulation, schematic diagram of the process, process description, finished product specification, estimated cost of ingredients for the preparation of fine peanut bar, and requirements for the control of quality of fine peanut bar during preparation.

The collaborator's personnel were trained on the standardized process for fine peanut bar to produce a product with a quality that was consistently in accordance with specifications established by FDC as judged by collaborator and FDC. The fine peanut bar produced from the 4 trials were consistently crunchy, golden brown in color, sweet with no bitter taste, and with moderate to strong roasted peanutty, slight to moderate roasted sesame and caramel aromas.

Fine peanut bar packed in polypropylene bag had a shelf life of 82 days at ambient conditions due to loss of crunchiness which can be attributed to the gain in moisture of the product from 0.31% at 0 day to 1.53% at 82 days of storage.

INTRODUCTION

A technology for fine peanut bar, a type of peanut brittle from Thailand referred to as "Tuub-Taab", is available to the Philippine food industry. An FDC researcher learned the processing of fine peanut bar through attendance to the US-Thailand PCRSP sponsored "International Training Program on Technology Transfer of Storage Handling, Processing, and Quality Measurement of Peanuts and Peanut Products" on September 29- October 7, 2003 in Bangkok, Thailand. The Thailand process was standardized at FDC using locally available equipment and ingredients (FDC, 2005a). It is relatively simple and can be easily adopted by small to medium-scale peanut processors. Transferring the technology for fine peanut bar will open new opportunities to peanut processors, increase income and bring a new product in the market. It is the aim of PCRSP that all developed peanut products under the project be transferred to the peanut processors. The process however needs to be standardized using the collaborator's facilities, ingredients and manpower, when transferred to interested entrepreneurs, to ensure consistent product quality. The production system, likewise, should optimize use of time and labor. One of the factors that affect the marketability of peanut-based products is shelf life. The shelf life of a food product varies among others, with the type of packaging material, raw materials and ingredients, and the conditions of processing and storage. The shelf life of fine peanut bar is essential for marketing strategies.

OBJECTIVES

The objectives of this study were to: (1) transfer the technology for processing of fine peanut bar developed in Thailand to a Philippine peanut processor, (2) to assist the processor in adoption of the technology to ensure consistent product quality, and (2) determine the shelf life of fine peanut bar.

METHODS

ESTABLISHMENT OF COLLABORATION

The collaborator for the study was identified based on the existing peanut products in the market. The collaborator agreed to the proposal to transfer the technology of fine peanut bar. Based on the Memorandum of Agreement, shown in Appendix B, the collaborator agreed to shoulder the costs of raw materials and ingredients during the standardization of the process at the collaborator's plant, transportation, samples of fine peanut bar for shelf life study, and production and sales data for assessment of project impact.

STANDARDIZATION OF PROCESS FOR A FINE PEANUT BAR

Evaluation of Equipment and Processing Operation of the Collaborator

The equipment used by the collaborator in preparing his company's traditional peanut products were evaluated by visually comparing these with what are normally used for processing peanuts and estimating if the same can continue to be used for the method to be introduced. A comparison of each piece of equipment used for equivalent purposes was made. The results are found in Table 5.2.

Validation of the Length of Time of the Dry Blanching Step

The 4-hour dry blanching step of the collaborator described in Appendix C had to be validated by the FDC researcher during the standardization of the process at the collaborator's plant as it used a stationary fabricated oven instead of a rotating oven. The ease with which skin could be removed after dry blanching was considered the test for evaluating adequacy of the dry blanching process. Peanuts were withdrawn for evaluation every 15 minutes and the ease of skin removal evaluated manually and visually. The results are shown in Table 5.3.

Validation of the Roasting Process

The collaborator's roasting process described in Appendix C had to be validated by the FDC researcher during the standardization of the process at the collaborator's plant as it used a non-rotating turbo oven. The test for evaluating the suitability of the roasting process was by sensory evaluation of the roasted peanuts. Roasted peanuts were checked for the desired medium to dark brown color, with medium to strong peanutty aroma.

The Final Process for Fine Peanut Bar

The FDC fine peanut bar process using collaborator's equipment was finalized after validation of the dry blanching and roasting steps. The final process is presented in detail in Appendix D

Number of Trials

The above process was carried out using the collaborator's equipment on 4 Kg batches of peanuts four (4) times. Trials were conducted using the available ingredients and equipment at the collaborator's plant.

Product Evaluation

Adequacy of the process was evaluated by evaluating the product after each trial. An informal sensory evaluation was conducted by FDC and the collaborator due to the unavailability of sensory panelists. Five (5) persons, which included the FDC researcher, two (2) owners and two (2) plant personnel, evaluated the product by visual evaluation of the appearance and color and tasted the product for taste, aroma and texture.

Training of Collaborator's Personnel

A hands-on training of the collaborator's personnel was conducted by the FDC researcher who attended the peanut postharvest handling and processing training in Thailand using the standardized process shown in Appendix D. The adequacy of the training of the collaborator's personnel was evaluated using the results of sensory evaluation of the fine peanut bar they processed during the training.

SHELF LIFE STUDY OF FINE PEANUT BAR

Preparation of Samples

Samples for shelf life study were prepared by the industry collaborator in the collaborator's plant under the supervision of the FDC researcher who transferred the technology. Samples for the study were prepared five (5) months after the technology adoption.

Experimental Design

The shelf life study was conducted by investigators at the FDC. The objective was to determine the actual shelf life at 30^0C of fine peanut bar packed in polypropylene bags. The initial quality of the product was checked by visual evaluation of packaging condition, chemical analysis for aflatoxin and moisture content, and sensory evaluation by descriptive analysis tests using 150 mm line scales. Samples were stored at ambient conditions of approximately 30^oC. Changes in sensory characteristics were evaluated by 30 consumers at pre-determined storage times, through a consumer acceptance tests. At the end of storage, a descriptive analysis test using 150 mm line scales was conducted.

Storage of the Product at Ambient Conditions

Fine peanut bar with a total net weight of 70 g per bag, and with a dimension of 5.0 cm x 2.5 cm (length x width) was wrapped in 15 cm x 8 cm (length x width) polypropylene (PP) bags with an average thickness of 0.014 mm. Each PP bag contained 8 pieces of the product. The packages were labeled with the product name, date samples were received, date of storage, and storage temperature, and stored at ambient temperature at approximately 30^oC in a shelf life storage room. Control samples were stored in an incubator at $0\text{-}4^o$C

Schedule of Product Testing During Storage

Samples of the product were withdrawn from storage every 15 days for a total of 6 evaluations, for 75 days; after 7 days, at 82 days; then after 1 day at 83 days of storage. Consumer acceptance tests were conducted at every sampling period. Descriptive analysis was conducted when the product was rated below 5 by the consumer panel. Moisture content was determined initially and at end of storage.

Product Test Methods Used

Packaging Condition

Presence of defects such as improper sealing, punctures of the polypropylene jars were evaluated visually (USFDA, 2001).

Sensory Evaluation Through a Consumer Test

The method used was a consumer test using a 9-point hedonic scale (Meilgaard *et al*., 1988). Thirty (30) consumers who were employees from the Food Terminal Inc. (FTI) were recruited to participate in the test. The criteria for the selection of the consumer panel were as follows: (1) had no food allergies, (2) were between the ages of 18 and 70, and (3) were consumers of peanut brittle. This information is indicated in the demographic questionnaire (Appendix D). The consumer test was conducted in an open room, the Multipurpose Hall of the Food Terminal Inc. (FTI Complex, Taguig City).

Two pieces of fine peanut bar samples, wrapped in polypropylene bags, were presented to each of the 30 panelists for evaluation of its acceptability. The samples were coded with three digit numbers and assigned randomly to each panelist. Each panelist was presented 2 samples at a time, a control sample and a sample stored at ambient conditions.

Panelists were also provided with a glass of water for rinsing their mouths before and after tasting each sample. Testing was conducted in a well-lighted air-conditioned room (25^{o}C). The panelists were provided with incentives, *i.e.* cake slices, after each session.

Panelists evaluated samples in the order designated on their ballot. They were instructed to answer five (5) questions by placing a check mark in the square corresponding to the category that best reflected their feelings about the sample on a nine-point hedonic scale.

Sensory Evaluation by Descriptive Analysis

Descriptive analysis using unstructured line scales, 150 mm was conducted when the fine peanut bar samples were rated as unacceptable by the consumer panel, or had ratings below 5 (dislike slightly). The procedure used for conducting the descriptive analysis was is similar to that used in the sensory profiling of peanut brittle (FDC, 2005b).

Panel selection. Previously trained panelists who had previously participated in sensory tests at FDC were recruited for the test. The criteria for selection of panelists were as follows: (1) willingness to participate and ability to discriminate differences in sensory properties of fine peanut bar, (2) had natural dentition, (3) no food allergies, and (4) did not smoke. .

Training. Ten panelists who passed the selection process underwent training for descriptive tests. Training of the panelists was conducted using a 150-mm unstructured line scales with anchors, 12.5 mm from each end (Meilgaard *et al*., 1993). Terminology, definitions, and evaluation techniques were developed by the panelists during training and agreed on references (Table 5.1) to be used during evaluation. The attribute's definitions were obtained from published references (Meilgaard *et al.*, 1993; ASTM, 1992). Ballots were generated by the panelists using reference samples and descriptors that represented attributes likely to be encountered in the product.

Sample evaluation. The 10 panelists evaluated the samples before and after end of shelf life (as determined through the consumer tests) at ambient conditions, approximately 30^{o}C. The samples were coded with three-digit random numbers. All references (Table 5.1), soda crackers, water, and cups for expectoration were provided. Each panelist evaluated the samples in partitioned booths in an environmentally controlled room with incandescent lights.

Table 5.1 Descriptors and definitions of attributes developed in the descriptive analysis of fine peanut bar with references and intensity ratings

Attribute	Definition	Standard Reference	Intensity of Standard Reference[a]	Intensity of Warm-up Sample[b]
1. Texture				
First bite Hardness[c]	The force required to bite through with incisors	Planter's peanuts Carrots	95 110	90
First bite Fracturability	The force with which the sample breaks	Graham crackers Corn chips Chichacorn	42 55 65	70
First chew Hardness	The force required to bite through with incisors	Planter's peanuts Carrots	90 100	80
First chew Fracturability	The force with which the sample breaks	Graham crackers Corn chips Chichacorn	35 45 60	50
2. Appearance				
Color - Off-white	The color associated with plain popcorn	Washed sugar Ludy's peanut butter	20 90	90
- brown	The color associated with powdered cocoa			
Surface shine - glossy	Not dull	Ludy's peanut butter Anchor butter	130 150	95

Table 5.1 *continued*

Attribute	Definition	Standard Reference	Intensity of Standard Reference[a]	Intensity of Warm-up Sample[b]
3. Aromatics				
Roasted peanutty [c]	The aromatic associated with medium roasted peanuts (L value = 49.3)	Planter's peanuts	70	55
Sesame aroma	The aroma associated with sesame	Raw sesame seeds Roasted sesame seeds Sesame oil	0 25 150	15
Caramel aroma	The aroma associated with caramelized sugar	2% sucrose 5% sucrose 10% sucrose 16% sucrose	20 50 100 150	100
4. Tastes				
Sweet [c]	The taste on the tongue associated with sugars	2% sucrose 5% sucrose 10% sucrose 16% sucrose	20 50 100 150	110
Salty [c]	The taste on the tongue associated with sodium chloride	0.2% NaCl solution 0.35% NaCl solution 0.5% NaCl solution	25 50 85	35
Bitter [c]	The taste on the tongue associated with caffeine	0.05% caffeine solution 0.08% caffeine solution 0.15% caffeine solution	20 50 100	5

[a] A 150 mm unstructured line scale was used. Intensity scores were agreed upon by consensus by the descriptive panel

[b] The warm up sample is the fine peanut bar samples prepared at the collaborator's plant.

[c] Meilgaard, 1993

Chemical Analyses

Aflatoxin . The thin layer chromatography method for aflatoxin content described in AOAC 970.45 (18th Edition, 2005) was followed.

Peroxide value. The titration method for peroxide content described in AOAC 965.33 (18th Edition, 2005) was followed

Moisture content of the product. The vacuum-oven method for moisture content described in AOAC 925.45 (18th Edition, 2005) was followed. A milled test portion weighing 2 grams was dried in an aluminum dish for 2 hours at $\leq$ 70°C, under pressure $\leq$ 50 mm Hg (6.7 Kpa). The dish was removed from the oven, covered with tight-fitting cover, cooled in a desiccator, and weighed. The sample was redried for 1 hour and the process repeated to constant weight, until change in weight between successive dryings at 1 h intervals was $\leq$ 2 mg.

Procedure for Establishing the End of Shelf Life

The shelf life of a food product is defined as the period at which it will retain an acceptable level of eating quality from a safety and sensory point of view (Labuza, 2002). The end of shelf life of the product was established when the average rating of by 30 consumers of 5 or less which corresponds to “dislike slightly”. Descriptive analysis was used to describe the properties of the reference and the product at end of shelf life.

RESULTS

STANDARDIZATION OF PROCESS FOR A FINE PEANUT BAR

Evaluation of Equipment and Process Used by Collaborator for Processing Peanuts, for Suitability to Fine Peanut Bar Production

Table 5.2 presents the equipment available at the collaborator's plant for the preparation of fine peanut bar. Most of the equipment were evaluated to be suitable for fine peanut bar production except for the pan-type weighing scale and the plastic rolling pin. The pan-type weighing scale may not produce a consistent product quality due to inaccurate weight measurements of ingredients below 50 grams, while the use of the plastic rolling pin to reduce peanut size is a slow process and thus could affect productivity. The roasting oven was also not the circulating type and the dry blanching tine and temperature were different. Thus the roasting process and the time and temperature of blanching had to be validated.

Validation of the Dry Blanching Step

Blanching of peanuts was validated to determine the suitability of the process to deskin peanuts easily. Results showed that blanching time and temperature used by the plant at 80°C for 4 hours was adequate to deskin peanuts easily (Table 5.3).

Table 5.2 Evaluation for suitability of equipment available at the collaborator's plant for the preparation of fine peanut bar

Equipment / processing implement	Description	Evaluation
Battery operated digital weighing scale	Has a capacity of 2 Kg with 0.01-gram graduation	Suitable for weighing small amounts of ingredients due to the 0.01g graduation
Pan-type weighing scale	Otex brand, has a capacity of 10 Kg with 50-gram graduation	Not accurate for weighing peanuts, sugar, water and other ingredients where the weight required is between 0 to 50 grams
Fabricated oven	Gas-operated stainless steel cabinet-type oven, non-rotating with 6 layers of drying trays. Maximum temperature reached is around 80°C.	Suitable for dry-blanching a 12 Kg batch of shelled peanuts at 80°C for 4 hours. A higher temperature would have made the blanching step faster. Manual mixing of peanuts every 30 minutes made it labor-intensive.
Plastic table covered with formica	Each table has a dimension of about 1m x 1.5 m (W x L) and covered with formica	Suitable for sorting of peanuts and flattenning of the fine peanut bar mixture
"Bilao" or winnowing tray	Oval-shaped mat-like implement used to contain blanched peanuts while manually deskinned. Also used to separate the peanut skin from the peanuts by winnowing	Suitable for separating deskinned blanched peanuts from the peanut skin
Plastic rolling pin	A plastic rolling pin used to reduce the size of roasted peanuts to about 0.2 to 0.6 cm.	Capable of reducing the size of roasted peanuts into the desired size, However, production output is minimal due to the slow process of manually reducing the peanut size Another plastic rolling pin was used to flatten the newly cooked fine peanut bar mixture.
Electric stove	Tecnogas (TEC-6) brand, one burner with coiled hot plate	The heat can be easily controlled with a knob
Cooking pan	Approximately 12 inches in diameter and 3 inches deep in the middle; made of cast iron	The cooking pan is deep enough to accommodate a 4-Kg mixture of peanut brittle per cooking batch

Table 5.2 *continued* . . . .

Equipment / processing implement	Description	Evaluation
Stainless steel knives	Approximately 12 inches long with sharpened edge	The knife is sharp enough to cut the peanut brittle into desired sizes
Portable impulse sealer	With heat control knob	Suitable for sealing flexible packaging materials
Portable turbo roaster	3D brand, non-rotating, with temperature control knob	Suitable for roasting 1.5 Kg blanched peanuts. However, manual mixing of peanuts during roasting required the opening of the turbo roaster thus lowering the temperature and prolonging the roasting time

Table 5.3 Effect of blanching time on ease in deskinning peanuts using a fabricated oven at 80°C

Time of blanching (in minutes)	Evaluation
0-3 hours	No peeling off of peanut skins, not acceptable
3 hours 15 minutes	Some peeling off of peanut skins when rubbed between fingers, not acceptable
3 hours 30 minutes	Some peeling off of peanut skins when rubbed between fingers, not acceptable
3 hours 45 minutes	Some peeling off of peanut skins when rubbed between fingers, not acceptable
4 hours	Peanut skins easily peeled off when rubbed between fingers, acceptable

Validation of the Roasting Step

The collaborator's existing process for roasting a 1.5 Kg batch of peanuts was validated. Results showed that roasting at 150°C for 40 minutes, accompanied by manual mixing of the peanuts for 30 seconds every 3 minutes, is adequate in producing an acceptable roasted peanuts with the following sensory characteristics: 1) uniform medium to dark brown color without burnt kernels; 2) medium to strong roasted peanutty aroma; and 3) crunchy texture.

The Final Process for Fine Peanut Bar

The final process steps as presented in Appendix D for fine peanut bar were the following: 1) receiving of raw materials; 2) storage of raw materials; 3) preparation of roasted sesame seeds; 4) preparation of roasted peanuts; 5) weighing; 6) spreading half of roasted sesame seeds on table; 7) mixing of glucose syrup, water, washed sugar, vegetable oil, and industrial salt in a cooking pan; 8) heating the mixture with occasional stirring every about 5 minutes to 165-170°C; 9) adding in the roasted peanuts; 10) transferring and flattening the mixture in the bed of roasted sesame seeds in step number 6 above; 11) flattening the mixture again with the remaining half of the roasted sesame seeds spread on the top; 12) cutting immediately while hot to 5 cm x 2.5 cm (length x width); 13) cooling at ambient conditions; 14) packing in polypropylene bags; and 15) storage at ambient conditions.

Detailed description of the ingredients and standardized process are contained in the "Manual of the Standardized Process for the Preparation of Fine Peanut Bar at the Collaborator's Plant" (Appendix C). The manual includes product formulation, schematic diagram of the process, process description, finished product specification, estimated cost of ingredients for the preparation of fine peanut bar, and requirements for the control of quality of fine peanut bar during preparation.

Product Evaluation

The fine peanut bar samples from the four (4) trials had consistent acceptable sensory characteristics. Results of sensory evaluation are as follows: 1) color/appearance: glossy surface, golden brown in color; 2) taste: sweet; 3) aroma: moderate to strong roasted peanutty, slight to moderate roasted sesame and caramel aromas; and 4) texture: crunchy.

Training of Industry Personnel on the Standardized Process

A hands-on training of the industry personnel was conducted by FDC Peanut CRSP investigators at the collaborator's plant using the standardized process from Appendix D. Detailed description of the ingredients and standardized process are contained in the "Manual of the Standardized Process for the Preparation of Fine Peanut Bar at the Collaborator's Plant" (Appendix C). The manual includes product formulation, schematic diagram of the process, process description, finished product specification, estimated cost of ingredients for the preparation of fine peanut bar, and requirements for the control of quality of fine peanut bar during preparation. A total of 5 personnel including the two owners were trained. The fine peanut bar produced had consistent acceptable quality as described above.

SHELF LIFE STUDY OF FINE PEANUT BAR

The mean ratings for acceptability of the product during storage at ambient conditions is shown in Table 5.4 and the shelf life plot in Fig. 5.1. The number of responses for ratings 6 and above, 5, and 4 and below for the acceptability of fine peanut bar during storage is shown in Table 5.5. After 82 days or 2.7 months, the mean ratings for liking for texture/crunchiness was considered "dislike slightly" with a mean rating of 4.4 by the consumer panel except for overall liking; acceptance of color, appearance and flavor which were still considered as "dislike slightly" with mean ratings of 4.5, 4.9, 4.7 and 4.8, respectively. The control samples after 82 days of storage were considered as "like very much" by the consumer panel. The shelf life plot of fine peanut bar stored at ambient conditions is shown in Fig. 5.1. The plot shows that a rating of 4.9 would be obtained after approximately 90 days of storage for texture/crunchiness, 120 days for color, 120 days for appearance, 120 days for flavor/taste, and 110 days for overall liking.

In the descriptive test, hardness and fracturability after the first bite and the first chew, were the characteristics used to measure texture. Hardness after the first bite decreased from 90 to 70 after 82 days of storage and the fracturability after the first bite also decreased from 70 to 52 (Table 5.6). Hardness after the first chew on the other hand decreased from 80 to 48, a larger decrease, and fracturability, also decreased from 50 to 42. Above results showed that the product became less brittle or became less crunchy during storage. The other sensory attributes had no significant change during storage.

The fine peanut bar packed in polypropylene bags had a shelf life of 82 days at ambient conditions. After that the product lost crunchiness which can be attributed to the gain in moisture of the product from 0.31% at 0 day to 1.53% after 82 days of storage.

