Physicochemical and sensory properties of a peanut drink

Dida Iserliyska[1*], Manjeet S. Chinnan[2], Anna V. A. Resurreccion[2]

(1. *Food Research and Development Institute, 154 Vassil Aprilov Blvd., Plovdiv 4000, Bulgaria*;
2. *Department of Food Science and Technology, University of Georgia, 1109 Experiment Street, Melton Building, Griffin, GA 30223-1797, USA*)

Abstract: A Peanut drink (PD) and a Chocolate-flavored peanut drink (CFPD) were developed in a pilot plant. Three different formulations of CFPD and one formulation of the PD were evaluated for quality changes during storage. Two separate batches were processed on two different days, to yield two replications, and each was then stored at 4℃ for a total of 21 days. Microbiological tests using the standard plate counts (SPC) and psychrotroph plate counts (PPC) were performed at 1, 8, 14, and 21 days on PD and the CFPD with 1.5% flavoring. Physical properties such as product color, pH, suspension stability index (top-bottom solids) and viscosity were analyzed to evaluate their changes during storage. Consumer acceptance tests were conducted to assess general acceptability and potential marketability of the fresh product treatments. The pH and suspension stability index (top-bottom solids) remained constant while viscosity increased with time in all the treatments. Changes in color lightness were negligible.

Keywords: beverage-processing protocol**,** chocolate-flavored peanut drink, sensory properties, suspension stability, viscosity, color

Citation: Iserliyska, D., M. S. Chinnan and A. V. A. Resurreccion. 2012. Physicochemical and sensory properties of a peanut drink. Agric Eng Int: CIGR Journal, 14 (2): 49－57.

1 Introduction

Physicochemical reactions during storage of food may lead to undesirable changes in its sensory and nutritional qualities. Changes in the physicochemical properties of pasteurized milk products may result in deterioration of product quality and become a limiting factor for the shelf life of the product. Contamination of milk with psychrotrophic bacteria is considered to be the most critical control factor influencing the keeping quality of milk (Craven and Macauley, 1992). The factors that limit the shelf life of refrigerated pasteurized milk products are: (1) time and temperature of pasteurization; (2) presence and activity of post pasteurization contaminants; (3) types and activity of pasteurization resistant microorganisms and (4) storage temperature after pasteurization (Cromie, 1991; Zadow, 1989). A fluid milk product with added sweeteners, such as chocolate milk, must be pasteurized at or above 75℃ for 15 s (FDA/CFSAN, 2001). Although it is designed to inactivate pathogenic bacteria in milk, pasteurization does not usually destroy all bacteria that are present in the product. As a result, extending sell-by dates beyond 21 days is not recommended, even under the best of processing conditions (Douglas et al., 2000).

The dairy beverage market is a competitive and growing category in the food industry. Chocolate milks are among the dairy beverages that vary widely in flavor, color, and viscosity. Creating a nutritious, flavored milk alternative would give consumers increased choices. Understanding the sensory properties that reflect consumer liking and purchase intent of chocolate milk is critical to maximize market share and profit for producers. The dairy foods industry would benefit from this knowledge in the improvement of existing and creation of

Received date: 2011-11-17 **Accepted date:** 2012-04-08
***Corresponding author: Dida Iserliyska,** email: dida_isser@yahoo.com.

new chocolate milk products (Thompson et al., 2004).

Chocolate has begun to draw scientific attention due to the potential health benefits provided by its antioxidant content (Coggins et al., 2004). The concept of using chocolate to compliment the milk flavor of milk-based beverages and drinks has been quite successful in the marketplace. Compatibility of milk and chocolate has been well recognized over the years. Since the introduction of products like Hershey®'s chocolate milk and chocolate flavored soymilks, many other chocolate flavored drinks have found much success with consumers. Development of a peanut-based, milk-like beverage would be of interest. There is very little reported information available for the compatibility of milk with peanut butter and their various combinations with chocolate.

The objectives of this investigation were to: 1) study changes in selected physicochemical properties; 2) determine microbial growth in peanut-based chocolate flavored beverage during storage; and 3) determine consumer acceptance and market potential of a peanut-based, chocolate flavored, milk like drink.