Table 5.4 Mean ratings for the acceptability of fine peanut bar packed in its traditional packaging material during storage at ambient conditions

Storage temperature (°C)	Storage time (days)	Mean ratings [a]				
		Texture/ crunchiness	Overall liking	Color	Appearance	Flavor/Taste
4 (control)	0 (initial)	7.7	7.4	7.5	7.4	7.5
	15	7.7	7.4	7.5	7.4	7.5
	30	7.9	7.8	7.5	7.8	7.8
	45	7.8	7.6	7.4	7.4	7.5
	63	7.7	7.7	7.5	7.5	7.6
	75	7.7	7.9	7.7	7.8	7.9
	82	7.7	7.7	7.5	7.5	7.7
	83	7.6	7.8	7.7	7.8	7.8
28-32 (ambient)	0 (initial)	7.5	7.4	7.4	7.4	7.4
	15	7.5	7.4	7.4	7.4	7.4
	30	7.2	7.4	7.6	7.7	7.6
	45	6.5	6.7	6.7	6.7	6.6
	63	6.2	6.5	7.1	7.1	7.0
	75	6.8	6.9	7.2	7.4	7.2
	82	4.4	4.5	4.9	4.7	4.8
	83	3.8	3.9	4.8	4.2	4.0

[a] A 9-point hedonic scale was used for acceptability means scores (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely)

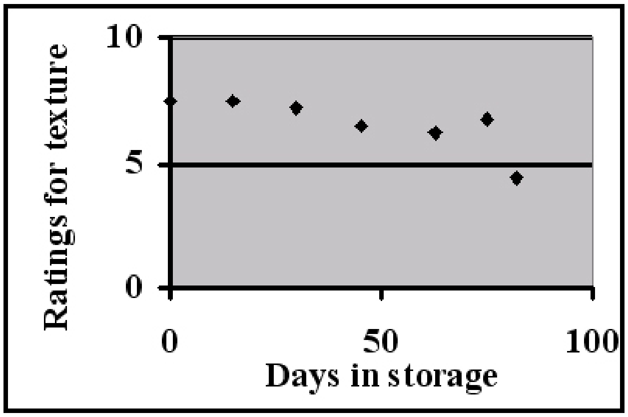
Table 5.5 Frequencies of responses for ratings 6 and above, 5, and 4 and below for the acceptability of fine peanut bar packed in its traditional packaging material during storage at ambient conditions

Storage temperature (°C)	Storage time (days)	Rating	Number of Responses				
			Texture/ crunchiness	Overall liking	Color	Appearance	Flavor/ taste
4 (control)	0 (initial)	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	15	6 and above	29	28	29	28	29
		5	0	0	0	0	0
		4 and below	1	2	1	2	1
	30	6 and above	30	30	29	29	30
		5	0	0	1	1	0
		4 and below	0	0	0	0	0
	45	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	63	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	75	6 and above	28	29	29	29	29
		5	0	0	0	0	0
		4 and below	2	1	1	1	1
	82	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	83	6 and above	29	29	30	30	29
		5	0	0	0	0	0
		4 and below	1	1	0	0	1

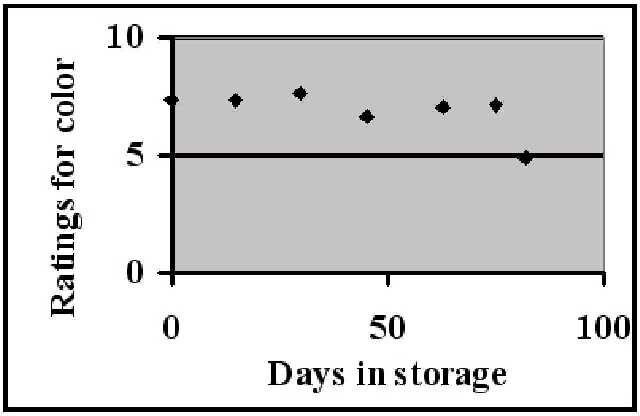
Table 5.5 *continued...*

Storage temperature (°C)	Storage time (days)	Rating	Number of Responses				
			Texture/ crunchiness	Overall liking	Color	Appearance	Flavor/ taste
28-32 (ambient)	0 (initial)	6 and above	30	30	30	30	30
		5	0	0	0	0	0
		4 and below	0	0	0	0	0
	15	6 and above	30	29	30	28	29
		5	0	0	0	1	0
		4 and below	0	1	0	1	1
	30	6 and above	29	29	29	30	30
		5	0	1	1	0	0
		4 and below	1	0	0	0	0
	45	6 and above	26	26	27	24	26
		5	0	1	2	3	0
		4 and below	4	3	1	3	4
	63	6 and above	26	27	30	30	29
		5	2	0	0	0	1
		4 and below	2	3	0	0	0
	75	6 and above	27	29	29	29	29
		5	0	0	0	0	0
		4 and below	3	1	1	1	1
	82	6 and above	12	13	16	14	14
		5	0	1	0	2	2
		4 and below	18	16	14	14	14
	83	6 and above	8	7	13	9	9
		5	0	1	0	1	0
		4 and below	22	22	17	20	21

[a] A 9-point hedonic scale was used for acceptability ratings (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely)



TEXTURE / CRUNCHINESS



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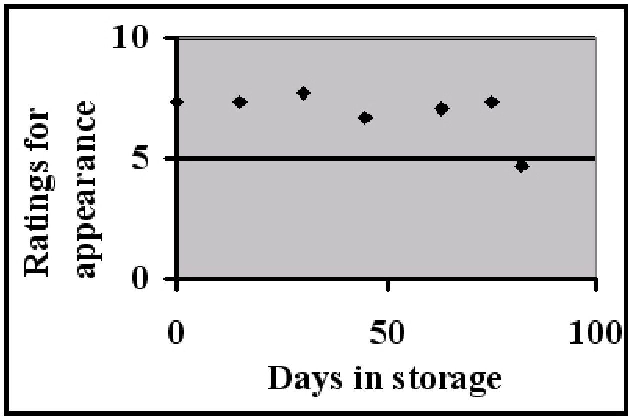
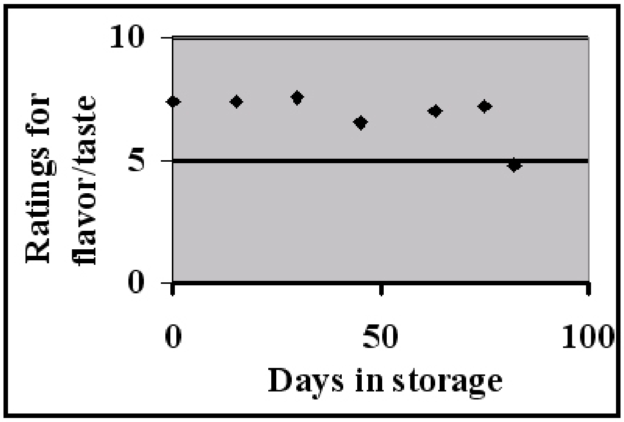
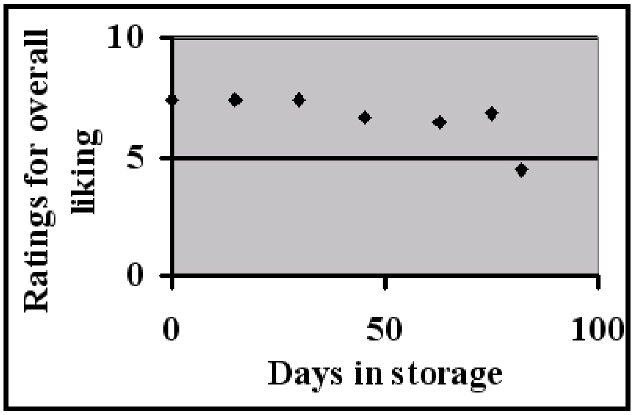


APPEARANCE



FLAVOR / TASTE



OVERALL LIKING

Fig. 5.1 Shelf life plots of fine peanut bar packed in polypropylene bags and stored at ambient conditions at approximately 30°C.

Table 5.6 Quality characteristics of fine peanut in its traditional packaging material prior to storage and at end of its shelf life at 30ºC

Parameters	**Prior to storage at 30ºC**	**At end of shelf life at 30ºC**
1. Packaging condition		
Presence of defects such as improper sealing of polypropylene (PP) bags	None	None
2. Chemical quality		
2.1 Aflatoxin content (ppb) [a]	None detected	None detected
2.2 Moisture content (g/100g)	0.31	1.53
2.3 Peroxide value (meq peroxide/Kg oil)	0.00	not done
3. Acceptability of the product [b]	Mean ratings	Mean ratings
3.1 Texture (crunchiness)	7.7	4.4
3.2 Overall acceptability	7.4	4.5
3.3 Color	7.5	4.9
3.4 Appearance	7.4	4.7
3.5 Flavor	7.5	4.8
4. Sensory characteristics of the product [c]	Mean ratings	Mean ratings
4.1 Texture		
Hardness on first bite	90	81
Fracturability on first bite	70	54
Hardness on first chew	80	71
Fracturability on first chew	50	42
4.2 Appearance		
Color	95	109
Surface shine	95	116
4.3 Aromatics		
Roasted peanutty aroma	55	54
Sesame aroma	15	13
Caramel aroma	100	102

Table 5. 6 *continued*

Parameters	**Prior to storage at 30ºC**	**At end of shelf life at 30ºC**
4.4 Tastes		
Sweet taste	100	102
Salty taste	35	32
Bitter taste	5	6

[a] Limit of Detection (LOD) = 5 ppb

[b] The sample was evaluated by 30 consumers in two replications for a total of 60 responses. A 9-point hedonic scale was used for acceptability mean ratings (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely).

[c] Means are from ratings of 8 panelists in two replications. The test was conducted using unstructured line scales with anchors 12.5 mm from each end for the attributes of (1) texture: hardness on first bite (12.5 = very soft, 137.5 = very hard); fracturability on first bite (12.5 = crumbly, 137.5 = brittle); hardness on first chew (12.5 = very soft, 137.5 = very hard); fracturability on first chew (12.5 = crumbly, 137.5 = brittle); (2) appearance: color (12.5 = off-white, 137.5 = brown) ; surface shine (12.5 = dull, 137.5 = glossy); (3) aromatics: perceptible (=12.5) and strong (= 137.5) for roasted peanutty, sesame, and caramel aroma; and (4) taste: perceptible (=12.5) and strong (=137.5) for sweet, salty and bitter tastes.

RESULTS OF TECHNOLOGY TRANSFER

The technology for fine peanut bar was adopted by the collaborator. The product was first introduced through direct selling. The product was launched in supermarkets five (5) months after technology transfer and after government permits were obtained. Technology adoption resulted in increased income of the collaborator. Impact of the technology transfer and adoption is discussed in Monograph 9.

CONCLUSIONS

The process for fine peanut bar was successfully standardized at the collaborator’s plant using the equipment and ingredients available in the processing plant. The characteristics of fine peanut bar produced were crunchy, golden brown in color, sweet with no bitter taste and with moderate to strong roasted peanutty, slight to moderate roasted sesame and caramel aromas. A total of 5 plant personnel were trained on the standardized process. The critical supervisory steps were emphasized by explaining their importance in producing a consistent good quality product.

Fine peanut bar packed in polypropylene bags had a shelf life of 82 days at ambient conditions. Shelf life can be increased by packing the product in a material with greater moisture barrier properties, such as laminated foil packs.

The technology transfer of fine peanut bar to the collaborator was successful. The collaborator's adoption of the technology resulted in increased income through the introduction of a new product in the market. Impact of the technology transfer and adoption is discussed in Monograph 9.

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APPENDIX A

STANDARDIZED PROCESS FOR THE PREPARATION OF FINE PEANUT BAR AT THE FOOD DEVELOPMENT CENTER (FDC, 2005a)

STANDARDIZED PROCESS FOR THE PREPARATION OFFINE PEANUT BAR AT THE FOOD DEVELOPMENT CENTER (FDC, 2005a)

A. Preparation of Ingredients

1. Preparation of roasted sesame seeds

1.1 Roasting at medium heat

a. Place 200 grams of sesame seeds in a 12” frying pan for use in roasting the sesame seeds.
b. Set fire to medium. Stir continuously to prevent over roasting.
c. Roast sesame seeds for 15 to 20 minutes or until the color turns to golden brown to brown.

1.2 Immediate cooling to 45^{o}C

a. Cool immediately by spreading the sesame seeds on a tray at room temperature.
b. Set aside until intended use.

2. Preparation of roasted peanuts

2.1 Dry blanching at 140^{o}C

a. Preheat peanut roaster with motorized perforated rotating drum to 140°C.
b. Add 20 Kg of peanuts at 140°C and for about 20 minutes or until the skin can be peeled off easily between fingers.

2.2 Immediate cooling to 45°C

After dry blanching, spread the peanuts on top of stainless steel working tables. Immediately cool the peanuts and mix occasionally to facilitate cooling. Blowing air through a clean electric fan or similar equipment is also advisable. The Cooling Step ends when the peanuts can be handled by the hands. The temperature of peanuts at this point is approximately 45°C.

2.3 Deskinning

Remove the skin of the peanuts taking care not to crush the peanuts. Deskinning may be done manually by hand or with the use of a peanut skin blancher from the University of Georgia, or any equipment that can remove the skin of peanuts. Use a clean electric fan to facilitate the removal of the skin from the peanut kernels.

2.4 Sorting for aflatoxin infected peanuts

a. Transfer the blanched peanuts to a well-lighted room and spread on top steel working tables.

b. Sort out mold-contaminated and damaged peanuts from the sound peanuts. Also remove skin adhering to peanuts that were not properly de-skinned to facilitate sorting of aflatoxin-contaminated kernels. The following defective peanuts should be sorted out to ensure absence of aflatoxin:

<u>*Moldy kernels*</u> kernels with mold filaments visible to the naked eye (Codex Alimentarius Commission, 1994a).

<u>*Decayed kernels*</u> or those showing visibly significant decomposition (Codex Alimentarius Commission, 1994a).

In addition, <u>*Rancid kernels*</u> should be checked by getting a few pieces of seemingly defective nuts and smelling the nut for signs of rancidity.

2.5 Roasting of peanuts

a. Roast peanuts at 140°C until the color is light to medium brown, the texture is crunchy and a roasted peanutty aroma is present.
b. Transfer the peanuts on top of stainless steel working tables and immediately cool to 45°C with the aid of clean electric fans. Mix occasionally to facilitate cooling.
c. Transfer roasted peanuts into a large container with plastic liner..
d. Store roasted peanuts until intended use.

2.6 Chopping of peanuts

Chop roasted peanuts to a size range of 0.2 to 0.4 cm. Chopping may be done manually using a sharp knife or with the use of equipment such as silent cutter. The size is established visually.

Sift chopped peanuts in a fine stainless steel wire mesh (Sieve # 18, Tsutsui, Tokyo, Japan) to remove off-sized chopped peanuts. The sifted peanuts should be less than 0.4 cm in size, otherwise the peanuts should be cut further into the desired size.

3. Weighing

3.1 Weigh the dry ingredients using a calibrated, dry, and clean weighing scale in clean and dry containers such as bowls, plastic or glass containers and spatula.

3.2 Weigh glucose syrup directly into the frying pan intended for cooking the mixture. Glucose syrup is highly viscous and weighing in a container and transferring this to a pan may glucose syrup to adhere to the container resulting in inaccurate weight.

3.3 For a 4-Kg mixture of fine peanut bar, the amount required for each ingredient is as follows (Adapted from PCRSP, 2003):

Ingredients used in the formulation	% of ingredient in the formulation	Amount required in grams
Roasted peanuts	35.0	1,400
Water	30.0	1,200
Washed sugar	28.0	1,120
Glucose syrup	4.7	188
Vegetable oil	2.0	80
Industrial salt	0.3	12
Total	**100.00**	**4,000.0**
Roasted sesame seeds		Approximately 200 g

B. Steps in the Preparation of Fine Peanut Bar

1. Spreading half of sesame seeds on table

Evenly spread half of sesame seeds on table or any clean flat surface where the cooked mixture will be flattened.

2. Mixing of water, washed sugar, glucose syrup, vegetable oil and industrial salt in a cooking pan

Mix water, washed sugar, glucose syrup, vegetable oil and industrial salt in a cooking pan.

3. Heating the mixture with occasional stirring every about 5 minutes to 165–170°C

Place the pan with glucose syrup, water, washed sugar, oil, and industrial salt over medium fire and stir the mixture every about five (5) minutes. When the temperature of the mixture reaches 165–170°C, remove from heat.

4. Adding in the roasted peanuts

4.1 Immediately add the chopped roasted peanuts. Mix thoroughly to enable uniform distribution of the peanuts.

5. Transferring and flattening the mixture in the bed of roasted sesame seeds in Step B.1 above

5.1 Immediately transfer the mixture from the cooking pan to the bed of sesame seeds in Step B.1 above. *Caution:* ***Mixture is very hot.***

5.2 Using a rolling pin, immediately flatten the hot mixture to a thickness of about 0.4 cm.

6. Flattening the mixture again with the remaining half of the sesame seeds spread on the top

Evenly spread the remaining half of the sesame seeds on the flattened mixture and flatten again to embed the sesame seeds.

7. Cutting immediately while hot to 5 cm x 2.5 cm (length x width)

Manually cut the flattened mixture into the desired size, 5 cm x 2.5 cm (length x width) while the mixture is hot, at approximately 85-90^{o}C, using a sharp knife.

8. Cooling at ambient conditions

Cool the fine peanut bar pieces at ambient condition.

9. Packing in polypropylene bags

Pack the fine peanut bar pieces in suitable packaging material.

10. Storage at ambient conditions

Store the product at ambient (room) temperature.

APPENDIX B

MEMORANDUM OF AGREEMENT WITH THE NUTCRACKER HOMEMADE PRODUCT

MEMORANDUM OF AGREEMENT

between

THE UNIVERSITY OF GEORGIA,

THE NATIONAL FOOD AUTHORITY
THRU THE FOOD DEVELOPMENT CENTER

and

THE NUTCRACKER HOMEMADE PRODUCT

concerning

"TECHNOLOGY TRANSFER OF FINE PEANUT BAR"

KNOW ALL MEN BY THESE PRESENTS:

This **Agreement** entered into and made this __________ day of ________2006 at __________________, by and between:

The **University of Georgia, Department of Food Science and Technology**, herein referred to as the "UGA", with office address at 1109 Experiment Street, Griffin Campus, Griffin, Georgia, U.S.A., represented by Dr. Anna V.A. Resurreccion;

The **National Food Authority** thru **the Food Development Center,** hereinafter referred to as the "FDC", with office address at FTI Complex, Taguig, Metro Manila, Philippines, represented herein by its Administrator, Gregorio Y. Tan, Jr. and

The **Nutcracker Homemade Product**, hereinafter referred to as the "Industry Collaborator", with plant address at Puntod, Cagayan de Oro City, Philippines, represented by its Manager, Ruben T. Uy, Jr.

WHEREAS, the University of Georgia and the Philippine Department of Agriculture have signed a Memorandum of Understanding (MOU) establishing a collaborative research relationship for the implementation of the Project entitled "Peanut Collaborative Research Support Program" or (Peanut CRSP). The project is to provide technical assistance through a collaborative research effort between the U.S. and the Philippines as the host country institution. The combined goal of this effort is to allow the host country and the U.S. to improve the well being of the farmers and consumers through the use of peanut as a crop and food.

WHEREAS, the University of Georgia and the Food Development Center of the National Food Authority have entered into a sub-agreement under the above MOU to implement a research proposal on "Development of Peanut Postharvest Handling and Processing Technologies". The goal of the proposed research is to stimulate economic growth through expansion of markets for high quality products from peanuts.

WHEREAS, the UGA and the FDC have the technology for processing fine peanut bar product referred to as "Tuub-Taab" in Thailand.

WHEREAS, the Nutcracker Homemade Product, is a company engaged in the manufacture of quality peanut products such as toasted peanuts with and without skin, salted peanuts with and without skin, sugar coated, chocolate coated peanuts and hot peanuts with and without skin.

WHEREAS, the Nutcracker Homemade Product has a distribution system in place with some of the major department stores and has independent dealers for direct selling.

WHEREAS, the Nutcracker Homemade Product, is willing to collaborate with UGA and FDC for the "Technology Transfer of the Process for Fine Peanut Bar".

WHEREAS, all the parties will cooperate with one another for the effective implementation of the aforesaid project through the provision of the following support:

University of Georgia

1. Provide funds needed for the implementation of the above-mentioned project based on the attached Plan of Work, in the amount of One Thousand One Hundred Seventy US Dollars (US$ 1,170).

FDC-Peanut CRSP Philippines

1. Establish suitability of equipment at collaborator's plant for production of fine peanut bar based on the attached plan of work.

2. Provide manpower during the standardization of the process for fine peanut bar at industry collaborator's plant.

3. Provide raw materials and ingredients during the standardization of the process of fine peanut bar at FDC.

4. Provide product support as Good Manufacturing Practices (GMP), if necessary.

5. Conduct the shelf life study and impact assessment.

6. Shoulder the air ticket of FDC personnel during the transfer of technology of fine peanut bar at the industry collaborator's plant.

The Nutcracker Homemade Product

1. Provide raw materials and ingredients during the standardization of the manufacturing process at the collaborator's plant. Cost will vary with capacity of equipment to be used in the collaborator's plant. Three (3) production runs are usually necessary to standardize the process.

2. Make available appropriate personnel, equipment and facilities during the standardization of the manufacturing process at collaborator's plant.

3. Provide needed logistical support (land transportation from hotel to collaborator's plant, accomodation and meals) of two (2) trainors during the standardization of the process of fine peanut bar at the collaborator's plant.

4. Provide sixteen (16) kilograms of fine peanut bar for the shelf life testing after manufacturing process is successfully standardized.

5. Provide data such as but not limited to production volume, product sales, marketing outlets before and after technology adoption for assessment of project impact.

6. Endeavor to market the product in 1-2 months from technology adoption.

NOW, THEREFORE, in consideration of the above premises and their mutual covenants herein setforth, the parties have agreed as follows:

1. **That** the **FDC** shall transfer the technology for processing fine peanut bar and control of aflatoxin to the industry collaborator.
2. **That** the **FDC** shall provide technical manpower support to the industry collaborator within one year from technology transfer.
3. **That** the **Industry Collaborator** shall agree to market the fine peanut bar within 1 – 2 months from technology transfer.
4. **That** the **Industry Collaborator** shall provide FDC with information such as production volume, product sales, number of marketing outlets before and after technology adoption, beneficial socio-economic changes and other parameters needed to measure impact of the technology transfer to the company.

IN WITNESS HEREOF, the parties hereunder set their hands on the date and place first above written.

UNIVERSITY OF GEORGIA

DR. ANNA V.A. RESURRECCION
Professor

FOOD DEVELOPMENT CENTER

GREGORIO Y. TAN, JR.
Administrator

THE NUTCRACKER HOMEMADE PRODUCT

RUBEN UY, JR.
Manager

SIGNED IN THE PRESENCE OF

DR. ALICIA O. LUSTRE
Director, NFA- FDC

ENGR. EDWIN B. ANDOT
President, CAFFINORMIN

APPENDIX C

PROCEDURE FOR THE COLLABORATOR'S DRY BLANCHING AND ROASTING STEPS

PROCEDURE FOR THE COLLABORATOR'S DRY BLANCHING AND ROASTING STEPS

A. Dry Blanching of Shelled Peanuts

- a. Pre-heat fabricated oven to 80°C.
- b. Evenly layer 2 Kg of peanuts in each stainless steel tray. One dry blanching batch is 12 Kg raw peanuts evenly distributed and layered in 6 trays.
- c. Dry blanch peanuts at 80°C for 4 hours. Manually mix the peanuts every 30 minutes.

B. Roasting of Sorted Blanched Peanuts

- a. Pre-heat portable turbo roaster to 150°C.
- b. Load 1.5 Kg of sorted blanched peanuts into the roaster.
- c. Roast peanuts for 40 minutes at 150°C or until a moderate to strong roasted peanutty aroma with a medium to dark brown color is obtained. Roasting time is accompanied by manually mixing the peanuts for 30 seconds every 3 minutes.
- d. Immediately transfer peanuts to a clean stainless steel tray. Allow to cool at ambient (room) temperature.

APPENDIX D

MANUAL OF THE STANDARDIZED PROCESS FOR THE PREPARATION OF FINE PEANUT BAR AT THE COLLABORATOR'S PLANT

MANUAL OF THE STANDARDIZED PROCESS FOR THE PREPARATION OF FINE PEANUT BAR AT THE COLLABORATOR'S PLANT

Prepared by:

The Food Development Center
National Food Authority
FTI Complex, Taguig City

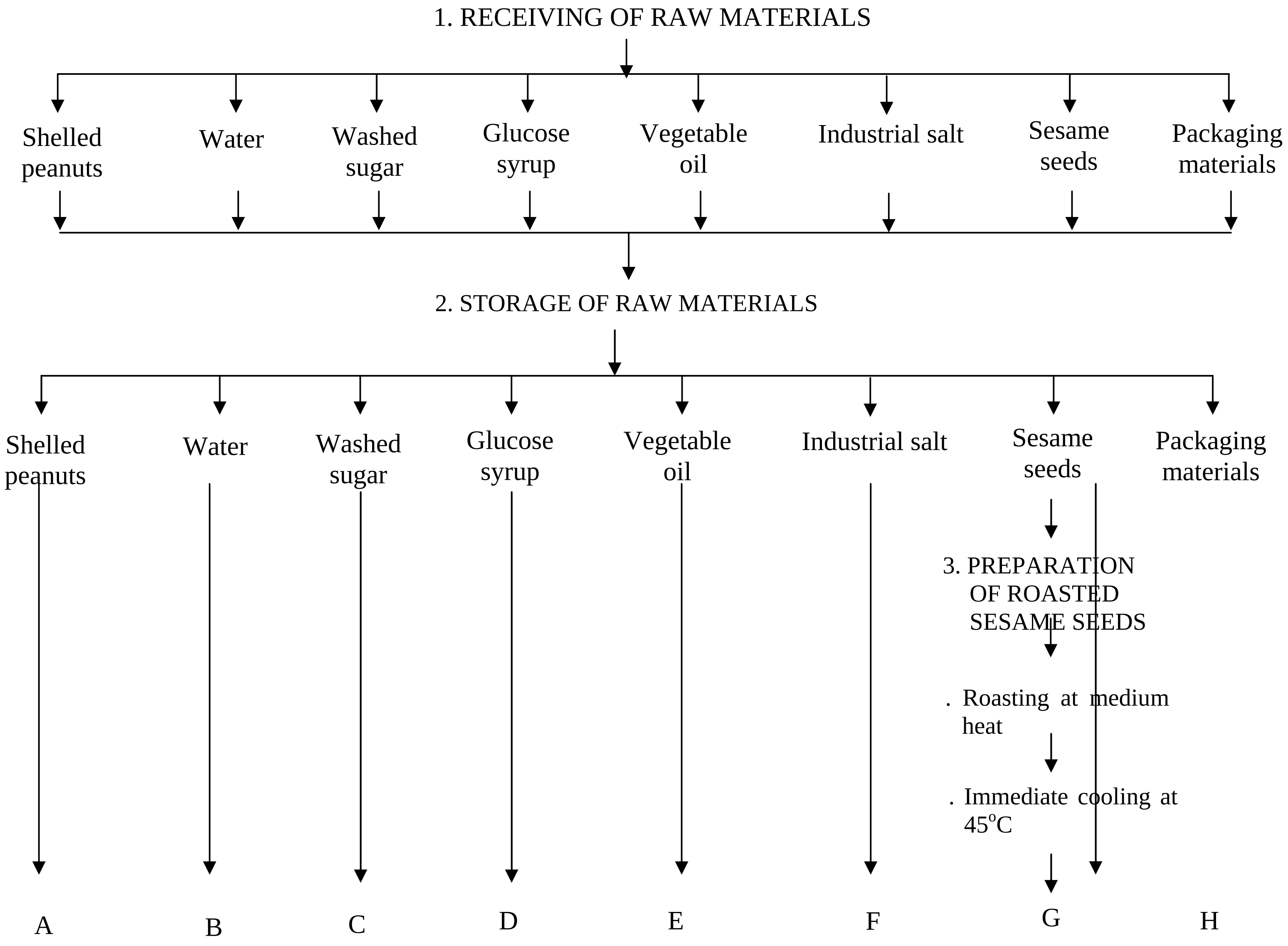
December 2006

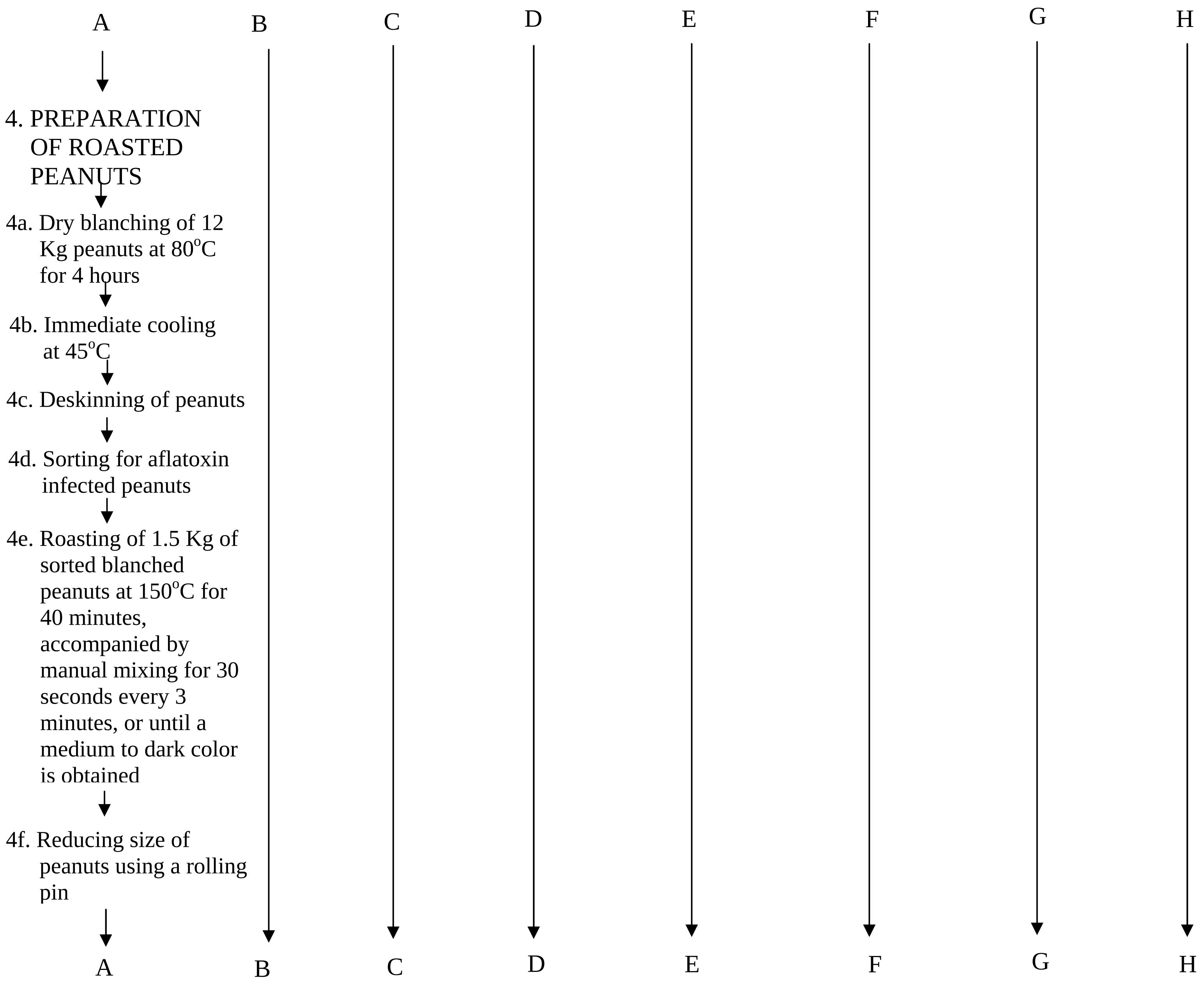
TABLE OF CONTENTS

I. FINE PEANUT BAR FORMULATION (Adapted from PCRSP, 2003a)

Ingredient		**% in Formulation**
Roasted peanuts		35
Water		30
Washed sugar		28
Glucose Syrup		4.7
Oil		2
Industrial salt		0.3
	Total	**100.00**
Roasted sesame seeds		Approximately 200g

II. FLOW DIAGRAM FOR THE PROCESSING OF FINE PEANUT BAR




A
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G
H
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4a. Dry blanching of 12 Kg peanuts at 80°C for 4 hours
4b. Immediate cooling at 45°C
4c. Deskinning of peanuts
4d. Sorting for aflatoxin infected peanuts
4e. Roasting of 1.5 Kg of sorted blanched peanuts at 150°C for 40 minutes, accompanied by manual mixing for 30 seconds every 3 minutes, or until a medium to dark color is obtained
4f. Reducing size of peanuts using a rolling pin
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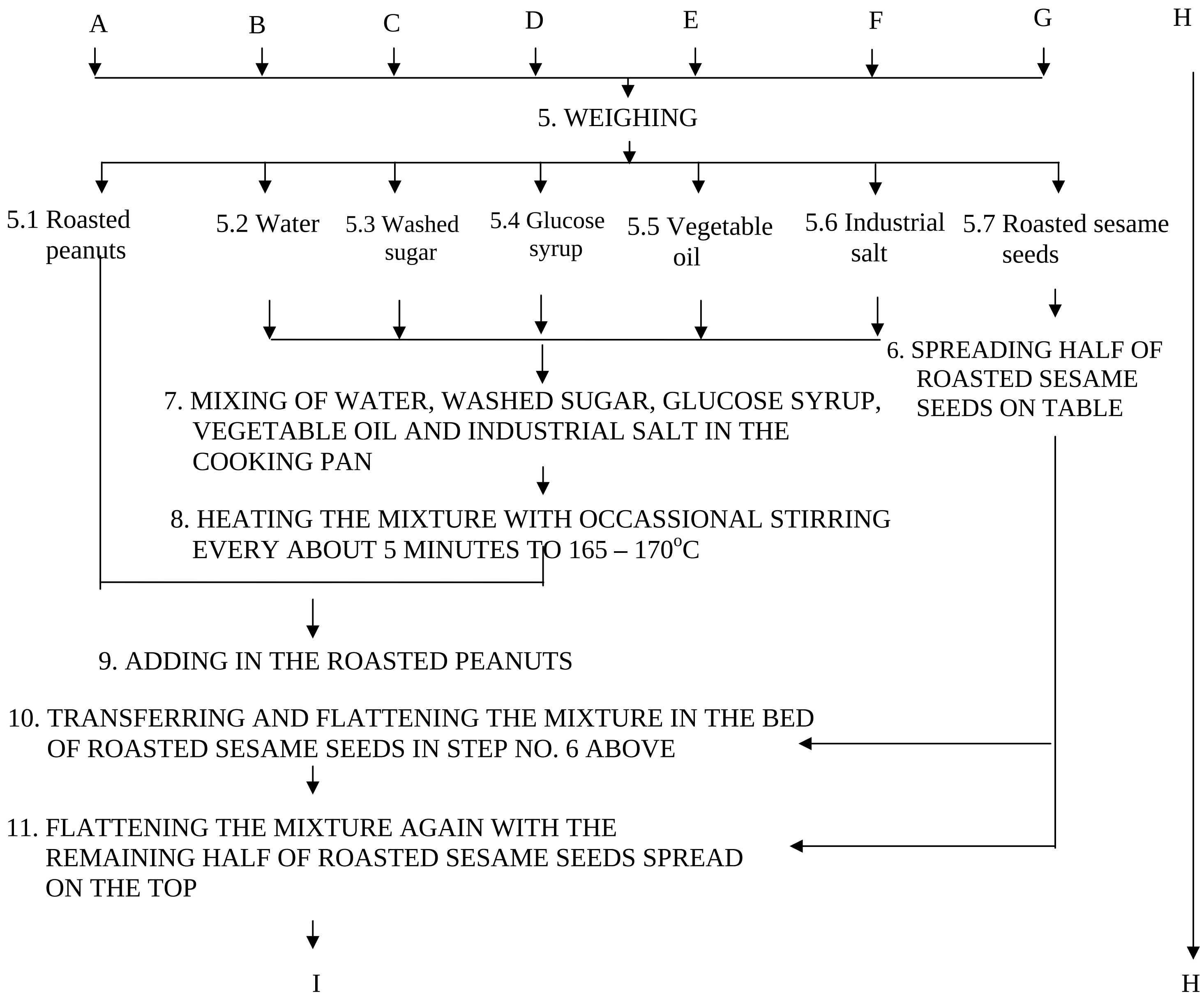
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G
H
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11. FLATTENING THE MIXTURE AGAIN WITH THE REMAINING HALF OF ROASTED SESAME SEEDS SPREAD ON THE TOP
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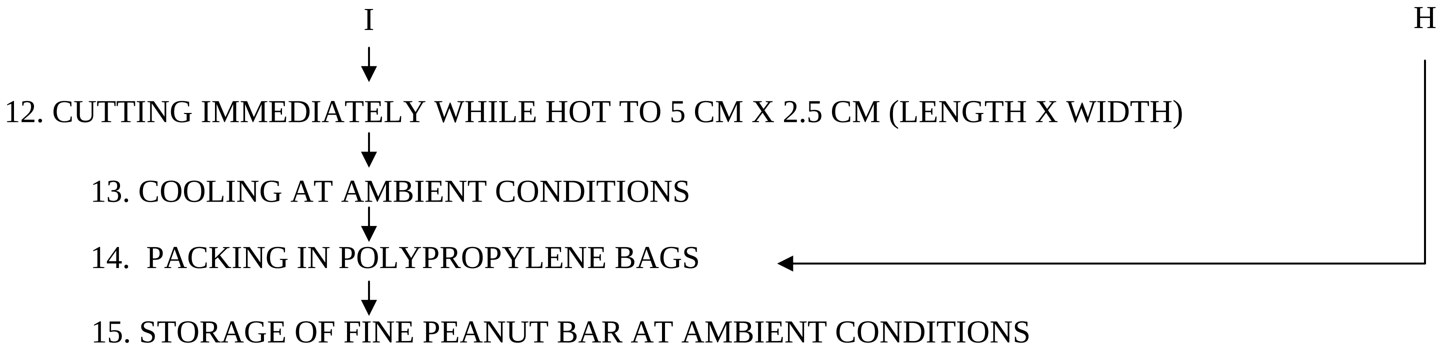

12. CUTTING IMMEDIATELY WHILE HOT TO 5 CM X 2.5 CM (LENGTH X WIDTH)

13. COOLING AT AMBIENT CONDITIONS

14. PACKING IN POLYPROPYLENE BAGS

15. STORAGE OF FINE PEANUT BAR AT AMBIENT CONDITIONS

III. PROCESS DESCRIPTION

A. Receiving of Raw Materials

Inspect raw materials and ingredients on arrival to make sure that these conform to the raw material specifications below.

Segregate defective raw materials/ingredients and record results of inspection. Only lots which pass the quality specifications should be used for processing.

1. Shelled peanuts

1.1 Raw shelled, medium sized Florunner type peanuts (*Arachis hypogaea* L.) grown locally were purchased from the suppliers of the collaborator in Cagayan de Oro City .
1.2 Free from abnormal flavours, odours, living insects and mites (Codex Alimentarius Commission, 1994a)
1.3 Maximum moisture content of 9.0% (Codex Alimentarius Commission, 1994a).
1.4 Mouldy, rancid or decayed kernels should not be more than 0.2% mass/mass (Codex Alimentarius Commission, 1994a).

Mouldy kernels kernels with mould filaments visible to the naked eye (Codex Alimentarius Commission, 1994a).

Decayed kernels or those showing visibly significant decomposition (Codex Alimentarius Commission, 1994a).

Rancid kernels seemingly defective nuts that smells rancid.

1.5 Aflatoxin content: 15 ppb maximum level (Codex Alimentarius Commission, 1994a)

2. Water

2.1 Odorless, colorless, and free from any kind of flavor and taint
2.2 Potable which conforms to the following microbiological specifications:

Aerobic Plate Count, cfu. mL	:	<100	(Marshall, 1986)
Coliforms, MPN/100ml	:	0	(World Health Organization, 1985 and Marshall, 1986)
E. coli, MPN/100 ml	:	0	(World Health Organization, 1985 and Marshall, 1986)

2.3 Free residual chlorine of not less than 0.25 to 0.5 ppm (Troller, 1983)

3. Washed sugar

3.1 Free flowing
3.2 Free from dirt, metal fragments and any foreign matter
3.3 No objectionable taste or odor in dry or in 10% sugar solution (Philippine National Standards, 1993)

4. Glucose syrup

4.1 Clear, thick and viscous liquid
4.2 Total soluble solids should not be less than 70°Bx (Codex Alimentarius Commission, 1994b)

5. Vegetable oil

1.1 Free from off-odor and off-flavor, i.e. rancid, stored
1.2 Should have a free fatty acid content of less than 0.05% (Lawson, 1985)
1.3 Clean and free from any foreign matter

6. Industrial salt

6.1 Food grade
6.2 Fine grained and free flowing
6.3 Free from dirt and any foreign material as sand, hair, insect fragments, stones, and others.

7. Sesame seeds

7.1 Free from off-odor and off-flavor, i.e. rancid, stored
7.2 Free from filth as impurities of animal origin, including dead insects

8. Packaging materials

The packaging materials shall be polypropylene bag or any flexible packaging material that is clean and free from foreign material on the surface.

B. Storage of Raw Materials

All containers of ingredients should be labeled and marked with the date of arrival so that the policy of "first in first out" can be followed.

1. Shelled peanuts

1.1 Store peanuts in clean jute sacks or kraft paper sacks in an environment with a relative humidity of 55 to 65% to prevent mould growth.
1.2 Place sacks of peanuts in pallets and should not come in contact with the walls of the storage room to avoid dampness.

2. **Water**

Water is stored in clean and fully enclosed elevated stainless steel water tanks.

3. **Washed sugar**

Washed sugar should be kept in a dry, cool and ventilated pace. A damp environment will cause caking of these ingredients.

4. **Glucose syrup**

Glucose syrup should be stored at room temperature in a properly sealed container.

5. **Vegetable Oil**

Vegetable oil should be stored at room temperature in a properly sealed container

6. **Industrial salt**

6.1 Industrial salt is kept in a dry, cool and ventilated place. A damp environment will cause caking of the ingredient.
6.2 The sacks, bags or containers of industrial salt should not come in contact with the walls of the shelves to avoid dampness.

7. **Sesame seeds**

7.1 Sesame seeds should be stored in a freezer to prevent development of off-odors and off- flavors, especially when there is a big volume of this raw material.
7.2 The sacks, bags or containers of ingredients should not come in contact with the walls of the shelves to avoid dampness.

8. **Packaging materials**

Accepted lots of packaging materials are stored on pallets in the storage warehouse.

C. Preparation of Ingredients

1. Preparation of roasted sesame seeds

1.1 Roasting at medium heat

a. Place 200 grams of sesame seeds in a 12” frying pan for use in roasting the sesame seeds.
b. Set fire to medium. Stir continuously to prevent over roasting.
c. Roast sesame seeds for 20 to 25 minutes or until the color turns to medium brown and has a moderate to strong roasted sesame aroma.

1.2 Immediate cooling to 45°C

a. Cool immediately by spreading sesame seeds on a tray at room temperature.
b. Set aside until intended use.

2. Preparation of roasted peanuts

2.1 Dry blanching of 12 Kg peanuts at 80°C for 4 hours

a. Pre-heat fabricated oven to 80°C.
b. Evenly layer 2 Kg of peanuts in each stainless steel tray. One dry blanching batch is 12 Kg raw peanuts evenly distributed and layered in 6 trays.
c. Dry blanch peanuts at 80°C for 4 hours. Manually mix the peanuts every 30 minutes.

2.2 Immediate cooling to 45°C

After dry blanching, spread the peanuts in a native container called "bilao" or winnowing tray. Immediately cool the peanuts and mix occasionally to facilitate cooling. The Cooling Step ends if the peanuts can be handled by the hands. The temperature of peanuts at this point is approximately 45°C.

2.3 Deskinning of peanuts

a. Place approximately 1 to 2 Kg of dry blanched peanuts in a native container called "bilao" or winnowing tray.
b. Deskin peanuts by manually rubbing off the peels with the fingers.
c. Separate peanuts from the skin by a process locally called "pagtatahip" or winnowing.

2.4 Sorting for aflatoxin infected peanuts

a. Transfer the de-skinned peanuts to a well-lighted room and spread in a native container called "bilao" or winnowing tray.

b. Sort out mold-contaminated and damaged peanuts from the good peanuts. Also remove skin adhering to peanuts that were not properly de-skinned to facilitate sorting of aflatoxin-contaminated kernels (PCRSP, 2003b). The following defective peanuts should be sorted out to ensure absence of aflatoxin:

Mouldy kernels kernels with mould filaments visible to the naked eye (Codex Alimentarius Commission, 1994a).

Decayed kernels or those showing visibly significant decomposition (Codex Alimentarius Commission, 1994a).

In addition, *rancid kernels* should be checked by getting a few pieces of seemingly defective nuts and smelling the nut for signs of rancidity.

2.5 Roasting of 1.5 Kg peanuts at 150^oC

a. Pre-heat portable turbo roaster to 150^oC
b. Load 1.5 Kg of sorted blanched peanuts into the roaster.
c. Roast peanuts for 40 minutes at 149^oC or until a moderate to strong roasted peanutty aroma with a medium to dark brown color is obtained. Roasting time is accompanied by manually mixing the peanuts for 30 seconds every 3 minutes.
d. Immediately transfer peanuts to a clean stainless steel tray. Allow to cool at room temperature.

2.6 Reducing size of peanuts using a rolling pin

a. Place approximately 2 Kg of roasted peanuts on the formica-covered plastic table.
b. Reduce size of peanuts by rolling a plastic rolling pin on the peanuts until the desired size of approximately 0.6 cm is obtained. Place peanuts in a plastic container with cover.
c. Sift chopped peanuts in a stainless steel wire mesh to remove off-sized peanuts. The sifted peanuts should be less than 0.6 cm in size, otherwise the peanuts should be cut further into the desired size. Use a fine stainless steel wire mesh to remove peanut fines with size of less than 0.2 cm.

3. Weighing of ingredients

3.1 Determine the required amount of ingredients based on the fine peanut bar formulation shown in section 1. For a four (4) Kg mixture, the required amount of ingredients are as follows (Adapted from PCRSP, 2003a):

Ingredients used in the formulation	% of ingredient in the formulation	Amount required in grams
Roasted peanuts	35	1,400
Water	30	1,200
Washed sugar	28	1,120
Glucose syrup	4.7	188
Vegetable oil	2	80
Roasted sesame seeds	1	40
Industrial salt	0.3	12
Total	**100.00**	**4,000.0**
Roasted sesame seeds		Approximately 200 g

3.2 Weigh the dry ingredients using a calibrated, dry, and clean weighing scale in clean and dry containers such as bowls, plastic or glass containers.

3.3 Weigh glucose syrup directly into the cooking pan intended for cooking the mixture. Glucose syrup is highly viscous and weighing in a container and then transferring this to a pan may result in inaccurate weight of the ingredient.

D. Preparation of Fine Peanut Bar

1. Spreading half of sesame seeds on table

Evenly spread half of sesame seeds on a clean table where the cooked mixture will be flattened.