2 Materials and methods

2.1 Materials

Liquid, fat free, vitamin A&D skim milk (The Mayflower Co., Tulare, CA), fine premium pure cane sugar (Domino Foods, Inc., Yonkers, NY), liquid, fat-free caramel (Kroger Co., Cincinnati, OH) and two commercial beverages - vanilla soy milk (Silk, White Wave Foods, Broomfield, CO) and Hershey®'s chocolate milk (The Hershey Co., Hershey, PA) were purchased from a local grocery store. Natural peanut butter, Krema, with no added salt, sugar or hydrogenated oils was provided by Tara Foods, Albany, GA. In a previous preliminary study, the Satiagel X-amp 4000 (Degussa Texturant Systems Sales, LLC, Atlanta, GA), a stabilizer, that imparts suspension stability similar to that of commercial cow's milk and low viscosity comparable to that of commercial chocolate milk was identified and tested in sample formulations. This stabilizer was used in the present study. The selected flavor of chocolate was Hershey®'s European style, Dutch processed cocoa powder (The Hershey Co., Hershey, PA) purchased from the local market.

2.2 Methods

2.2.1 Preliminary work

The initial formulation and processing steps for beverage formulation were based on extensive literature review (Abdul, 1988; Hinds, Beuchat and Chinnan, 1997) and preliminary beverage preparation trials. The processing protocol established is presented in Figure 1. Six preliminary batches were made and changes in the physicochemical properties and microbiological safety were evaluated.

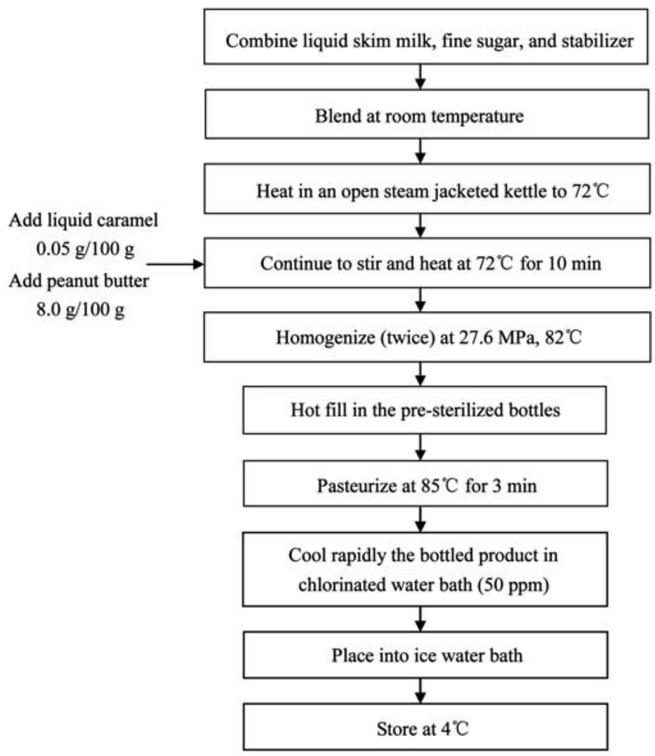

Figure 1 Pilot plant processing of peanut drink

2.2.2 Beverage processing

The base formulation, also referred to as 'control' (C_0), had no cocoa powder and the following ingredients: skim milk –85.43 g (100 g)$^{-1}$ of formula; fine sugar –6.5 g (100 g)$^{-1}$ of formula; stabilizer –0.02 g (100 g)$^{-1}$ of formula; peanut butter –8.0 g (100 g)$^{-1}$ of formula; and liquid caramel –0.05 g (100 g)$^{-1}$ of formula. Three chocolate flavored formulations were $C_{0.5}$, $C_{1.0}$ and $C_{1.5}$ consisting of 0.5, 1.0 and 1.5 g of cocoa, respectively, per 100 g of base formulation. Protocol for processing the beverage is described in Figure 1. Various ingredients were incorporated into the skim milk in sequence beginning with dry powders using a hand held mixer (General Electric, Co., Fairfield, CT) while heating the product in a steam jacketed kettle to 72℃ before transferring to a homogenizer set at 82℃ and 27.6 MPa (Gaulin, Everett, MA). Homogenization was done in two passes to ensure product consistency. Bottles used for packaging were sterilized in a retort at 120℃ and 1.03 MPa for 20 min. Bottled product was then pasteurized at 85℃ for 3 min followed by instant cooling in two stages, to prevent any breakage, first by placing in a chlorinated water bath (5 mg solute/1 L solution) and then in an ice bath.