2. Mixing of water, washed sugar, glucose syrup, vegetable oil, and industrial salt in a cooking pan

Mix water, washed sugar, glucose syrup, vegetable oil, and industrial salt in a cooking pan.

3. Heating the mixture with occasional stirring every about 5 minutes to 165–170°C

Place the pan with glucose syrup, water, washed sugar, oil, and industrial salt over medium fire and stir the mixture every about five (5) minutes. When the temperature of the mixture reaches 165–170°C, remove from heat.

4. Adding in the roasted peanuts

Immediately add the roasted peanuts. Mix thoroughly to enable uniform distribution of the peanuts.

5. Transferring and flattening the mixture in the bed of roasted sesame seeds in Step D.1 above

5.1 Immediately transfer the mixture from the cooking pan to the bed of sesame seeds in Step D.1 above. ***Caution: Mixture is very hot.***

5.2 Using a rolling pin, immediately flatten the hot mixture to a thickness of about 0.6 cm.

6. Flattening the mixture again with the remaining half of the sesame seeds spread on the top

Evenly spread the remaining half of the sesame seeds on the flattened mixture and flatten again to embed the sesame seeds.

7. Cutting immediately while hot to 5 cm x 2.5 cm (length x width)

Manually cut the flattened mixture into the desired size, 5 cm x 2.5 cm (length x width) while the mixture is hot, at approximately 85-90°C, using a sharp knife.

8. Cooling at ambient conditions

Cool the fine peanut bar pieces at ambient condition.

9. Packing in polypropylene bags

Pack the fine peanut bar pieces in a suitable packaging material.

10. Storage at ambient conditions

Store the product at room temperature.

IV. FINISHED PRODUCT SPECIFICATIONS

A. Sensory Properties

1. Appearance/ Color : Glossy surface
   Golden brown in color
   Rectangular in shape with a dimension of 5 cm x 2.5 cm x 0.6 cm (length x width x thickness)
2. Taste : Sweet taste
   No bitter taste
3. Aroma : Moderate to strong roasted peanutty aroma
   Moderate roasted sesame aroma
   Caramel aroma
4. Texture : Crunchy

B. Chemical Specifications

Aflatoxin Content : 10 ppb (processed) (Codex Alimentarius Commission, 1994a)

C. Microbiological Specifications

Salmonella : Negative for products consumed without heating or other treatment to destroy microbes (ICMSF, 1986)

D. Packaging Specifications

1. The packaging material should not absorb moisture.
2. Should not have any off-odors that would adversely affect the acceptability of the product.

V. ESTIMATED COST OF INGREDIENTS FOR THE PREPARATION OF FINE PEANUT BAR

A. Cost of Ingredients per 1-Kg Mixture

Raw Material	Unit cost	Amount (grams)	Total Cost (PhP)
Roasted peanuts*	130.00/ Kg	350	45.50
Water	0.25/ gal or 0.000065/g	300	0.02
Washed sugar	27.00/Kg	280	7.56
Glucose syrup	50.00/Kg	47	2.35
Vegetable oil	65.00/L	20	1.30
Roasted sesame seeds	130.00/Kg	50	6.50
Industrial salt	12.00/Kg	3	0.04
TOTAL		**1,000**	**63.27**

* Cost based on cost of shelled peanuts and cost of roasting at FDC (PhP=Philippine peso)
** Cost based on cost of sesame seeds and cost of roasting at FDC
Yield: 600 g of fine peanut bar
Recovery: 60%

B. Cost of ingredients per 1 Kg of finished product

$$\frac{\text{Cost of ingredients per 1 Kg mixture of raw materials}}{\text{\% recovery}} = \frac{\text{PhP 63.27/ Kg}}{60\%} = \text{PhP 105.45/ Kg}$$

VI. REQUIREMENTS FOR CONTROL OF QUALITY OF FINE PEANUT BAR

Table 1 presents the critical supervisory activities during the preparation of fine peanut bar to ensure that product samples are prepared in accordance to the standardized process.

Table 1. Critical supervisory activities at each processing step

Processing Step	Description of Critical Supervisory Activities
A. Preparation of Ingredients for Fine Peanut Bar	Visually check for the following:
1. Preparation of Roasted Sesame Seeds	
1a. Roasting at medium heat	Correct weight of sesame seeds is 200 grams using a 12-inch frying pan for use in roasting the sesame Heat setting is medium Roasting time is ≈15 to 20 minutes or when color turns to golden brown to brown Cleanliness of equipment
1b. Immediate cooling to 45°C	Ensure that roasted sesame seeds is immediately spread on a tray to cool at room temperature to prevent further cooking.
2. Preparation of Roasted Peanuts	
2a. Dry blanching of 12 Kg peanuts at 80°C for 4 hours	Temperature gauge of the fabricated oven is 80°C before and during the blanching step
2b. Immediate cooling to 45°C	Immediate cooling of dry-blanched peanuts to 45°C
2c. Deskinning of peanuts	Cleanliness of equipment
2d. Sorting for aflatoxin infected peanuts	Proper sorting for mold infected peanuts. Sorted blanched peanuts should be free from mold infected peanuts. Cleanliness of equipment
2e. Roasting at 150°C	Temperature of the portable turbo roaster before putting sorted dry-blanched peanuts is 150°C

Table 1 *continued . . .*

Processing Step	Description of Critical Supervisory Activities
2f. Immediate cooling to 45^{o}C	Immediate cooling of roasted peanuts to 45^{o}C Cleanliness of packaging material Proper labeling and package coding Cleanliness of equipment
2g. Reducing size of peanuts using a rolling pin	Cleanliness of equipment
C. Weighing	Correct weight of ingredients Cleanliness and proper calibration of weighing scales Glucose syrup is weighed directly in the cooking pan Cleanliness of bowls and plastic containers for the weighed ingredients
B. Preparation of Fine Peanut Bar	
1. Spreading half of sesame seeds on table	Cleanliness of table where the cooked mixture will be flattened
2. Mixing of water, washed sugar, glucose syrup vegetable oil and industrial salt in a cooking pan	All required ingredients such as washed sugar, glucose syrup, vegetable oil, iodized salt and water are mixed in the cooking pan to be used in heating the mixture. Cleanliness of cooking implements such cooking pan and ladle
3. Heating the mixture with occasional stirring every about 5 minutes to 165-170^{o}C	Proper use of calibrated thermometer. The tip of the thermometer should not touch the cooking pan. Proper heat setting during heating is medium heat Correct temperature of 165 to 170^{o}C during heating, to attain brittleness of texture and to prevent development of a burnt aroma in the product Proper mixing of ingredients to ensure even distribution in the mixture
4. Adding in the roasted peanuts	Thorough mixing for even distribution of roasted peanuts.
5. Transferring and flattening the mixture in the bed of roasted sesame seeds in B.1 above	Even distribution of sesame seeds Cleanliness of table and rolling pin
6. Flattening the mixture again with the remaining half of the roasted sesame seeds spread on the top	Even distribution of sesame seeds Cleanliness of rolling pin

Table 1 *continued . . .*

Processing Step	Description of Critical Supervisory Activities
7. Cutting immediately while hot to 5 cm x 2.5 cm (length x width)	Clean equipment Correct temperature of mixture before cutting is 85- 90°C Product is uniformly cut for a size of 5cm x 2.5cm (length x width)
8. Cooling at ambient conditions	Visually check that fine peanut bar is cooled at ambient condition to prevent sticking of fine peanut bar pieces
9. Packing in polypropylene bags	Product is packed at 8 pieces per bag Cleanliness of packaging materials
10. Storing of at ambient conditions	Clean and dry storage area

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APPENDIX E

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE CONSUMER TEST OF FINE PEANUT BAR

DEMOGRAPHIC QUESTIONNAIRE FOR PARTICIPANTS TO THE CONSUMER TEST OF FINE PEANUT BAR

Panelist # ________

NAME: ____

OFFICE ADDESS: _____________________________________ TEL.NUMBER: ___________

POSITION/ OCCUPATION: ______________________________

GENDER: ____ Male _____ Female

AGE: _______ CIVIL STATUS: _____ Single _____ Married

DO YOU HAVE FOOD ALLERGIES? _____ Yes _____ No

DO YOU EAT PEANUT BRITTLE? _____ Yes _____ No

IF YES, HOW OFTEN?

_____ Rarely	______ Three times a month
_____ Less than once a month	______ Once a week
_____ Once a month	______ 2-3 times a week
_____ Twice a month	______ Daily

Thank you very much!

APPENDIX F

BALLOT FOR THE CONSUMER TEST
OF FINE PEANUT BAR

BALLOT FOR THE CONSUMER TEST OF FINE PEANUT BAR

CENTRAL LOCATION TEST: February 1, 2005

Panelist # __________

Sample # _________

Instruction: Please answer the following questions by putting a check mark in the square that best reflects your feelings about this sample.
Please bite half of the sample and answer the first 2 questions; then look at the sample and answer questions 3 and 4; lastly, eat the rest of the sample and answer question 5.

1. OVERALL, how would you rate this 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 would you rate the COLOR of this 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 would you rate the APPEARANCE of this 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 would you rate the FLAVOR/TASTE of this 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 would you rate the TEXTURE/ CRUNCHINESS 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
☐	☐	☐	☐	☐	☐	☐	☐	☐

Thank you !

APPENDIX G

BALLOT FOR THE DESCRIPTIVE TEST OF FINE PEANUT BAR

NAME:_______________________ CODE:______________
Date:__________________________

Ballot for Fine Peanut Bar

Please put a vertical mark through the line scale to indicate the amount of each attribute (the scale is from 0 to150mm)

Texture

First Bite

0 150
|____

Definition:
First Bite: Bite through a pre-determined size of sample with incisors
Hardness- the force to bite through the incisors
Reference/ Intensity Rating- Planter's Peanut= 95; Carrots= 110; Warm-up= 90

0 150
|____

Definition:
First Bite: Bite through a pre-determined size of sample with incisors
Fracturability- the force with which the sample breaks
Reference/ Intensity Rating- Graham crackers= 42; Corn chips= 55; Chichacorn= 65; Warm-up= 70

First Chew

0 150
|____

Definition:
First Chew: Bite through a pre-determined size of sample with molars
Hardness- the force with which the sample breaks
Reference/ Intensity Rating- Planter's Peanut= 90; Carrots= 100; Warm-up= 80

0 150
|____

First Chew: Bite through a pre-determined size of sample with molars
Fracturability- the force with which the sample breaks
Reference/ Intensity Rating- Graham crackers= 35; Corn chips= 45; Chichacorn= 60; Warm-up= 50

Appearance

Color

0 150
|____
Off-white Brown

Definition:
Off-white- the color associated with plain popcorn
Brown- the color associated with powdered cocoa
Reference/ Intensity Rating: Washed sugar= 20; Ludy's Peanut Butter= 90; Warm up= 95

Surface Shine

0 150

|____

Definition:

Glossy- not dull

Reference/ Intensity Rating:; Ludy’s Peanut Butter = 130; Anchor butter =150; Warm-up= 95

Aromatics

Roasted Peanutty

0 150

|____

Definition:

Roasted Peanutty aroma- the aroma associated with medium roasted peanuts

Reference/ Intensity Rating- Raw Peanut- 0; Planter's Peanut = 70; Warm-up = 55

Sesame Aroma

0 150

|____

Definition:

Sesame Aroma- the aroma associated with sesame

Reference/ Intensity Rating- Raw Sesame= 0; Roasted Sesame Seeds= 25; Sesame oil= 150; Warm-up=15

Caramel aroma

0 150

|____

Definition:

Caramel-like aroma – the aroma associated with caramelized sugar

Reference/Intensity Rating: 2% sucrose solution = 20; 5% sucrose solution = 50; 10% sucrose solution = 100; 16% sucrose solution = 150; Warm up= 100

Tastes

Sweet

0 150

|____

Definition:

Sweet taste – the taste stimulated by sucrose

References/Intensity Rating: 2% sucrose solution= 20; 5% sucrose solution = 50; 10% sucrose solution = 100; 16% sucrose solution = 150; Warm-up = 100

Salty

0 150

|____

Definition:

Salty taste – the taste stimulated by sodium chloride

Reference/Intensity Rating: 0.2% sodium chloride solution = 25; 0.35% sodium chloride solution = 50; 0.5% sodium chloride solution = 85; Warm-up= 35

Biitter

0 150

|____

Definition:

Bitter taste- the taste stimulated by caffeine

Reference/ Intensity Rating; 0.05% caffeine solution= 20; 0.08% caffeine solution= 50; 0.15% caffeine solution= 100; Warm- up= 5

THANK YOU!

NOTE ON CONSUMER-BASED OPTIMIZATION OF PEANUT COOKIES

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ABSTRACT

Peanut cookies, a specialty of Tagbilaran, Bohol, Philippines has become very popular as a take-out product for visitors to the area. However, inconsistencies in color and other sensory characteristics need to be minimized in order to produce a better product. A study was conducted in order to optimize the baking temperature and time at 290^0C, 300°C, 310^0C, and 45, 60 and 75 min, respectively, employing response surface methodology. The baking temperature and time experiment was conducted at the plant at Tagbilaran, Bohol, Philippines but the analyses were performed at the Leyte State University, formerly Visayas State College of Agriculture, Baybay, Leyte and Food Development Center, Taguig City, Philippines.

Standard sampling, presentation of samples, and sensory evaluation procedures were followed. Results showed significant differences in terms of form, flavor, and overall acceptability as influenced by temperature and time of baking peanut cookies. The optimum zone included the company's existing baking process combination but also included both lower temperature and shorter time of baking which could reduce production time and cost of peanut cookies. Form (as cookies) of the product seemed to be one of the limiting factors in the optimization procedure. This can be explained by the manual molding process as one of the aspects that needs improvement for consistency. The management is willing to invest on a molding equipment.

Furthermore, a better quality product with no or minimum holes at its bottom was observed with products produced from combinations of baking temperature and time located at the optimum region. The appearance of the bottom of the product has also been used by the company as a quality index. This could reduce rejects during finished product inspection.

INTRODUCTION

Peanut (*Arachis hypogea*) is an important crop in the Philippines as a source of snack and dessert preparations and a supplement for low protein diets. At 25% protein and 45% oil, peanuts promote an inexpensive, high protein, high energy food for human and livestock. It is one of the most nutritious crops available as a compliment to cereal grains (P-CRSP, 1994). It has also more plant protein than any other nut. In addition to containing good unsaturated fat, peanuts provide fiber, as well as vitamin E, folate, potassium, magnesium, and zinc. Peanuts also contain bioactive components.

Peanut is already a naturally compounded food, ready to be eaten with minimum preparation, by simple roasting and grinding process (Rhee, 1985). Peanuts can be eaten as a snack, usually roasted and salted, either in the shell or without the shell. Peanuts are incorporated in candy bars, peanut brittle, and in baked goods (NSE, 1990). Based on the survey conducted by Garcia *et al*. (1990), peanuts were popularly consumed as fried, boiled, peanut butter, or roasted.

There are a number of peanut processors within the Visayas area. However, majority belong to micro- to small scale industry. As such, the major problems identified are lower and inconsistent quality. The processors recognize these problems but they are either technically or financially incapable in maintaining and/or improving the quality of their products.

Peanut cookies are small symmetrical-shaped peanut cookies patterned after the popular imported chocolate cookies. The product is considered as healthy snack item rich in protein with no cholesterol content. Its basic ingredients consist of roasted partially ground peanuts, egg white, sugar, vanilla, and shortening. It has become a very popular delicacy with a shelf-life of about six months.

Baking is one of the critical factors in the processing of peanut cookies especially so that the company has three different kinds of ovens namely, rotary, electric, and gas-fed oven. If the rotary ovens are used, the baking process is simplified. Since the pans rotate inside the oven; thus heat is evenly distributed throughout the baking process.

OBJECTIVES

This study was conducted to optimize the baking process in the production of peanut cookies. Specifically, the study was conducted to: 1) identify peanut and peanut-flavored products among company collaborators; 2) determine aspects of improvement or standardization; 3) determine the effect of varying the temperature and time of baking on the quality of Bohol peanut cookies; 4) evaluate the consumer acceptability of the different treatments; and 5) optimize the baking process of peanut cookies.

METHODS

Identification of Collaborators and Their Corresponding Peanut Product

Potential products and collaborators in the Visayas and Mindanao were identified through the Department of Trade and Industry's listings, through food product labels in supermarket displays, and other selected sources of information. Different products identified and selected were peanut cookies of a peanut company of Bohol, Philippines as the product and collaborator, respectively.

Experimental Design

The experiment was set-up in a 3 x 3 factorial with three temperatures (290^{0}F, 300^{0}F, and 310^{0}F) at 45, 60, 75 minutes (Table 1). The resulting products or samples were presented to a group of consumers consisting of Leyte State University (formerly ViSCA) staff and students in the incomplete block design (IBD) of Cochran and Cox (1957). The set plan was t=9 and k=5, r = 10 b = 18, λ= 5, E = 90,where t refers to the number of treatments, k the no. of samples presented to panelists, r the number of replications based on the plan IBD, b the number of blocks and E the efficiency factor. The data were subjected to analysis of variance (ANOVA) and regression analysis with time-temperature as the independent variables and consumer acceptance for the sensory properties such as color, form, texture, flavor, and presence of off-flavor and general acceptability as the dependent variables.

Table 1. Treatments used in the optimization of baking temperature and time in the processing of peanut cookies

Treatment Number	Temperature of Baking (^{o}F)	Time of Baking (min)
1	290	45
2	290	60
3	290	75
4	300	45
5	300	60
6	300	75
7	310	45
8	310	60
9	310	75

Product Processing

The experiment on peanut kisses was set-up at the collaborator's plant at Tagbilaran, Bohol, Philippines. The master baker was greatly involved in sample preparation of various time and temperature treatments. The samples were packed and sent to ViSCA where sensory and other analyses were conducted.

Sensory Evaluation

Sensory evaluation employing a consumer panel composed of staff and students of ViSCA was the main analysis used to evaluate the developed and standardized products, Standard sensory evaluation procedures were used.

Statistical Analyses

The data were subjected to analysis of variance (ANOVA) and regression analysis with time-temperature as the independent variable and consumer acceptance for the sensory properties such as color, form, texture, and flavor, presence of off-flavor and general acceptability as the dependent variables.

RESULTS

Consumer Acceptance

Combination of low temperature and short time or high temperature and long time of baking resulted in peanut cookies with decreased acceptance scores especially for form or shape, texture, flavor and presence of off-flavor (Table 2).

Table 2. Mean consumer acceptance scores of peanut cookies baked at different temperatures and time

Temp. (^oF)	Time (min)	Sensory Ratings					
		Color	Form	Texture	Flavor	Off-flavor	Overall Acceptance
290	45	7.1a	6.8 a	7.0 a	3.4a	3.4a	6.6 bc
290	60	7.2a	6.3 ab	7.1 a	3.7a	3.7a	7.2 a
290	75	6.9a	6.1 b	6.8 a	3.5a	3.5a	6.8 ab
300	45	6.6a	6.3 ab	7.1 a	3.8a	3.8a	6.9 ab
300	60	6.9a	6.8 ab	7.2 a	3.6a	3.6a	7.0 ab
300	75	6.9a	7.0 a	7.2 a	3.8a	3.8a	7.0 ab
310	45	7.0a	6.8 ab	6.8 a	3.7a	3.7a	6.6 bc
310	60	7.1a	6.8 ab	6.8 a	3.6a	3.6a	7.0 ab
310	75	6.4a	6.3 ab	6.0 b	3.3a	3.3a	6.1 c

Means followed by the same letter are not significantly different from each other at 5% level of significance.

Overall acceptability

All peanut kisses formulations were acceptable (≥ 6.0) baked at 290°F for 60 minutes got significantly the highest consumer overall acceptability rating while products baked at 310°F for 75 minutes, the lowest.

Color

No significant difference was observed on color. This implies that the products produced in the rotary oven had almost similar color. A few inconsistencies in color observed on the products sold at the market may be attributed to the non-segregation of products baked from the different ovens rather than the temperature-time effect.

Form/Shape

Peanut cookies baked at 290°F for 45 minutes and 300°F for 75 minutes got significantly the highest acceptability for form or shape. These were not significantly different from other treatments except for products baked at 290°F for 75 minutes. Non-uniformity of form or shape of products within treatment and among treatments was observed. This must be due again to manual molding that produced different shaped-products especially since several workers were involved in the processing of the product.

Texture

There were also no significant differences observed on texture acceptability scores. The inconsistency in texture visually observed might be due to different types of oven used. Alkuino *et al.* (1998) noted that the products produced from the electric oven that were baked twice accounted for the difference in texture characteristics from among products produced from the other ovens.

Flavor

All treatments received low flavor acceptability ratings. None of the samples were rated acceptable in flavor.

Optimization and Modeling

The values of the nine (9) treatments were first plotted manually in a linear graph and then used as a guide in drawing the contour plots using Microsoft Excel (Version '95). The optimum temperature and baking time combination were determined with $\geq$6.5 or between like slightly and moderately as the minimum acceptable level.

Attaining the Optimum

Consumer acceptance scores for form or shape was the limiting factor during the optimization procedure. All baking temperature and time combinations resulted in products with over-all acceptance scores of $\geq$6.5. All combinations of baking temperatures of 295-310°C and baking time of 51-75 minutes resulted in a product with consumer acceptability scores of $\geq$ 6.50.

Verification of the Optimum Zone

Verification experiments were conducted in duplicates using three selected treatments, one within- and one outside- the optimum zone. Twenty-four (24) panelists were randomLy selected from the 42 who participated during the earlier sensory evaluation. Standard sensory evaluation procedures were followed. A paired-test (Berenson *et. al*. 1988) was performed to determine if the observed were different from the predicted values.

Verification trials revealed the predictive ability of all models developed. Comparisons between observed and predicted values for attributes of the treatment tested are presented in Table 3. The t-test resulted in non-significant t-values between the tabulated (predicted) values and calculated (observed) values at 5% level of significance.

Table 3. Predicted and observed values for the verification experiment of peanut cookies

Attributes	X_1			X_2			X_3		
	Predicted	Observed	t-values	Predicted	Observed	t-values	Predicted	Observed	t-values
Color	7.2	7.1	0.00ns	6.9	7.1	0.74ns	6.9	6.9	0.50ns
Form	6.3	6.9	1.35ns	6.8	6.7	1.27ns	7.0	6.6	2.13ns
Texture	7.9	7.0	0.71ns	6.8	7.1	0.96ns	6.8	6.9	0.48ns
Flavor	7.1	7.0	0.51ns	7.2	7.1	0.55ns	7.2	6.9	0.53ns
Off-flavor	3.7	3.9	0.27ns	3.6	3.8	1.32ns	3.8	3.9	0.00ns
Overall	7.2	7.3	0.29ns	7.0	7.2	0.60ns	7.0	6.9	0.67ns

X_1 = 290 F for 45 minutes; X_2 = 300 F for 60 minutes; X_3 = 300 F for 75 minutes.
ns = not significant at 5% level.
t- table valua = 1.67.

Quality Evaluation of the Product's Bottom Portion

Earlier discussions with the company confirmed that "porosity" of the bottom of peanut cookies as index for acceptance and rejection of the products. Ranking preference test done on the nine treatments employed during the optimization studies revealed the effects of the different temperature and time combination of baking. Product baked at 300°F for 60 min (Treatment No. 5) resulted in peanut cookies with preferred porosity of the bottom side of the product (Table 4). This might have a relationship with texture and breakage of the product with fine and few holes as the most preferred bottom of the product since products with these qualities do not easily break. Preference results may be associated with appearance of bottom of the product.

Table 4. Product's rank by consumers based on appearance of the bottom side of peanut cookies

Treatment Number	Temperature of Baking (°F)	Time of Baking (min)	Product's Rank
1	290	45	7.2
2	290	60	7.2
3	290	75	7.2
4	300	45	2
5	300	60	1
6	300	75	2
7	310	45	2
8	310	60	7.2
9	310	75	7.2

CONCLUSIONS

Results showed significant differences in terms of form, flavor, and overall acceptability as influenced by baking temperature and time of baking peanut cookies. The optimum zone included the company’s existing baking process combination and both the lower teperature and shorter time of baking which could reduce production time and cost. Furthermore, a corresponding product quality enhancement especially at the bottom of the cookies was observed that was used as a quality index by the company if an optimized process would be followed during baking.

Form (as cookies) of the product seemed to be the limiting factor in the optimization procedure. This can be explained by the manual molding practices as one of the aspects that need improvement for consistency. The management is willing to invest on a molding equipment.

Temperature and time combinations could influence the quality and acceptability of peanut cookies. Furthermore, different ovens especially if different fuel sources are used will produce inconsistent product quality. So, similar ovens should be used or else segregation of the finished products for a better product quality and presentation should be done.

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APPENDIX A

PROPOSAL OF RESEARCH COLLABORATION

PROPOSAL OF RESEARCH COLLABORATION.

Project No. 3.2.1.

Title: Formulation Modification of Bohol Peanut Cookies

Participant Name: L. S. Palomar, G. B. Fementira and A. O. Lustre

Justification for Modification:

The original proposal with the peanut industry collaborator is now the concentration instead of Jojie's and Bautista since the latter's peanut product they are interested to improve is Cai-cai which is only a peanut coated product**.** The company is the main peanut kisses producer and is now interested to collaborate to expand their product markets outside the Philippines to include Germany. Their R & D person is a UP-Diliman Food Science graduate and is also very interested not only on this problem but also on shelf-life and aflatoxin content reduction.

Executive Summary:

Peanut Cookies is a delicacy of Bohol, Philippines and has been in existence for more than twenty years. Results showed that problem of quality is not related to the formulation but to equipment and processing conditions. Inconsistency in color has been traced to the differences in performance of the three ovens used for baking. An experiment at the plant has already been planned to optimize the baking process.

Objective:

To modify formulation and process of peanut cookies.

Terms of Reference:

Anticipated Result	Enhanced quality of Bohol
Achievement Measure Achievement Target	Peanut Cookies and increased volume of production.
Activities Undertaken:	Estimated fraction of total P-CRSP Effort: 30%

The following activities were conducted:

Held discussions with staff of ATI, Tagbilaran, Bohol regarding possible collaboration to coordinate activities with the compay since ViSCA is far from Bohol.

1. Held discussions with manager/ R & D staff chief regarding problems and need for technical assistance and specific mechanisms.

2. Observations and analyses of the process at the plant.

3. Sensory evaluation of products at ViSCA.

Achievement:

Research	The above findings will lead to the development of baking processes for producing better quality (texture and color) of peanut cookies
Publication	Not applicable
Training	The staff/personnel in charge of baking will be trained to control temperature and time of baking

Describe how the activities results and modification have affected the Terms of Reference:

Anticipated Results	Not Applicable
Achievement Measure	Not applicable

APPENDIX B

SET PLAN OF INCOMPLETE BLOCK DESIGN

SET PLAN OF INCOMPLETE BLOCK DESIGN

(Cochran and Cox, 1957)

Block	Replication				
	I	II	III	IV	V
1	1	2	3	7	8
2	2	6	8	4	1
3	3	8	5	9	2
4	4	3	9	2	6
5	5	1	7	3	4
6	6	4	2	5	7
7	7	9	1	6	3
8	8	5	4	1	9
9	9	7	6	8	5
10	1	2	3	5	9
11	2	6	5	1	8
12	3	5	1	4	6
13	4	3	2	8	7
14	5	7	9	2	4
15	6	8	7	3	5
16	7	4	8	9	1
17	8	9	4	6	3
18	9	1	6	7	2

Type 5. t=9, k=5, r=10, b=18, λ =5, E = 90.

APPENDIX C

BALLOT USED IN THE CONSUMER ACCEPTANCE TEST

BALLOT USED IN THE CONSUMER ACCEPTANCE TEST

Consumer Acceptance Test

Peanut Cookies

Name: ____________________________
Age:________________
Judge No. ___________
Date:_______________

Please **TASTE SAMPLE NO**. ________ and place an **x** on the space provided for that best reflects your feeling about the sample.

1. **Overall, how do you rate 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 color 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 aroma 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 texture 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 taste (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
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

6. **How do you rate the flavor (combination of taste & aroma) 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
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

APPENDIX D

TASTING TECHNIQUE

TASTING TECHNIQUE

REMINDER: Please remember do not swallow the samples. Although the samples are safe to eat, having a full stomach can negatively impact the results of sensory tests.

Tasting Sample

A sample cup with a code number is provided.

1. Open the sample cup and using three small bunny sniffs, describe the aroma of the sample on the worksheet provided.
2. Describe the appearance of the sample on the worksheet provided.
3. Using the same sample, take a small piece and place it in your mouth. Bite down and chew slowly. Make sure that it comes in contact with all surfaces of the tongue. Describe the flavor and texture of the sample. Use specific terms.
4. Expectorate sample into spit cups.
5. Rinse mouths with water and then expectorate.
6. Repeat the sample steps for the other samples.

NOTE ON CONSUMER-BASED OPTIMIZATION AND SENSORY PROFILING OF PEANUT BRITTLE IN THE VISAYAS

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ABSTRACT

Peanut brittle was prepared following the indigenous recipe and process of the village processors at Buray, Paranas, Samar, Philippines using a fractional factorial design with roasting at 325^{o}F for 30, 50, and 70 min; formulation at 35, 45, and 55 percent sugar levels; and cooking of syrup at 14, 16, and 18 min. Consumer acceptance test was used to optimize roasting process, formulation and the cooking of syrup used in the production of peanut brittle. A Spectrum^{TM} descriptive analysis (SDA) method of the product's sensory attributes was also done. The data obtained from the sensory evaluation of the different treatments were analyzed using a Statistical Analysis System program package. SDA data were further subjected to stepwise regression analysis. Response surface regression analysis was used to determine the behavior of the response variable in relation to the set of factors of the independent variables studied. The response surfaces (3-dimensional graphs and contour maps) were plotted using prediction models. Analysis of variance was also used to determine the effects of the different processing variables on the sensory attributes of the products.

Statistical analysis showed significant difference in the linear and quadratic effects of all parameters analyzed except for the interaction of the different variables. Product with medium roasted peanut, higher sugar levels, and longer cooking time generated higher consumer acceptance scores compared to the dark roasted peanut with low sugar levels. Correlation analysis showed that taste had a greater influence on the overall acceptability of peanut brittle than any of the other attributes followed by texture.

Verification trials revealed the predictive ability of the models developed. Comparisons between tabulated and calculated values for the attributes tested revealed non-significant differences at the 1% level of significance.

Results of the sensory descriptive analysis employing a trained panel indicated that peanut color, caramel color, peanut aroma, sweetness, hardness, fracturability, and cohesiveness provided the most efficient combination of characteristics that were discriminatory. Roasting time had a more significant effect on the sensory attributes of the products.

Significant correlations ($p \leq 0.05$) between descriptive sensory (trained panel) and physical measurements were observed. Sensory color values were negatively correlated with physical color measurements of lightness (L), chroma, and hue. As sensory color intensity increased, physical color measurements of lightness (L), chroma, and hue decreased. Differences in color may be attributed to varying degree of roasting and amount of sugar. Physical measurements of color lightness (L) also correlated with peanutty aroma and sweet and bitter tastes. Chroma was also related to peanutty aroma and sweet and bitter tastes.

Peanut brittle had the following properties and intensity rating (15-cm line scale with 0.25 to 14. 72 anchors) specifications: peanut color (2.4), caramel color (3.6), peanutty aroma (10.1), sweetness (11.7), hardness (9.4), fracturability (5.8) and cohesiveness (3.8)

INTRODUCTION

Peanuts

Peanut (*Arachis hypogaea* L.) is a popular snack item in the Philippines not only due to its high nutritional value but also because of its appetizing aroma (del Rosario *et al*., 1992). Its use in the food industry has concentrated on its direct consumption as a snack food.

Some peanut candies, as brittle/praline, contain little other than peanuts and sugar; while others, as peanut roll bars, contain peanuts, sugar, butter, cream, milk solids, egg solids, chocolate, starch, and sometimes flavors and colors. In general, some of the most flavorsome, nutritious, and popular candies with most pleasing texture contain peanuts (Considine and Considine, 1982).

Peanut brittle, peanut praline or *piniato de mani*, is an indigenous peanut product prepared and marketed in Buray, Samar and which unlike other sweetened peanut products contains more than 80% peanuts in the formulation. Different formulations have been used in the production of this product yet there were no reported studies conducted in order to evaluate its sensory and physico-chemical characteristics to improve and standardize the formulation.

The variations in candied peanuts are many and they vary from region to region in the Philippines (Ghee et al., 1989). In the local setting, one of the more popular peanut confections is peanut praline, commonly known as *piñato,* the native counterpart of peanut brittle. Different formulations have been used in the production of this product yet no reported optimized or standard formulation exists. Response surface methodology (RSM) has been used to optimize both process and formulation employing consumers who are regular eaters of the specific product.

Spectrum Descriptive Analysis (SDA) is an analysis employed in sensory evaluation wherein sensory panelists are used similar to scientific instruments to measure specific parameters of products under study. As instruments of measurement, their performance needs to be validated as to the consistency of responses and discrimination of differences (Powers, 1984).

Uses of Peanuts

Three of the principal direct uses of peanuts in food products are (1) peanut butter, marketed separately, and as peanut butter sandwiches; (2) salted peanuts; and (3) peanut candies. Peanut butter accounts for 55 to 57% of the total quantity of peanuts shelled for direct food use. Of this amount, about 3% is used for prepackaged peanut butter sandwiches, frequently vended and marketed much as candy. Salted peanuts account for about 23% of the shelled peanut figure. Use of shelled peanuts in candies of various forms account for the remaining 20 to 22% of the total (Considine and Considine, 1982).

Peanuts are sold fresh as a vegetable, canned, frozen, baked or roasted in shell, toasted and salted, use in more than fifty confections and bakery products, and ground into butter for use in more than a hundred recipes (Woodroof, 1973).

Confectionery and Peanut Confections

Candy and other related confections, prepared from relatively few fundamental ingredients, demonstrate a remarkable degree of versatility. Egyptian writings and excavated artifacts from mines confirmed its existence. Most of the sweets of ancient times were based on honey, but sugar cane juices, crudely evaporated were used in India and China. It was not until the 16th century, when sugar refinery became a commercial process that sugar confectionery began to develop. As time went on, the introduction of other ingredients has resulted in various forms of confectionery which fill the sweet shops of today (Minife, 1980).

The Arabic word for sugar is *quand*, from which stems the word candy. In some areas, the term candy is used to refer to both chocolate and no chocolate confections (frequently called sweets), while confections made of chocolate are logically called chocolates. In the early 1800's, candies were generally called "boiled sweets" (Considine and Considine, 1982).

Much has been said about the harmful effects of over indulgence in sweets but these are probably much less than many other habits about which the public are warned with monotonous regularity. But what of the virtues of eating confectionery? First of all, it is nice to eat and has a pleasant flavor. Because of its high sugar content and physical structure, it is quickly digestible and a rapid source of supply of blood sugar – this means a quick replenishment of energy. It is a useful snack and many are the occasions when a confectionery or chocolate bar and a cup of coffee or tea are a welcome interlude. Chocolate particularly is much in demand for survival rations or as a constituent of food packs, during feats of endurance such as mountain climbing and rescue (Minifie, 1980).

About 20% of the peanuts produced go into various kinds of confectionery products. Peanut candies tend to be proprietary, with each processor using individualized recipes and formulations. The products range from simple formulations, such as peanut brittle which contains peanuts and sugar, to complex products in which peanuts may be blended in numerous ways with chocolate, starch, egg solids, butter, cream, etc. One generality of peanut-type candies is their comparatively high fat content. This tends to shorten shelf life. Therefore, the following alternatives are available: (1) Produce the candies essentially as needed, with high inventory turnover and a maximum targetted shelf-life of three months; (2) keep the products under refrigeration and at a relative humidity of around 40%; (3) incorporate antioxidants in the products to markedly increase shelf-life; (4) pack the products under vacuum. Research has shown that where proper precautions are taken (antioxidant in formulation; packaged to exclude air and moisture; stored at about 0°F (-17.8°C), peanut candies may remain in good condition for up to two years (Considine and Considine, 1982).

Peanuts and peanut butter add desirable flavor, texture, proteins, fats, vitamins, and minerals to more than fifty varieties of candies, and more are added every year. Among these peanut candies, peanut brittle is the most popular chiefly because it has the most peanut flavor. Sometimes other nuts are mixed with peanuts in brittle to capture the peanut flavor. Peanut brittle is made from blanched or unbalanced peanuts that are raw, partially cooked, or fully dry roasted. It is retailed in bulk, in boxes or in hermetically sealed containers of one- or two-lb. capacity. Due to its hygroscopic nature it must be held in a very dry place. Since peanuts in brittle are impregnated and covered with sugar coating, the shelf life is longer than that of most peanut candies (Woodroof, 1973).

Peanuts for brittle or similar types of low-moisture candy are partially cooked before mixing in the syrup and are finished in the candy kettles. They are usually large, blanched, and whole; but may be of any size, split, and unblanched.

Some of the more common peanut candies include, in addition to peanut brittle, peanut butter fudge, peanut crisp, peanut caramel, molasses peanut chews, nougat toffee peanut chews, peanut fondant, chocolate peanut fudge, peanut frappe, chocolate-coated bars, plain peanut bars or planks, cream coated peanuts, spun peanut bars, peanut clusters with milk, peanut kisses, and others. Many recipes for sweet potato soufflés, puffs, casseroles, and other delicious, nutritious, and flavorsome dishes may be made by using crushed peanut brittle as a flavoring and sweetening ingredient (Woodroof, 1973). Large quantities of peanuts are also found in various bakery products (Minifie, 1980).

Praline is a confection of nuts and caramelized sugar, often used as a center for chocolates and to decorate pudding. Pralines are difficult to define because the term means different things in different parts of the country and has been frequently misused in efforts to upgrade the image of certain products (Hui, 1992).

Sensory Descriptive Analysis

Descriptive analysis is a useful tool in defining the sensory properties being targeted for a food product (Meilgaard *et a*l., 1987). It is defined as the sensory method by which the attributes of a food material or product are identified, described, and quantified using human subjects. It involves the detection (discrimination) and the description of both the qualitative and the quantitative sensory aspects of products by trained panelists. Selected panelists must have the ability to detect and describe the perceived sensory attributes of a sample. In addition, they must learn to differentiate and rate the quantitative note present in that sample.

There are several descriptive analysis methods, both qualitative and quantitative, that have been developed and described in literatures. Some have in fact gained and maintained popularity as standard methods. Examples of such methods are the Flavor Profile (Caincross and Sjostrom, 1950; Caul, 1957), Texture Profile (Brandt *et al*., 1963; Szczesniak et al., 1963), Quantitative Descriptive Analysis (QDA^{R}) Method (Stone *et al*., 1974), and the Spectrum^{TM} Descriptive Analysis (Meilgaard *et al*., 1987).

Several studies employing descriptive analysis have been described in literatures. Some of these include the works of Holt *et al.* (1992), Galvez and Resurreccion (1990), Santos and Resurreccion (1989), Muego-Gnanasekharan and Resurreccion (1992), and Santos *et al*. (1989).

Descriptive sensory analysis also has its limitations. To enumerate some, it provides no measure of preference, requires qualified and specially trained subjects, it also requires several training sessions to obtain reliable results, its sensitivity may exceed the technology, and it provides no measure of the importance of each attribute (Stone, 1988).

OBJECTIVES

This study was conducted to optimize the formulation and process of Buray peanut brittle, specifically roasting and cooking of syrup and the formulation (sugar level, w/w%) for an association of farmers, the Wright Peanut Farmers Association, transfer the technology to the association, assist farmers who wish to adopt the technology. The objectives of the study were to : (1) determine consumer acceptability as an effect of roasting time, sugar levels, and cooking of syrup; (2) determine the optimum combinations of roasting time, sugar levels, and syrup cooking time; (3) determine sensory qualities and intensity as an effect of roasting, amount of sugar, and cooking time of the syrup; (4) determine the correlation between and among sensory attributes and between sensory attributes and physical measurements such as color and water activity (Aw); and (5) determine and set quality specification of peanut brittle.

METHODS

Establishment of Collaboration

Before the collaboration could take place, the president of the cooperative signed a letter of agreement (LOA), outlining the roles and responsibilities of each party, namely the cooperative and Peanut CRSP investigators at the Leyte State University (Appendix D). The LOA stipulated that the Cooperative:

1. Commit to adopt business and marketing plans and use unified branding.
2. Cost of 50% of the peanut/products during the experiments and subsequent evaluation
3. Cost of training of member-processors
4. Cost of packaging and product distribution (selling)
5. Provide the information on production volume/product sales.

In exchange, the PCRSP team provides technical assistance through training and standardization of process and formulation both at LSU and Project site and for the Collaborator to have exclusive use of the standard formulation and process for one year.

Preparation and Cooking of Product Samples

Roasting of peanuts was done using a 10-kg capacity oven with patent number UM9752, 9753 of F. USABAL Enterprises of Quezon City, at the Department of Food Science and Technology, Leyte State University, Visca, Baybay, Leyte at 325°F to 330°F. Peanut brittle was then prepared using the basic home recipe for *piñato* indigenous in Buray, Paranas, Samar, Philippines. Small-sized peanuts bought in one of the stores in Tacloban City were the raw materials used by the Collaborator, the Buray processors. The shelled peanuts were sorted to remove bad kernels, roasted for 30, 50, and 70 min, and deskinned before use. Sorting was again done after roasting. Sugar and an acidulant was dissolved in water, and heated to boil for 14, 16, and 18 min. Then the roasted peanuts were added to syrup and thoroughly mixed. The mixture was poured into the molder, cut, cooled, and wrapped using a wax paper before packaging and sealing prior to evaluation.

Experimental Design

A fractional factorial with three factors, each at three levels was employed (Clarke and Kempson, 1997). The factors and levels that were used in the optimization of the formulation and processing of peanut brittle are shown in Table 1. The experiment was replicated twice. There were however 16 treatments included in the descriptive analysis (Table 2). A control prepared using the indigenous process and formulation of the Buray processors was included during evaluation.

Sensory Evaluation

Consumer Acceptability Test

The different samples were presented to a group of consumers randomly selected from among employees of the Department of Agriculture (DA), Region 8, Tacloban City, Leyte, Philippines who are peanut consumers. The panel sessions were conducted in a room using a table on which an improvised 10-partitioned booths were installed below a fluorescent light.

Table 1. Treatments used in the optimization of the formulation and process of peanut brittle

Treatment No.	Roasting Time (min)	Amount of Sugar (w/w%)	Length of Cooking (min)
1	30	35	16
2	30	45	14
3	30	45	18
4	30	55	16
5	50	35	14
6	50	35	18
7	50	55	14
8	50	55	18
9	70	35	16
10	70	45	14
11	70	45	18
12	70	55	16
13	50	45	16
14	50	45	16
15	50	45	16

Table 2. Treatments used in the descriptive analysis of peanut brittle

Treatment No.	Roasting Time (min)	Amount of Sugar (w/w%)	Length of Cooking (min)
1	30	35	14
2	30	35	16
3	30	45	14
4	30	45	16
5	30	45	18
6	30	55	16
7	50	35	14
8	50	35	18
9	50	45	16
10	50	55	14
11	50	55	18
12	70	35	16
13	70	45	14
14	70	45	16
15	70	45	18
16*	70	55	16

Replicated twice.
* The indigenous process and formulation.

Each consumer panelist evaluated six samples each placed in a 2 oz white plastic cup following the incomplete block design of Cochran and Cox (1985) where t = 15, k = 6, r = 6, b = 16, λ = 2, E =.89, type I, where t refers to the number of treatments, k the no. of samples presented to panelists, r the number of replications based on the plan IBD, b the number of block, and E the efficiency factor

(Appendix A).. All panel sessions were conducted using 9-pt Hedonic scale where 1=dislike extremely while 9=like extremely and the ballots used is shown in Appendix B. The panelists were provided with water to rinse their mouth in between sample tasting, They were also provided with spit white plastic glasses.

Verification Studies

Verification experiment was conducted in two replicates using two selected treatments. The treatments included one within and one outside the optimum acceptable region. Thirty panelists were randomly selected from forty-five (46) panelists using the same ballot. A paired t-test was performed to determine if the observed values were significantly different from the predicted values.

Descriptive Analysis

Twelve panelists consisting of staff and students of the Leyte State University were trained for 18 hours over a two-week period but only eleven finally joined the group. During the training, the panelists were presented with standard references recommended for the descriptive analysis using the Spectrum^{TM} intensity scale method of Meilgaard *et al*. (1987). Panel consensus on the intensity of the standard reference was as follows: The dark brown sugar had an intensity of 15, Planters peanut 7.0, fracturability of Nabisco ginger snacks, 8.0, hardness of Eden cheese, 4.5, Sun-maid dried raisins, cohesiveness of 10 and Nabisco graham cracker toothpacking intensity of 7.5.

Panelists were also presented with peanut brittle samples representative of the characteristics of the product. The panelists suggested the descriptive terms using the lexicon of peanut flavor descriptors as a guide and came up with the final list of descriptors before product evaluation.

Each panelist evaluated a total of four sets of four samples. Panelists were instructed not to swallow the samples and were provided with cups for expectoration. They were also provided with water to clear their palate between sample tasting. All panel sessions were conducted in a sensory room equipped with partitioned booths and fluorescent lights. Evaluation was done on the ballots provided. At the beginning of each evaluation, warm-up peanut brittle sample was served for calibration and their responses were compared with the intensity ratings agreed upon during training. Reference standards were also provided to standardize the evaluation.

Physical Measurements

Color

Colorimetric measurements were done by the Food Development Center (FDC), National Food Authority, Taguig, Metro Manila using the CIELAB color scale (L*a*b*). Color parameters (L, a, and b) were recorded as average of three readings per sample. Two derived functions were calculated from the given Lab readings: Hue angle: $\tan^{-1}$ (b/a) and chroma:$(a^2+b^2)^{1/2}$.

Water Activity

Water activity was measured using an A_w Analyzer (Model 5803).

Statistical Analyses

The data obtained from the sensory evaluation of the different treatments were analyzed using the Statistical Analysis System (SAS, 1985) program package. These were further subjected to stepwise discriminant analysis to determine those attributes with significant discriminating power (Powers, 1984) and to determine whether the products can be grouped into their own class based on values assigned to the attributes (Resurreccion, 1988). Analysis of variance (ANOVA) was also used to determine the effects of the different processing variables on the sensory attributes of the products.

Response Surface Regression Analysis (PROC RSREG) was used to determine the behavior of the response variable in relation to the set of factors of the independent variables studied. The response surfaces (3-dimensional graphs and contour maps) were plotted using the models.

Stepwise Regression Analysis

RSM includes application of regression analyses in an attempt to gain a better understanding of the characteristics of the response system under optimization studies Most response surface investigations are sequential in nature and it has a dual role to verify that the factors are indeed influential, and to eliminate factors that are unimportant. Stepwise discriminant analysis was performed in order to seek out subsets of descriptors most useful to discriminate among peanut brittle samples.

Technology Transfer

Using the optimized formulation and roasting process, the technology was transferred to an association, the Wright Peanut Processors Association (WPPA). Technology transfer through training and seminars have been conducted..

RESULTS

Consumer Acceptance

The mean and predicted values for consumer acceptance scores of peanut brittle as a result of consumer acceptance and regression statistical tests are shown in Table 3. Combination of medium roasted peanuts, higher sugar levels, and longer time of cooking of syrup resulted in peanut brittle with increased acceptance scores especially for overall acceptability, color, aroma, and taste. However, the overall means for each sensory attribute were almost 7.0 which is like slightly to like moderately in the hedonic scale.

Overall Acceptability

Overall acceptability of peanut praline/brittle was affected linearly by roasting time and its quadratic effect. The predicted optimum value of 6.933 (Table 3) was at 46.95 min roasting time, 44.32 sugar, and 15.49 cooking time. For overall acceptability, medium roasted peanut at 35-55 % sugar and 14-18 min cooking time received high acceptance ratings compared to dark roasted peanuts with longer cooking time which got low consumer acceptance scores.

Table 3. Mean consumer acceptability ratings of peanut brittle with different times of roasting, amount of sugar, and length of cooking

Treatment	Factors			Sensory Qualities				
	X_1	X_2	X_3	Overall	Color	Aroma	Texture	Taste
1	30	35	16	6.50	6.41	6.73	6.5	6.23
2	30	45	14	6.54	6.01	6.41	6.36	6.61
3	30	45	18	6.77	6.91	7.04	7.07	6.39
4	30	55	16	6.61	6.39	6.46	6.32	6.36
5	50	35	14	6.89	6.64	6.75	6.73	6.96
6	50	35	18	6.59	6.07	6.16	6.23	6.43
7	50	55	14	6.98	6.61	6.84	6.70	6.64
8	50	55	18	6.91	6.54	6.57	6.68	6.77
9	70	35	16	6.98	6.88	6.50	6.77	6.75
10	70	45	14	6.54	6.66	6.73	6.59	6.50
11	70	45	18	6.97	7.14	6.82	6.93	6.84
12	70	55	16	6.30	5.89	6.16	6.27	5.98
13	50	45	16	6.66	6.43	6.43	6.57	6.61
14	50	45	16	6.43	6.11	6.32	6.52	6.30
15	50	45	16	6.16	6.43	6.02	6.23	6.32
Predicted optimum value				6.933	6.926	6.922	6.719	7.154

X_1 = roasting time (in minutes); X_2 = amount of sugar (%) and X_3 = length of cooking (in minutes).

Color Acceptability

Both roasting and amount of sugar had quadratic effects on product color. The predicted optimum value was 6.926 at an optimum condition of 47.90 min for roasting, 46.19% sugar and 15.66 minutes cooking time. Treatments with medium roasted peanut, 45-55% sugar, and 16-18 minutes cooking time were much preferred in terms of product color.

Aroma Acceptability

Aroma was also affected by both roasting and sugar with a predictive optimum value of 6.922 at an optimum condition of 47.70 minutes roasting time, 46.20 % sugar, and 16.50 min cooking time. Medium roasted peanuts got high acceptance ratings while dark roasted peanuts got lower ratings.

Texture Acceptability

No significant effects were observed for product texture. However, the predicted optimum value at 40.584 min roasting time, 48.24 % sugar, and 18.08 cooking time was 6.719. In terms of texture, treatments with light roasted peanut and 35-45 % sugar seemed to be preferred.

Taste Acceptability

Product taste was affected linearly by roasting time and its quadratic effect with a predicted optimum value of 7.154 which corresponds to like moderately in the Hedonic Scale. The optimum condition was at 15.36 min, roasting time, 52.45 % sugar and 28.25 min cooking time. Medium roasted peanuts; with 45-55 % sugar, and 16-18 min cooking time got higher ratings scores as well as light roasted peanuts with longer cooking time.

Attaining the Optimum

ANOVA results for response variables (Table 4) resulted in statistically significant ($p \leq 0.01$) quadratic regression models but only for overall and color acceptability. The response surfaces in Figs. 1a, to 1c, 2a to 2c, illustrate the results of the modeling of the sensory attributes. Non-significant ($p>0.05$) interactions among roasting time, peanut sugar level, and cooking time on consumer acceptance scores of peanut brittle exist except on color.

Table 4. F-values of the consumer acceptability scores of peanut brittle with different times of roasting, amount of sugar, and length of cooking

Regression	Sensory Quality Attributes[a]				
	Overall	**Color**	**Aroma**	**Texture**	**Taste**
Linear	0.3363	0.4227	0.6902	0.0507	0.3462
Quadratic	0.0440*	0.0054**	0.0167	0.2518	0.1584
Cross product	0.4284	0.4262	0.6259	0.6471	0.5440
Total Regression	0.1143	0.0325*	0.1433	0.1406	0.3015

[a] Significant level: ** Significant at $p \leq 0.01$ * Significant at $p \leq 0.05$

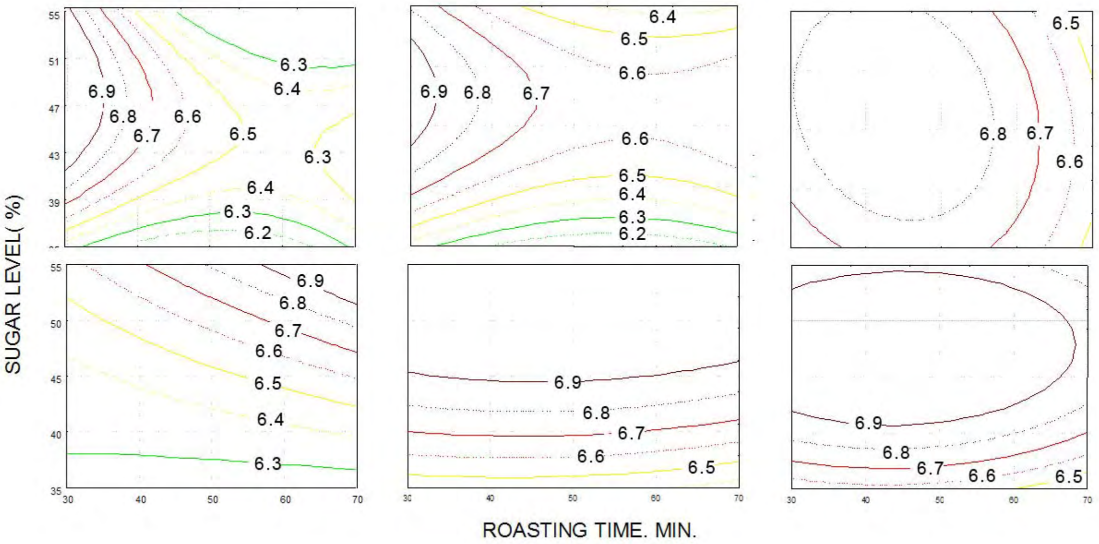

Fig. 1a. Contour plots on the sensory properties (over all, color, aroma, texture, flavor and sweetness acceptability) of peanut brittle processed to optimize peanut roasting process and percent sugar at constant caramel/syrup cooking time (18 mins). Shaded regions represent acceptance scores of ≥ 6.5. using 9-point Hedonic scales.

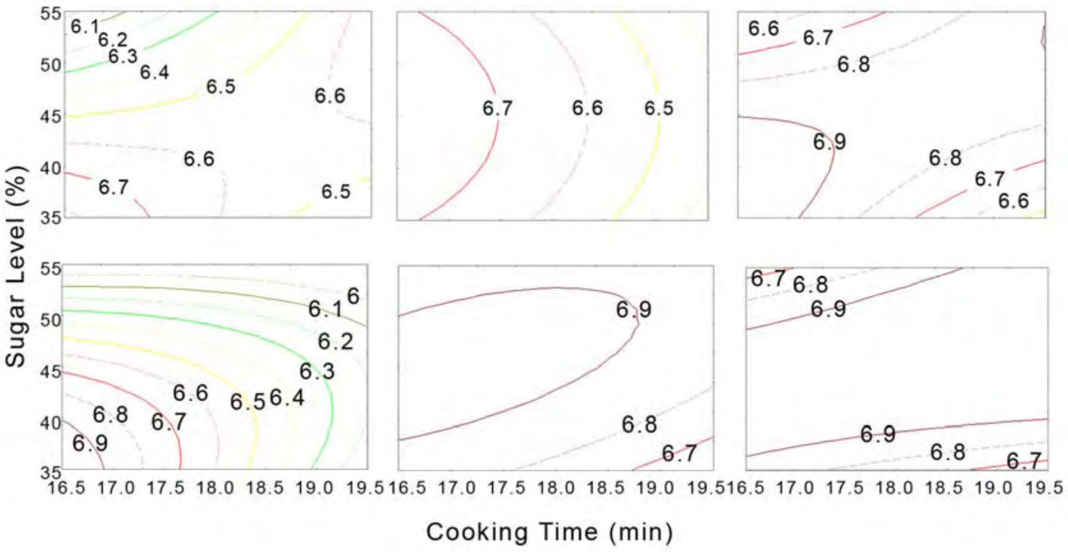

Fig. 1b. Contour plots on the sensory properties (over all, color, aroma, texture, flavor and sweetness acceptability) of peanut brittle processed to optimize syrup cooking time and percent sugar at constant peanut roasting time of 50 mins. Shaded regions represent acceptance scores of ≥6.5 using 9-point hedonic scales.

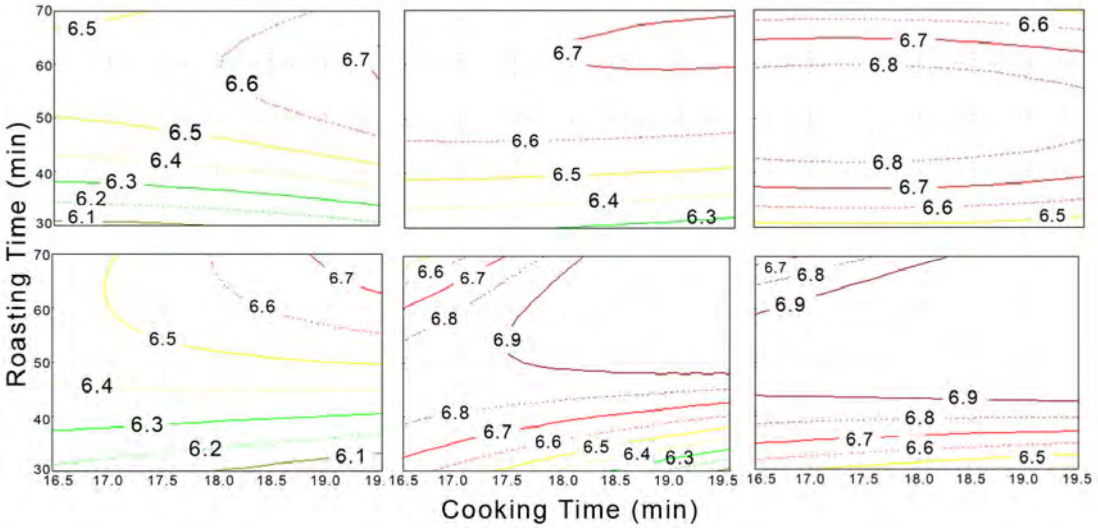

Fig. 1c. Contour plots on the sensory properties (over all, color, aroma, texture, flavor and sweetness acceptability) of peanut brittle processed to optimize syrup cooking time and peanut roasting time at constant sugar level of 45%. Shaded regions represent acceptance scores of ≥ 6.5. using 9-point hedonic scales.

Fig. 2a shows that there was an inverse relationship between roasting time of peanut and levels of sugar. At constant cooking time of syrup at 18 minutes, any combinations of 52-55% sugar, optimum formulation only need to roast the peanuts between 33-42 minutes roasting time in order to produce peanut brittle products with sensory scores of ≥6.5. However, at constant and high roasting time of 50 minutes, shown in Fig. 2b, the formulation only need 35-44% sugar with 15-18 minutes cooking time of syrup; and at constant sugar level of 45% (w/w), a higher roasting time of 56-58% minutes at 18-19.5 minutes of cooking the syrup (Fig. 2c) could produce peanut brittle products with sensory scores of ≥6.5.

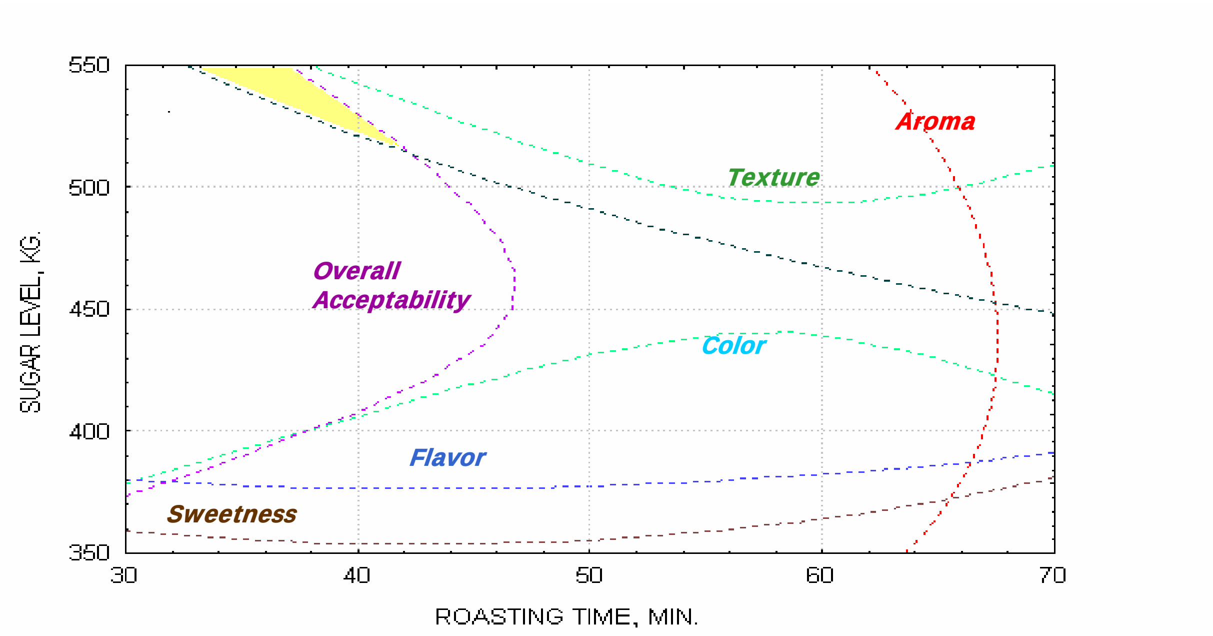

Fig. 2a. Optimum combination of roasting time and sugar level for peanut brittle superimposing contour plots of sensory properties. Shaded region represents consumer acceptance scores for overall, color, aroma, texture, flavor and sweetness ≥6.5 at 18 min syrup cooking time.

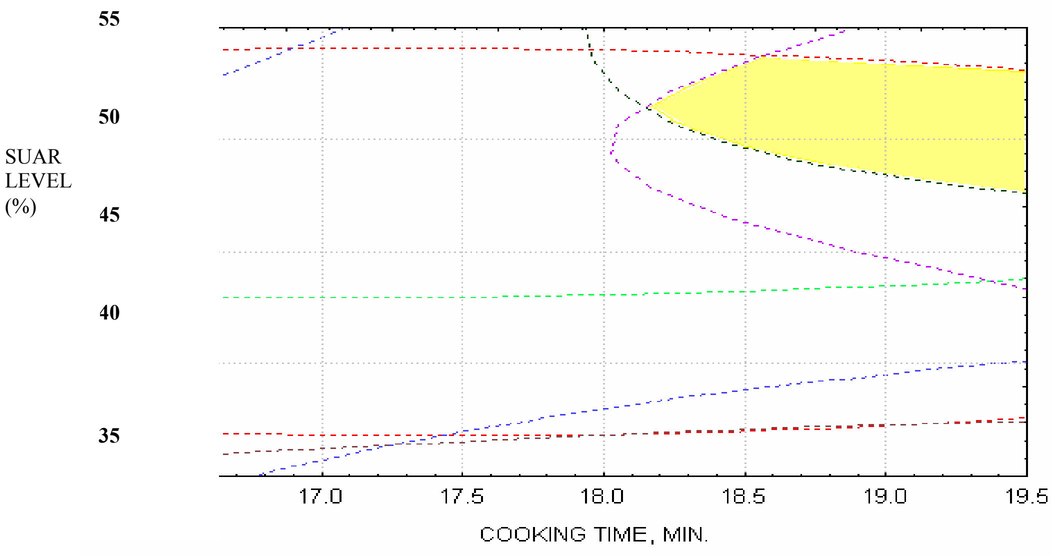

Fig. 2b. Optimum combination of cooking time of syrup and sugar level for peanut brittle by superimposing contour plots of sensory properties. Shaded region represents consumer acceptance scores for overall, color, aroma, texture, flavor and sweetness ≥6.5 at 50 min roasting time.

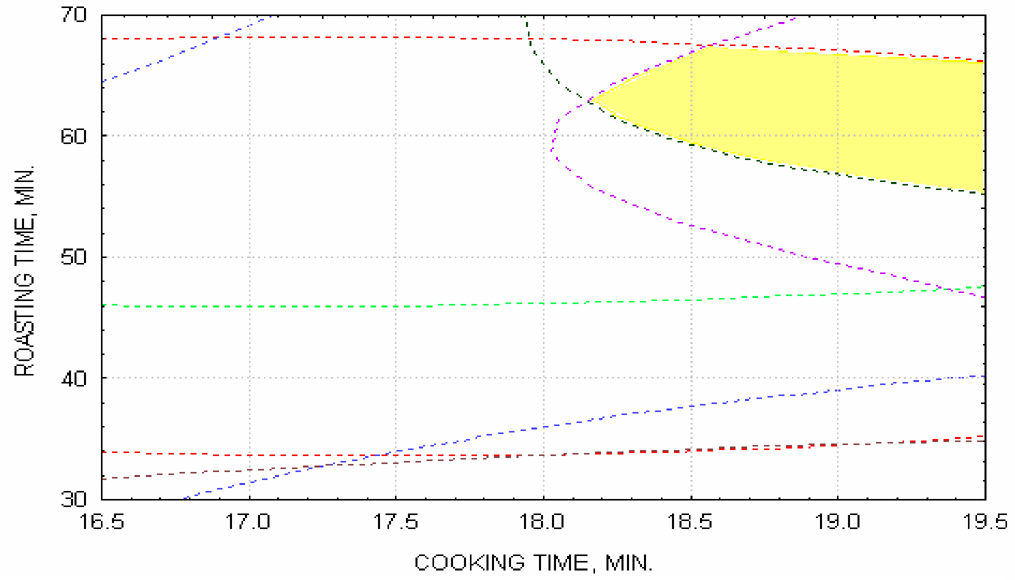

Fig 2c. Optimum combination of cooking time of syrup and roasting time for peanut brittle by superimposing contour plots of sensory properties. Shaded region represents consumer acceptance scores for overall, color, aroma, and texture flavor and sweetness ≥6.5 at 45% sugar

Verification Study

Verification trials revealed the predictive ability of the models developed especially that the comparisons between observed and predicted values for the attributes tested revealed non-significant differences at the 1% level of significance (Table 5).

Table 5. Predicted and observed values for the verification experiment

Sensory Attributes	X_1			X_2		
	Predicted	Observed	t-value	Predicted	Observed	t-value
Overall Acceptability	7.4	7.0	1.482ns	7.1	6.2	2.163ns
Color	6.6	6.8	0.527ns	6.6	6.5	0.229ns
Aroma	7.1	6.9	0.609ns	6.5	6.3	0.359ns
Texture	7.5	6.5	3.068ns	7.1	6.1	2.607ns
Taste	7.9	6.8	5.238ns	7.0	6.4	1.494ns

Physical Measurements

Color

Results from the instrumental analysis of color are summarized in Table 6. Increase in hue angles was due to higher "a" and lower "b" readings which was observed when all three variables were at its highest levels. The chroma scale which is a measure of the departure of the color perceived from gray of the same lightness or it is the intensity (brightness) of color had little changes noted. These changes in chroma could be attributed to the degree of roasting and amount of sugar rather than on the cooking time of syrup. The scale (*L*) is a lightness scale ranging from black (0) to white (10). Higher *L* values means lighter color (Joslyn, 1970). Table 6 further shows that color was darker at longer roasting time. Browning in foods during processing have been attributed to: (1) the reaction of aldehydes and ketones, among them the reducing sugars, with amino compounds such as amino acids, peptides and proteins and (2) caramelization, a change which occurs in polyhydroxycarbonyl compounds, such as reducing sugars and sugar acids when they are subjected to high temperature (Meyer, 1978). The varying amounts of sugar added and the extent of heat treatment would therefore explain the difference in color measurements obtained.

Table 6 Instrumental color analysis and water activity (A_w) of peanut brittle samples

Treatment No.	Factors[a]			Color Measurement			
	X_1	X_2	X_3	L	Chroma	Hue	A_w
1	30	35	14	64.82	29.31	77.61	0.552
2	30	35	16	61.70	29.38	77.98	0.473
3	30	45	14	66.39	30.20	77.57	0.492
4	30	45	16	67.43	30.23	79.19	0.531
5	30	45	18	65.26	29.91	78.00	0.474
6	30	55	16	62.55	31.62	77.45	0.472
7	50	35	14	67.10	29.50	77.47	0.457
8	50	35	18	63.29	30.70	78.27	0.446
9	50	45	16	63.51	29.93	76.67	0.477
10	50	55	14	66.52	30.62	76.88	0.476
11	50	55	18	66.23	27.33	77.17	0.457
12	70	35	16	59.28	27.13	71.59	0.458
13	70	45	14	60.16	28.81	71.52	0.493
14	70	45	16	51.36	31.30	67.65	0.430
15	70	45	18	55.36	30.97	70.67	0.437
16	70	55	16	54.56	27.79	71.28	0.441

X_1 = roasting time (in minutes); **X_2** = amount of sugar (%) and **X_3** = length of cooking (in minutes).

The amount of sugar did not seem to have any effect on the *L* value and chroma of the product, respectively (Table 7).

Table 7. F values of color and water activity (A_w) as affected by the three factors

Independent Variable	F-values			
	Color [a]			A_w [a]
	L	Chroma	Hue	
Roasting Time	48.9**	25.2**	155.7**	164.1**
Amount of sugar	0.503^{ns}	35.0**	19.7**	7.37**
Cooking Time	54.6**	$.261^{ns}$	4.8**	83.8**

[a] Level of significance: ** Significant at p≤0.01 * Significant at p≤0.05 ns means not significant

Water Activity

For peanut brittle water activity measurements averaged to 0.47. At low levels of water activity, the growth for microorganisms is reduced. The A_w would have to be below 0.62 to retard all chances for mold growth, although an A_w below 0.70 inhibits most spoilage molds (Frazier and Westhoff, 1988). Peanut praline, having low A_w would therefore have the added advantage of being microbiologically shelf stable since most of the water in food is not available to both microorganisms and enzymes. Water activity was significantly affected by the three independent variables (Table 6).

Sensory Descriptive Analysis

Stepwise Discriminant Test

Results of the sensory analyses employing a trained panel indicated that peanut color, caramel color, peanut aroma, sweetness, hardness, fracturability, and cohesiveness provided the most efficient combination of characteristics that were significantly discriminatory (Table 8) at 1% level. The three other characteristics (caramel aroma, bitterness, and toothpacking) out of ten sensory qualities were found to be unnecessary parameters, so were not included in the subsequent analyses.

Table 8. Stepwise discriminant analysis on the sensory characteristics of peanut praline as evaluated by a trained panel

Step	Variable Entered	F-values	Level of Significance
1	Peanut color	302.699	0.000
2	Caramel color	77.824	0.000
3	Peanutty aroma	18.800	0.000
4	Hardness	43.824	0.000
5	Fracturability	23.153	0.000
6	Cohesiveness	15.904	0.000
7	Sweet taste	30.249	0.000

Sensory Qualities

The mean ratings and standard deviations of sensory attributes by a trained panel are shown in Tables 9a and 9b.

Color. In general, there was an increasing descriptive intensity rating for color (both peanut and caramel) with increasing roasting time and levels of sugar. Longer caramel cooking affected significantly the caramel color (Table 9). Heat may have caused browning to occur and would thus account for the darker color of peanuts roasted at a longer time. Furthermore, sugars when heated to high temperature will undergo caramelization, which could contribute to browning. The color changes of peanuts as an effect of roasting could probably be due to non-enzymatic reactions since the product contains the reactants required for Maillard browning, an amino-bearing compound (protein), a reducing sugar, and water (Whistler and Daniel, 1985).

Table 9a. Mean ratings and standard deviations of four sensory attributes by trained panel.

Treatment No.	X_1	X_2	X_3	Color (Peanut)	Color (Caramel)	Aroma (Peanutty)	Texture (Hardness)
1	30	35	14	1.1 ± 2.89	6.5 ± 4.69	6.8 ± 1.76	8.7 ± 1.32
2	30	35	16	1.0 ± 2.99	5.0 ± 1.79	7.0 ± 1.48	8.7 ± 0.74
3	30	45	14	1.4 ± 0.52	6.7 ± 4.37	7.3 ± 1.69	8.9 ± 1.09
4	30	45	16	1.3 ± 0.63	2.8 ± 1.19	7.5 ± 1.90	7.6 ± 1.38
5	30	45	18	1.1 ± 0.36	3.8 ± 1.66	7.3 ± 1.42	9.2 ± 1.18
6	30	55	16	1.2 ± 0.47	2.5 ± 1.37	7.1 ± 1.66	8.3 ± 1.73
7	50	35	14	2.9 ± 1.10	2.9 ± 0.91	8.2 ± 1.54	9.1 ± 1.10
8	50	35	18	3.1 ± 1.17	3.3 ± 0.94	8.4 ± 1.61	8.7 ± 1.07
9	50	45	16	3.4 ± 1.23	3.2 ± 0.76	9.2 ± 1.15	9.1 ± 1.24
10	50	55	14	4.4 ± 1.64	3.7 ± 1.22	9.4 ± 0.78	10.2 ± 2.98
11	50	55	18	5.0 ± 0.63	5.1 ± 2.41	8.8 ± 1.14	10.1 ± 1.36
12	70	35	16	10.7 ±1.42	5.6 ± 1.16	11.9 ±1.17	8.4 ± 1.13
13	70	45	14	10.5 ±1.57	5.9 ± 1.29	12.3 ±1.10	8.2 ± 1.33
14	70	45	16	11.0 ±1.52	5.8 ± 1.66	11.7 ±1.68	9.1 ± 1.13
15	70	45	18	10.9 ±1.63	5.5 ± 1.40	11.8 ±1.23	9.4 ± 1.26
16	70	55	16	11.0 ±1.52	6.2 ± 1.32	12.7 ±1.20	10.1 ± 1.33

Intensity scale 15 cm line scale with anchors at 0.25 and 14.72.

Table 9b. Mean ratings and standard deviations of the remaining three sensory attributes by trained panel. .

Treatment No.	X_1	X_2	X_3	Texture (Fracturability)	Texture (Cohesiveness)	Taste (Sweet)
1	30	35	14	5.6 ± 0.82	4.3 ± 0.87	9.8 ± 1.65
2	30	35	16	6.1 ± 0.79	4.2 + 0.77	10.9 ± 1.57
3	30	45	14	6.3 ± 1.04	4.2 + 0.85	10.9 ± 1.59
4	30	45	16	5.2 ± 2.63	4.8 + 0.99	11.5 ± 1.03
5	30	45	18	6.3 ± 1.22	4.8 + 1.18	11.8 ± 1.00
6	30	55	16	5.4 ± 1.24	4.2 + 1.10	12.6 ± 1.42
7	50	35	14	7.0 ± 1.27	3.9 + 1.18	11.5 ± 0.77
8	50	35	18	6.6 ± 1.05	3.8 + 0.96	11.3 ± 1.24
9	50	45	16	6.1 ± 0.91	4.1 + 0.86	11.5 ± 0.92
10	50	55	14	7.0 ± 0.85	3.9 + 1.28	11.9 ± 0.98
11	50	55	18	6.7 ± 1.00	4.0 + 0.99	11.1 ± 1.10
12	70	35	16	5.7 ± 1.14	3.9 + 1.21	10.8 ± 1.40
13	70	45	14	5.7 ± 1.46	4.2 + 1.27	11.3 ± 1.09
14	70	45	16	6.1 ± 1.19	3.6 + 0.87	11.3 ± 1.10
15	70	45	18	6.4 ± 1.22	3.8 + 3.08	11.4 ± 1.23
16	70	55	16	6.6 ± 1.48	8.0 + 3.17	11.7 ± 1.12

Flavor. Peanut aroma and sweetness intensities significantly changed during processing (Table 8). Scores for peanut aroma increased with roasting time while sweetness as expected increased as amount of sugar increased (Figs. 2a to 2c). The change in flavor and color due to roasting of peanuts has been associated to the pyrolytic reaction between amino acids and reducing sugars, which produce volatile carbonyl compounds and pyrazines (Brown *et al*., 1972). Less severe heating conditions may eliminate the beany flavor but not produce enough or acceptable roasted flavor and brown color. Peanuts heated at 130°C or less even for considerable length of time did not develop an acceptable roasted flavor (Pickett, 1943).

Texture. Response surfaces for textural characteristics (hardness and fracturability) of peanut brittle are also shown in Figs. 2a to 2c. Hardness scores ranged from 7.6 to 10.2. Increasing roasting time from 30 to 50 min increased but further increase caused the values to decrease. This could probably be attributed to the fact that longer heat treatment results in greater protein denaturation and carbohydrate gelatinization (Meyer, 1978). Results also showed that hardness is directly related to sugar level. Fracturability or the force with which the sample breaks was found to be principally affected by roasting time with amount of sugar and cooking time playing a lesser role (Table 8). Cohesiveness, the degree to which the sample deforms rather than crumbles, cracks or breaks, was greatly affected by the amount of sugar.

Correlation

Among Sensory Attribute Descriptors

Pearson correlation coefficient indicated that although the correlation value was low (r = 0.286), significant correlation was observed between peanut color and caramel color (Table 9). This means that caramel color could have masked peanut color but because cooking was only done on syrup, it only had significant effect on caramel color due to caramelization reaction. Regression analysis also indicated that the variation in the observed peanut color values could only be explained by the variable, roasting time. The other variables, amount of sugar and cooking time and their interaction, could not explain the variations. However, variations in caramel color could be explained by roasting time, syrup or caramel cooking time and their interaction as well as the interaction between sugar and roasting time. However, most of the correlation coefficients were below 0.50 which are considered weak and practically worthless for predictive purposes (Bourne, 1982)

However, there was no significant relation observed between sweetness and peanut aroma since the latter only affected roasting time of peanuts. As for sweetness, variations can be explained by the interaction among the three variables, amount of sugar, peanut roasting time and cooking of syrup.

Between Sensory Attributes Descriptors and Physical Measurements

Significant correlations ($p \leq 0.05$) between descriptive sensory (trained panel) and physical measurements were observed (Table 5.10). Sensory color values negatively correlated with physical color measurements of lightness (*L*), chroma, and hue. As sensory color intensity increased, physical color measurements of lightness (*L*), chroma, and hue decreased. Differences in color may be attributed to varying degree of roasting and amount of sugar in peanut praline. Physical measurements of color lightness (*L*) also correlated with peanutty aroma, and sweet and bitter tastes. Chroma was also related to peanutty aroma, sweetness and bitter tastes.

Table 10 Correlation between sensory scores and physical measurements

Sensory Qualities	Physical Measurements Chroma	Hue	A_w
Over-All acceptability	ns	*	ns
Color	ns	ns	ns
Aroma	ns	ns	ns
Texture	ns	*	ns
Taste	ns	*	ns

Results of Technology Transfer

A standard specification has been established and disseminated to the Collaborator. Peanut brittle obtained from the optimum region had the following intensity and quality specifications: 2.4 peanut color, 3.6 cararamel color, 10.1 peanutty aroma, 11.7 sweetness, 9.4 hardness, 5.8 fracturability, and 3.8 cohesiveness in a 15-cm line with 0 and 15 anchors. The main constraint to adoption was the lack of capital for the commercialization activity especially since arrangements with most outlets is on consignment basis. So proposals have been developed for counterpart funding. The activities of WPPA have been monitored including the utilization of the counterpart funds given by DOLE through the LGU_Paranas. Information on economic impact is also on-going, the results of which will be reported in monograph series no. 9, Impact Assessment of Peanut CRSP Projects in the Philippines – Part 2. Commercialization is on going with 25% of the processors producing products for the outside Buray markets and the others are continuing their processing for the Buray markets.

CONCLUSIONS

Roasting time significantly affected peanut color, caramel color, peanut aroma, sweetness, hardness, and fracturability. The length of cooking significantly affected caramel color and product sweetness. The amount or levels of sugar did not have significant effects on fracturability. Physical color measurements correlated with sensory color values as well as with peanutty aroma, bitter taste, and cohesiveness.

At constant cooking time of syrup at 18 minutes, any combinations of 52-55% sugar, only need to roast the peanuts between 33-42 minutes roasting time; at constant and high roasting time of 50 minutes, the formulation only need 35-44% sugar with 15-18 minutes cooking time of syrup; and at constant sugar level of 45% (w/w), a higher roasting time of 56-58minutes at 18-19.5 minutes of cooking the syrup could produce peanut brittle products with sensory scores of $\geq$6.5.

The optimum formulation resulted in intensity specifications of peanut color (2.4), caramel color (3.6), peanutty aroma (10.1), sweetness (11.7), hardness (9.4), fracturability (5.8), and cohesiveness (3.8) on a 15-cm line scale with 0.25 to 14. 72 anchors.

The optimized process and formulation was transferred through a training first at LSU and later at WPPA's processing area. The members take turns in processing the prodcts especially for the outside Buray markets. With 25% or 6 members at a time, there has been an increasing volume of annual sales especially now that there are more product outlets aside from he Tacloban Pre-Departure Area Store and BAHANDI Pasalubong Center

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APPENDIX A

SET PLAN FOR INCOMPLETE BLOCK DESIGN

SET PLAN FOR INCOMPLETE BLOCK DESIGN.

(Cochran and Cox, 1957)

Block	Replication				
	I	II	III	IV	V
1	1	2	3	7	8
2	2	6	8	4	1
3	3	8	5	9	2
4	4	3	9	2	6
5	5	1	7	3	4
6	6	4	2	5	7
7	7	9	1	6	3
8	8	5	4	1	9
9	9	7	6	8	5
10	1	2	3	5	9
11	2	6	5	1	8
12	3	5	1	4	6
13	4	3	2	8	7
14	5	7	9	2	4
15	6	8	7	3	5
16	7	4	8	9	1
17	8	9	4	6	3
18	9	1	6	7	2

Type 5. $t=9$, $k=5$, $r=10$, $b=18$, $\lambda=5$, $E = 90$.

APPENDIX B

BALLOT USED IN THE CONSUMER ACCEPTANCE TEST

BALLOT USED IN THE CONSUMER ACCEPTANCE TEST

Consumer Test

Peanut Praline

Name: ____________________________
Age:_______________
Judge No. ________
Date:_______________

Please **TASTE SAMPLE NO**. ________ and place an **x** on the space provided for that best reflects your feeling about the sample. Please rinse your mouth with water in between samples.

1. Overall, how do you rate 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 color 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 aroma 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 texture 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 taste (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
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

6. **How do you rate the flavor (combination of taste & aroma) 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
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

APPENDIX C

SPECTRUM INTENSITY SCALES FOR DESCRIPTIVE ANALYSIS

SPECTRUM^{TM} INTENSITY SCALES FOR DESCRIPTIVE ANALYSIS

1. Standard Hardness Scale

Scale Value	**Reference**	**Brand/type/manufacture**	**Sample size**
1.0	Cream cheese	Kraft/Philadelphia light	½ in. cube
2.5	Egg white	Hand cooked	½ in. cube
4.5	Cheese	Yellow American pasteurized processed/Land O'Lakes	½ in. cube
6.0	Olives	Goya Foods/giant size, stuffed	1 olive pimento removed
7.0	Frankfurter	Large, cooked 5 min./ Hebrew National	½ in. slice
9.5	Peanuts	Cocktail type in vacuum	1 nut, whole
11.0	Carrots	Uncooked, fresh, unpeeled	½ in. slice
11.0	Almonds	Shelled/Planters	1 nut
14.5	Hard candy	Life savers	3 pcs., 1 color

Technique: For solids, place food between the molars and bite down evenly, evaluating the force required to compress the food.

Definition: The force to attain a given deformation, such as:
* force to compress between molars, as above
* force to compress between tongue and palate
* force to bite through with incisors
(Soft -------------------------------------- Hard)

2. Standard Fracturability Scale

Scale value	**Reference**	**Brand/type/manufacture**	**Sample size**
1.0	Corn muffin	Thoma's	½ in. cube
2.0	Egg Jumbos	Stella D'Oro	½ in. cube
4.2	Graham crackers	Nabisco	½ in. square
6.7	Melba Toast	Plain, rectangular/ Devonsheer, Melba, Co.	½ in. square
8.0	Ginger Snaps	Nabisco	½ in. square
10.0	Rye wafers	Finn Crisp/Shafter, Clark and Co.	½ in. square
13.0	Peanut brittle	Kraft	½ in. square candy part
14.0	Hard candy	Life savers	1 piece

Technique: Place food between molars and bite down evenly until the food crumbles, cracks or shatters.

Definition: The force with which the sample breaks. (Crumbly--------------------- brittle)

3. Standard Cohesiveness Scale

Scale Value	Reference	Brand/type/manufacture	Sample size
1.0	Corn muffin	Pepperidge Farm	½ in. cube
5.0	Cheese	Yellow American pasteurized processed/Land O' Lakes	½ in. cube
8.0	Pretzel	Soft pretzel	½ in. piece
10.0	Dried fruit	Sun dried seedless raisins/ Sun-Maid	1 tsp.
12.5	Candy chews	Starburst/Mand M Mars	1 piece
15,9	Chewing gum	Freedent	1 stick

Technique: Place sample between molars; compress fully (can be done with incisors).

Definition: The degree to which sample to deforms rather than crumbles, cracks, or breaks. (breaking/rupturing ------------------------ deforming)

4. Standard Tooth Packing Scale

Scale Value	Reference	Brand/type/manufacture	Sample size
0.0	Mini-clams	Geisha/Nozaki America	3 pieces
1.0	Carrots	Uncooked, fresh, unpeeled	½ in. slice
3.0	Mushrooms	Uncooked, fresh, unpeeled	½ in. slice
7.5	Graham cracker	Nabisco	½ in. square
9.0	Cheese	Yellow American pasteurized processed/Land O' Lakes	½ in. cube
11.0	Cheese Snacks	Wide-Borden Cheese Doodles	5 pieces
15.0	Candy	Ju-Jubes	3 pieces

Technique: After sample is swallowed, feel the tooth surfaces with tongue.

Definition: The degree with which product sticks to teeth.
(None stuck--------------------------- Very much stuck)

APPENDIX D

R&D PROPOSAL FOR COLLABORATION

R&D PROPOSAL FOR COLLABORATION

PROPOSAL FOR R & D COLLABORATION
WITH PEANUT COLLABORATOR

A. Title : Formulation and Process Optimization of Buray Peanut Brittle (Praline)

B. Objective : To optimize the formulation and process of Buray peanut brittle

C. Rationale:

There is a great potential on Buray peanut brittle product for increased volume, consistent quality and expanded market. This can be possible through optimization of formulation and process and subsequent standardization. Scaling-up of the process and strengthening cooperativism could reduce production cost and increase profit especially if there is an accompanying expansion of market of the product.

D. Output:

1. Optimized peanut brittle formulation and process.
2. Standardized peanut brittle formulation and process.
3. Peanut brittle products in the market outside of Buray especially in the cities of Tacloban and Ormoc.

E. Duration: 4 months (December 16, 2000-April 15, 2001)

F. Activities and Cost Sharing Scheme

1. Optimization of formulation and process at ViSCA
2. Standardization and verification of the process at the plant of industry collaborator.
3. Transfer of technology and scaling-up at the plant of industry collaborator.

2. Processing line establishment and improvement for increase processing efficiency of the plant of industry collaborator

G. Cost Sharing Scheme

<u>ViSCA-FDC</u>

1. Manpower, chemicals and facilities during the optimization and sensory evaluation at LSU.
2. Technical support and coordination during the transfer, training, scaling-up and marketing.

Industry Collaborator

1. Commit to adopt business and marketing plans and use unified branding.
2. Cost of 50% of the peanut/products during the experiments and subsequent evaluation.
3. Cost of training of member-processors.
4. Cost of packaging and product distribution (selling).
5. Provide the information on production volume/product sales.

H. Terms for Collaboration

- Industry to have exclusive use of the standard formulation and process of peanut brittle for one year.
- ViSCA to provide technical manpower support during the one-year period.
- Industry to agree to supply production volume and sales information.
- Industry to agree to the publication generic portion of the study, e.g. "Optimization of Peanut Brittle Formulation and Process" after due review of the material.

Proposed by: The Leyte State University

(SGD)
DR. LUTGARDA S. PALOMAR
Co-Principal Investigator

Conforme:

Industry Collaborator

APPENDIX E

LETTER OF AGREEMENT FOR COLLABORATION

LETTER OF AGREEMENT FOR COLLABORATION

December 06, 2000

DR. LUTGARDA S. PALOMAR
Co-Investigator, P-CRSP-Philippines
and Professor
Visayas State College of Agriculture
Baybay, Leyte

Dear Dr: Palomar:

This is to formally accept your invitation for St. John's Farmers and Producers Cooperative to become the industry collaborator for the project on the Formulation and Process Optimization of Buray Peanut Brittle (Praline).

I have read the Proposal for R & D Collaboration and I agree in behalf of the Cooperative which I represent to abide by the Cost Sharing Scheme and the Terms of Reference stipulated in the proposal.

Very truly yours,

(SGD)
JULIO C. GABON
Chairman
St. John's Farmers and Producers Cooperative
Buray, Paranas, Samar

NOTE ON OPTIMIZATION OF LEVELS OF GARLIC FLAVORANT AND ROASTING TIME ON THE ACCEPTABILITY OF OVEN-ROASTED PEANUTS

Lorina A. Galvez[1]
Lutgarda S. Palomar[2]
Benjamin L. Cinto[3]
and
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ABSTRACT

A study was conducted in order to determine the effects of different levels of garlic flavorant and roasting time on the sensory qualities of flavored oven-roasted peanut, to manufacture a grease and mess-free roasted peanuts, to evaluate the consumers acceptance of the product, to optimize the combination and levels of flavorant and roasting time in processing the product and to verify the optimum acceptable region obtained in the optimization procedure. A 3 x 3 full factorial experiment using three levels each of garlic (4, 6 & 8 %(w/w)) and roasting time (40, 45 & 50 min) was then conducted to optimize the formulation and process of oven-roasted peanuts. Consumer acceptance test was done using the 9-point Hedonic scale in an incomplete block design. Statistical analyses revealed significant linear and quadratic effects in almost all of the parameters studied. Roasting time affected significantly the parameters while the amount of garlic did not show any significant effect. The verification experiment also revealed the predictive ability of the models used. Therefore, any formulation and process combinations containing any level from 4-8% (w/w) of the garlic flavorant and any level of roasting time below 47 minutes could produce a roasted peanut with an acceptability score of $\geq$6.50. Color seemed to be the limiting factor in the optimization procedure.

INTRODUCTION

Peanuts is a global crop (PCRSP, 1994) since it is widely distributed and important to both developing and industrialized countries. It has much to contribute to the solution of the world's food shortage, whether the need is for protein, edible oil, or calories and it is produced in more than 50 countries in all six continents (Garcia *et al*., 1990). Peanuts are described as nature's masterpiece of food values. Practically everybody likes them because of their pleasant aroma, irresistible nutty flavor, and smooth crisp texture.

Peanuts provide niacin, magnesium, Vitamin C, manganese, and chromium in significant amounts and smaller amounts of potassium, Vitamin B6, folic acid, phosphorus, copper, and biotin (http://www.allergysa.org/html/peanut.html). Peanuts are a good source of unsaturated fats. In fact, they contain 85 percent unsaturated by content and are cholesterol free. Peanuts do not contain *trans* fat but contain 52 percent monounsaturated and 33 percent polyunsaturated fat content. The fat in peanuts is needed to help maintain our immune system with a natural anti-inflammatory function to fight disease and infection. Unsaturated fat is a component of cell membranes, called phospholipids, needed for cell growth and daily repair in most of our body's cells (http://www.peanutbureau.ca/index.cfm?fuseaction=home.page&pid=47).

Raw and processed peanut products, however, have to be free of foreign matter, unadulterated with toxic or noxious substances, such as pesticides and aflatoxin. They should not be infected with insects or rodents, and free of spoilage and pathogenic microorganisms. To attain such, two stage roasting will be done with sorting out of infected kernels after the first stage roasting (KAAPII, 2003).

Roasted nuts are more flavorful and spoil less quickly, yet how they are roasted makes a big nutritional difference. Dry roasted nuts do not have any added fat while oil roasted nuts means the nuts are fried in oil, which adds around 10% more fat calories to the nuts. Furthermore, roasted nut is less costly in terms of processing expenses than oil roasted peanuts, because it does not need oil in its processing. In addition, the presence of oil could add greasy appearance to the nut, which is unsightly to the consumers.

Flavoring additives are necessary for improving the acceptability of most snack foods. Natural flavorants are favored nowadays because of its beneficial effects to ones health. Garlic is a natural flavorant commonly used in oil-roasted peanuts which is readily available in fresh and other forms that are powerful natural antibiotic including reduction of blood pressure in hypertension and other medical uses (Chevalier, 1996).

Garlic-flavored roasted peanut is one of the several processed products from peanut, which is flavorful and lasts for about 3-6 months. As a snack food, it is popular especially in the western countries like Europe, and US (KAAPII, 2003). Mostly, peanut products can be bought with messy, oily, and powdery textures. There is therefore a need to search for possible ways in order to reduce messiness, increase desirability, quality and increase peanut utilization and product diversification.

OBJECTIVES

This study was conducted to determine the effects of different levels of flavorant and roasting time on the sensory qualities of flavored oven-roasted peanut; to manufacture a grease-free and mess-free roasted peanuts; to evaluate the consumer acceptance of the product, to optimize the combination and levels of flavorant and roasting time in processing the product; and to verify the optimum acceptable region.

METHODS

Establishment of Collaboration

The search for a collaborator was done in order to identify a company to adopt the technology after which a memorandum of agreement was made incorporating the counter part funding and other issues

Procurement of Raw Materials

Raw peanuts were purchased from a supplier at Ormoc City, while garlic and salt were purchased at LSU, Visca market.

Experimental Design

A 3 x 3 full-factorial experimental design in randomized complete block design (RCBD) in 2 blocks or replicates was used in the study making a total of 9 treatments.

Preparation of Sample

Inspection and subsequent sorting out of infected shelled peanuts were done based on color, size and possible contamination of molds before it was introduced to first roasting. Peanuts having bad quality were sorted out and were separated from the batch.

Product Processing

Peanuts with skins, were sorted especially for shriveled kernels, then roasted in an oven at temperature of 185 ± 5 ^{o}C for 25 min then allowed to cool enough to be handled. The skin was removed manually after which the skin was separated from the peeled peanuts with the use of electric fan. Then, peanuts were manually sorted following the method of KAAPII (2003) to remove defective seeds, which are having yellowing color and other indication of possible contamination of aflatoxin using a standard (KAAPII, 2003). The sorted roasted peanuts were soaked in garlic-salt solution at 4%, 6%, and 8%(w/w) garlic at 12 %(w/w) salt concentration for 10 minutes with the ratio of 1:1 peanut:garlic-salt solution, and allowed to drain for 5 minutes. After draining, the peanuts were roasted at 185± 5^{o}C for 40.0, 45.0 and 50.0 minutes and were stirred every 5 minutes interval using a ladle. Finished products were cooled at room temperature for 45.0 minutes and were packed in 0.01 mm thick polyethylene plastic pouch and stored at room temperature prior to sensory and other product evaluation method.

Sensory Evaluation

The procedure of Palomar *et al.* (1994) was followed with some modifications. Forty (45) consumer panelists were randomly selected from among the employees and clients of the Department of Agriculture and City Court Ormoc City. The test was conducted on a table in a well-lighted room using a consumer testing ballot with 9-point hedonic scale. Each panelist evaluated five samples from the nine treatments employing the $\underline{t}$=9, $\underline{k}$=5, $\underline{r}$=10, $\underline{b}$=18, λ = 5, $\underline{E}$=.90 of Cochran and Cox (1957) where $\underline{t}$ refers to the number of treatments, $\underline{k}$ the number of samples presented to panelists, $\underline{r}$ the number replications based on the plan Incomplete Block Design (IBD), $\underline{b}$ the number of block and $\underline{E}$ the efficiency factor. The set plan was replicated 2.5 times so that each sample was evaluated by at least 25 consumers per replication.

Statistical Analyses

The data obtained from the sensory evaluation of the processed product was analyzed using Statistical Analysis System (SAS, 1985) program package. Analysis of Variance (ANOVA) based on F-test was used to determine the significance of the effects of processing variables on the sensory attributes of the product.

Optimization and Modeling

Response Surface Regression (RSREG) analysis using statistical computer software (SAS, 1985) was used to determine the effects of independent variables on the sensory qualities of the product and determine the optimum combinations of roasting time and garlic concentration for each dependent response studied. Response surface plots were made for all analyses as reference points using STATISTICA (version 5.0, Statsoft, Inc. 1984-1985) computer program to clarify the effects of variables on the response studied. Contour plots of each parameter were superimposed to come up with the optimum acceptable region with acceptability rating of $\geq$6.50.

Verification of the Optimized Region

Verification was conducted using three treatments selected from the range of values used. One treatment represented the optimum whereas the others did not. A t-test was conducted to determine if the observed values from the consumer test were significantly different from the predicted values (Spiegel & Stephens, 1999).

Technology Transfer

Standardization was first done at LSU and later on at the Collaborator's site. Due to some technical and economic constraints, since the modified process was adopted. So a search for another collaborator was done. The actual transfer has been done and commercialization is on going. The information on volume of production and other economic impacts will be reported in the Impact Assessment Project.

RESULTS

Sensory Evaluation

The summary of the ANOVA F-values on the different sensory qualities and overall effect of the independent variables are shown in Tables 1 and 2. Statistical analyses revealed that all of the sensory attributes were affected significantly by the linear effect of roasting time except texture (crunch). Significant quadratic effects of roasting time were also observed in overall acceptability, color, texture (crunch) and flavor acceptability. Furthermore, no significant crossproduct interactions were observed in all of the variables studied. Moreover, garlic concentration did not significantly affect its linear and quadratic effects to all parameters studied.

Table 1. ANOVA and model fitting for response variables[a].

Independent Variable	Overall	Color	Aroma	Texture	Taste	Flavor
Linear	10.969***	59.727***	3.517*	0.562 ns	7.569***	7.965***
Quadratic	3.656*	3.992**	0.331ns	3.418*	1.869 ns	3.265*
Cross product	0.179 ns	1.103 ns	0.0921ns	2.027 ns	0.0165 ns	0.706 ns
Total	5.886***	25.708***	1.558 ns	1.998 ns	3.779**	4.633***

[a] Significant level: *** Significant at $p \leq 0.001$ ** Significant at $p \leq 0.01$
* Significant at $p \leq 0.05$ ns=not significant

Table 2. ANOVA: Overall effect of the independent variables on response variables[a].

Independent Variable	Overall	Color	Aroma	Texture	Taste	Flavor
Amount of Garlic (%w/w)	0.260ns	0.393 ns	0.121 ns	1.149 ns	0.0707 ns	0.285 ns
Roasting time (min.)	9.612***	42.822***	2.506*	2.861*	6.234***	7.654***

[a] Significant level: *** Significant at $p \leq 0.01$ * Significant at $p \leq 0.05$ ns=not significant

Color acceptability. The means of the color acceptability values are shown in Table 3 which ranged from 5.68-7.27, neither like nor dislike to like moderately in the 9-point hedonic scale. The response was affected by the linear and quadratic effects of roasting time (Tables 1 and 2) since roasting process produce a darker color product (Woodroof, 1973). This could be attributed to the formation of pyrazine, the basic peanut flavor components which have a dark color (Woodroof, 1973). Koehler (1971) as cited by Woodroof (1973) found that the level of pyrazine compounds in roasted peanuts and similar foods appeared to be proportional to the extent of product browning, that is, the higher the amount of pyrazines formed, the more brown the product. The most direct route of their formation results from the interaction of alpha-dicarbonyl compounds (intermediate products in the Maillard reaction) with amino acids through the Strecker degradation reaction. Maillard reaction is a nonenzymatic browning reaction which undergo a sequence of three chemical reactions namely; condensation, rearrangement, and polymerization. Intermediate reaction with the potential for continued rearrangements are more complex in scope that in general color and flavor development begins at this stage (Murano, 2003).

It can be noticed that flavorant did not affect the color acceptability of the products (Table 2). Roasting time contribute much to the color acceptability rating as shown by the decreasing trend of the rating when roasting time was increased to 45 and 50 minutes . With the increase of roasting time, the color of the product becomes darker (brown) and consequently, color becomes a visual indication of the extent of roasting (Woodroof, 1973). Results further revealed that panelists neither like nor dislike the color of the products roasted at 50 minutes since they were already very dark which resulted from advance stage of Maillard reaction that caused a negative effect on food color which has been used as an indicator of economic value (Murano, 2003).

Table 3. Mean consumer acceptability ratings of the different treatments of garlic flavored roasted peanut.

Treatments			Overall	Acceptance Mean Rating				
Trt	X_1	X_2	Acceptability	Color	Aroma	Texture	Taste	Flavor
1	4.0	40	6.91	7.23	6.68	7.12	6.99	7.00
2	4.0	45	7.20	6.97	6.71	7.47	7.05	7.28
3	4.0	50	6.18	5.68	6.38	6.73	6.38	6.51
4	6.0	40	6.93	7.27	6.67	6.84	6.70	6.77
5	6.0	45	7.03	6.66	6.69	7.31	6.93	6.97
6	6.0	50	6.72	5.90	6.58	7.02	6.44	6.70
7	8.0	40	6.96	7.14	6.92	7.13	7.00	7.04
8	8.0	45	6.91	6.77	6.93	7.20	6.83	6.98
9	8.0	50	6.04	5.68	6.51	6.99	6.74	6.75

X_1 = percent garlic (w/w%); X_2 – roasting time (minutes)

Aroma. The means of the aroma acceptability ratings are found in Table 8.3. The means ranged from 6.38-6.93, like slightly to like moderately in the 9-point hedonic scale. Statistical analysis as shown in Tables 8.1 and 8.2 revealed that the variation of aroma acceptability was only affected significantly by the linear effect of roasting time. No significant difference was observed on the quadratic and crossproduct interactions. This can be explained by the heat processing or the roasting itself which can greatly improve the aroma of the roasted peanuts (Woodroof, 1973). Statistical results further revealed that any level of garlic did not affect significantly the aroma acceptability despite of its aromatic nature which can be explained by the low concentration of the garlic levels used in the study which resulted to the lowered intensity of the character note as perceived by the panelist. According to Murano (2003), the degradation of Amadori compounds favors formation of furfural, cyclic aldehydes in the form of a 5-membered ether ring. Perhaps the most desired compounds produced during intermediate reactions are pyrazines which have pleasant aroma and generated mostly in roasted products like roasted peanuts, coffee, and baked breads. Generally, acceptability ratings lowered significantly when the roasting time was extended to 50 minutes. At this stage, burnt aroma was developed due to the extended Maillard reaction which could affect negatively the aroma of the products.

Texture (Crunch). Texture of food is often related to the sound that may be produced by a food since sound can be important in the acceptance of the products. Means of the response ranged from 6.73-7.47, like slightly to like very much in the 9-point hedonic scale which implies that the different products have an acceptable sound when one bites it. Statistical analysis revealed a significant linear effect of roasting time on the texture (crunch) acceptability of the products (Tables 8.1 and 8.2). Quadratic and crossproduct interactions of roasting time caused no significant variation of the response. Of all the parameters studied, only texture (crunch) had rating of not lower than 6.5 which is a good indication of high acceptance of the products. It can be noted that texture (crunch) acceptability values were highest at the midlevel of the roasting time which is 45 minutes. Murano (2003) mentioned that food water activity can be viewed as a predictor of food texture. Furthermore, food texture of roasted peanut belong to the hard and crisp (lowest Aw) category. Hard textured foods are associated with bound water and relatively low moisture and Aw levels. Furthermore, food fat and moisture content also play a role in texture measurement and perception (Murano, 2003). When roasting time is extended to 50 minutes, a negative effect on the texture or crunch acceptability occurred since texture plays an important role in food acceptance by consumers which roasted peanuts should possess (KAAPII, 2003). Moreover, if the expected texture did not happen to a certain food, a panelist may dislike it.

Taste. The means of the taste acceptability scores are found in Table 3, which ranged from 6.38-7.05 in the 9-point hedonic scale. In some foods the sense of taste is the most important aspect of their acceptance. Statistical analysis showed only significant linear effect of roasting time on the response evaluated (Tables 8.1 & 8.2). Garlic levels did not affect the taste significantly since the panelists were not able to detect significant difference on the taste which means that the levels of garlic probably are too small to cause a significant variation on the taste acceptability considering that taste is the ability to respond to dissolved molecules and ions (Murano, 2003).

Generally, it can be observed that acceptability increases to the midlevel of roasting time which simply suggests that the taste of peanut plus the roasted flavor and garlic was more dominant in the midlevel of roasting time. Further heating caused a bitter taste on the product since burnt product was produced which could affect the consumer taste acceptability.

Flavor. Flavor is mainly composed of taste and odor or aroma (Deman, 1980). In this experiment, flavor acceptability rating were affected significantly by the linear and quadratic effects of roasting time (Tables 8.1 and 8.2) which means that roasting time was responsible for flavor of the product which might be due to its strong influence on the taste and aroma on the product which coincided with the results of aroma and taste acceptability.. While cross product interactions had no significant effect on the flavor acceptability. Maillard reaction produced a pyrazine compound which has pleasant aroma and odor (Murano, 2003). Alkyl pyrazines were contributors to the flavors of all roasted, toasted or similarly thermally processed foods which are viewed as products from browning reactions (Fennema, 1996). Furthermore, heating or roasting of nuts does enhance the flavor of the products (Woodroof, 1973). Fennema (1996) mentioned that browning reactions are almost always involved in the development of process flavors in foods. They contribute general nutty, meaty, roasted, toasted, burnt, or caramel odors.

Again, the acceptability scores were very high ranging from 6.51 to 7.28 since flavor is an overall integrated perception of all the contributing senses (Fennema, 1996). This simply suggests that the products had a good flavor.

Overall Acceptability. Overall acceptability serves as the reference parameter or the overall reaction or perception by the consumer panel. Results revealed that linear and quadratic effects of roasting time caused a significant difference on the overall acceptability of the product (Tables 1 and 2). Garlic levels did not affect the variation of the response. This can be interpreted that roasting time played a major role on the overall acceptability than the garlic level. This might be due to the low levels of garlic in the experiment that panelists were not able to detect significant differences on the overall acceptability. Roasting time affected all the parameters or variables studied in the experiment which is expected because it caused a significant change on the color, aroma, texture (crunch), taste and flavor of the products. Generally, it can be noted that the acceptability of all the parameters studied increased to the midlevel but further heating to 50 minutes, score responses decreased which means that the acceptance of the products declined due to its negative effect on the products.

Results from the consumer acceptance test further show that the range of overall acceptability rating was 6.04 to 7.21, which are within like slightly to like very much category in the 9 - point Hedonic Scale which indicates that the products were acceptable to the panelists.

Attaining the Optimum

In product development, optimization study has always been the goal of the processors to produce the maximum or minimum value of the response (Fishken, 1983). Furthermore, product optimization is the set of activities leading to the choice of a best product formulation (Sidel and Stone, 1983). Sensory evaluation is important in optimization studies wherein it is used in developing models that identify the specific sensory attributes that are most important to product preference (Schutz, 1983).

The contour plots of the interaction between garlic concentration and roasting time in each sensory attribute using the ≥6.5 using the 9-point Hedonic scale acceptability score were superimposed and the optimum region is shown in Fig. 1. Color acceptability values seemed to be the limiting factor during the optimization study. Moreover, it can be observed that more than half of the contour map going to the top occupied by the optimum region that is any level of roasting time below 47 minutes combined with any level of garlic flavorant from 4-8% (w/w) could produce an optimum product with $\geq$ 6.50 acceptability rating, which falls between the like slightly to like moderately in 9-point Hedonic scale.

Verification Study

The comparison between observed and predicted values for the sensory attributes of the three treatments tested is presented in Table 4. The t-calculated values were determined following the procedure adopted by Palomar *et al.* (1994). These values were compared with the standard values in Spiegel and Stephens (1999) and if t-calculated were lower than the t-tabulated, then it means a non-significant result. Study revealed a non-significant result in all parameters studied which imply the predictive ability of the models used in the optimization study. Furthermore, the processor has the confidence to choose any combination from the optimum region and is assured that the product that he can produce can really get an acceptability score of $\geq$6.50 using the 9-point hedonic scale.

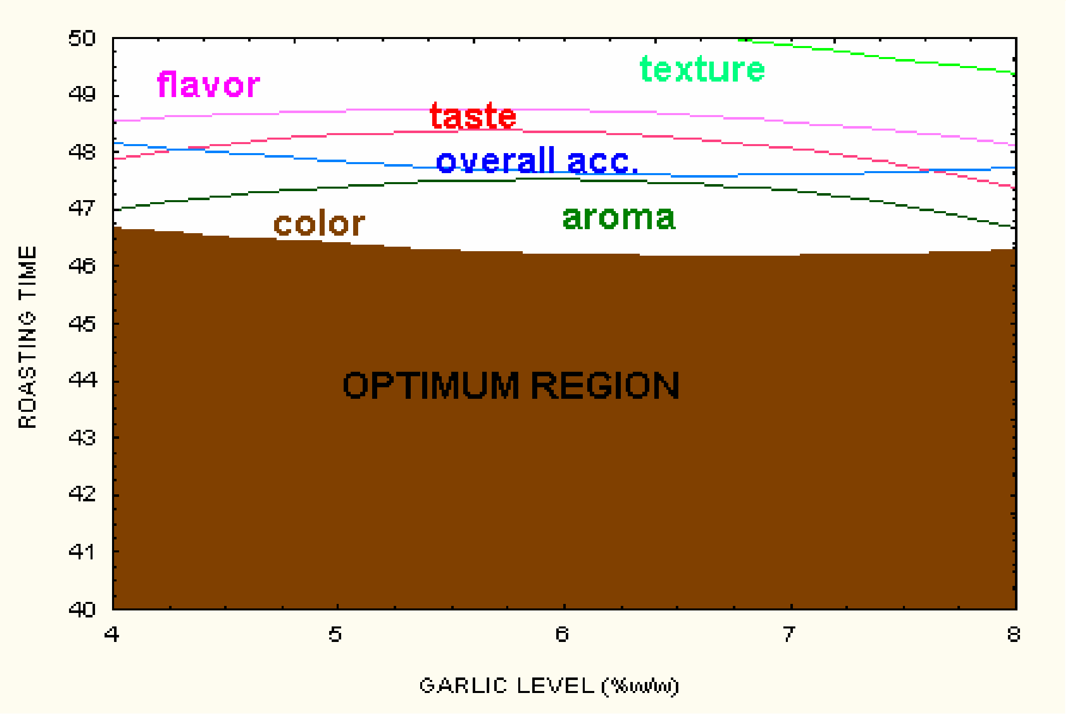

Fig. 1. Shaded region represents the optimum region between the roasting time in minutes and garlic level (%w/w)

Fig..2. Sample of roasted peanuts processed using the optimum conditions.

Table 4. Predicted and observed values for verification experiment

	X_1			X_2			X_3		
	Pred.	Obs.	t-value	Pred.	Obs.	t-value	Pred.	Obs.	t-value
Aroma	6.91	6.72	0.17 ns	6.39	6.62	0.15 ns	6.84	6.17	0.41 ns
Texture	7.21	6.98	0.20 ns	6.74	6.82	0.05 ns	7.17	6.92	0.19 ns
Taste	6.99	6.62	0.29 ns	6.43	6.75	0.18 ns	6.84	6.60	0.16 ns
Flavor	6.99	6.83	0.15 ns	6.54	6.65	0.07 ns	6.97	6.78	0.16 ns
Color	6.76	6.35	0.31 ns	5.74	7.20	1.17 ns	7.02	6.08	0.59 ns
Overall	6.89	6.83	0.05 ns	6.08	6.93	0.57 ns	7.10	6.65	0.29 ns

X_1 – RT= 50 min and GC = 6 %(w/w) ; X_2– RT = 40 min and GC = 8 % (w/w)
X_3 – RT= 48 min and GC = 5% (w/w) ;Ns-not significant at 5% level of significance
T-tab-1.67; where RT=Roasting Time and GC= Garlic Concentration

CONCLUSION

Roasting time affect significantly the sensory qualities namely; color, aroma, texture, flavor and taste of the different products. The levels of garlic did not have a significantly effects on the sensory qualities of the finished products. The.overall acceptability of roasted peanuts can be greatly affected by sensory qualities. The mess- and grease-free garlic-flavored roasted peanuts can be produced from high quality peanuts with high consumers' acceptance. The optimum garlic-flavored roasted peanuts with acceptability score of $\geq$6.5 can be processed using the combination of 4-8 % (w/w) of garlic and below 47 minutes of roasting time. The study showed the predictive ability of the models used in the experiment.

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http://www.allergysa.org/html/peanut.html visited March 8, 2007. Nutritive value of peanuts

http://www.peanutbureau.ca/index.cfm?fuseaction=home.page&pid=47 visited March 8, 2007 (85% of the fat in peanuts is the 'good' unsaturated fat (about 52% monounsaturated and 33% polyunsaturated); Unsaturated fats are important in heart health.

APPENDIX A

BALLOT FOR THE SENSORY EVALUATION OF GARLIC–FLAVORED ROASTED PEANUT

BALLOT FOR THE SENSORY EVALUATION OF GARLIC–FLAVORED ROASTED PEANUT

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 texture of the sample?	____	____	____	____	____
4. How do you rate the flavor of the sample?	____	____	____	____	____
5. How do you rate the taste of the sample?	____	____	____	____	____
6. 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

(Cochran and Cox, 1957)

SET PLAN OF INCOMPLETE BLOCK DESIGN USED FOR SENSORY EVALUATION

(Cochran and Cox, 1957)

(t=9, k=5, r=10, b=18, E=0.90, type V)

Block	**I**	**II**	**III**	**IV**	**V**
1	1	2	3	7	8
2	2	6	8	4	1
3	3	8	5	9	2
4	4	3	9	2	6
5	5	1	7	3	4
6	6	4	2	5	7
7	7	9	1	6	3
8	8	5	4	1	9
9	9	7	6	8	5
10	1	2	3	5	9
11	2	6	5	1	8
12	3	5	1	4	6
13	4	3	2	8	7
14	5	7	9	2	4
15	6	8	7	3	5
16	7	4	8	9	1
17	8	9	4	6	3
18	9	1	6	7	2