2.2.3 Storage experiment

Two batches were processed on two different days and stored at 4℃ for a total of 21 days. Physicochemical measurements and microbiological analysis were conducted at intervals of 1, 8, 14 and 21 days.

2.2.4 Microbial assay

An agar plate-count method using non-selective plate count agar (PCA, Difco, Beckton Dickinson, Sparks, MD) was used. Enumeration of total micro flora and psychrotrophic microorganisms in the base formula (C_0) and a chocolate-flavored peanut drink formulation ($C_{1.5}$) was done.

2.2.5 Physicochemical measurements

Color: A Mini Scan XE colorimeter with CIE L*a*b* color scale (Hunter Associates Laboratory Inc., Reston, VA), was used to measure color. The colorimeter was calibrated against black and white standard tiles. The lightness (L) of the sample (where 0 is black, 100 is white), yellow or blueness (b) (where higher is more yellow, lower is more blue) and redness or greenness (a) (where higher is more red, lower is more green) were automatically calculated. Color measurements were performed on 40 mL beverage in a Hunter sample cup. Hue angle (H), and chroma (C) were calculated using the following equation:

$$C = [(a^*)^2 + (b^*)^2]^{0.5}$$

$$H = \tan^{-1}(b^*/a^*) \text{ when } a^* > 0 \text{ and } b^* > 0$$

$$H = 180^o + \tan^{-1}(b^*/a^*) \text{ when } a^* < 0$$

$$H = 360^o + \tan^{-1}(b^*/a^*) \text{ when } a^* > 0 \text{ and } b^* < 0$$

Viscosity measurements: 15 mL of well-mixed sample were added to a UL-Adapter sample holder. It was attached to DV-II+ unit of Brookfield digital viscometer (Brookfield Engineering Laboratories, Inc., Stoughton, MA) with spindle number set at ‘00’. Viscosity (cp) of the sample was measured at 10 RPM. Two samples were taken from each bottle. Two bottles of each formulation were examined and average viscosity values were calculated to compare the consistencies of various formulations.

Suspension stability index (SSI): The suspension stability index is the ratio of total solids in the top 1/3 of the sample bottle to total solids in the bottom 1/3 of the bottle. Twenty-five milliliters of sample was pipetted from the top 1/3 portion of a bottle and poured into a moisture pan with an aluminum liner (previously dried and weighed). Similarly a 25-mL portion from the bottom 1/3 of the bottle was transferred to a moisture pan. They were dried in the forced air oven (GS Blue M Electric, Stabil-Therm Electric oven) at 101℃ for 8 hours. The dry weights of the sample portions were recorded to calculate SSI values. Two bottles of each formulation were examined and average SSI values were compared to evaluate various levels of cocoa and the basic formulation.

pH: The pH was measured with an electronic pH meter (440 – CORNING, UK). All measurements were done at 20 ± 2℃.

2.2.6 Consumer acceptance test

Experimental design: Chocolate-flavored peanut drinks were prepared using three levels of cocoa powder. A peanut drink with no cocoa was used as a control. The four formulations were prepared in two processing replications for a total of eight batches. Panelists in the consumer test evaluated four samples in each session. Each person was asked to evaluate a total of 8 samples in two sessions within two test days. A group of 15 panelists evaluated the first replication and a second group of 15 panelists evaluated the second replication. Samples in each replication were presented to the panelists in randomized sequential monadic order. The order of presentation was balanced across the panel (Compusense® five, version 3.8, Compusense, Inc., Guelph, Ontario, Canada). The number of consumers that participated in the test was 15 panelists per session.

Consumer panel: A consumer acceptance test was conducted in the sensory laboratory at the Department of Food Science and Technology, Griffin Campus. A panel of consumers (*N* = 30) was recruited according to demographic surveys about milk consumption patterns (Hammarlund, 2002) and age/gender groups (USDA Center for Nutrition Policy and Promotion, 2000) from an existing consumer database, which was established and maintained in the Department since 1984. Participants were screened to be regular consumers of milk and milk beverages (includes cocoa, soy milk, milk shakes, chocolate milk or any flavored milk, tea or coffee with milk, cereal with milk); between 18 and 64 years of age; have no allergies toward peanuts, sucrose, milk, cocoa, caramel or carrageenan; must like and consume milk and milk beverages at least once in every two weeks; be permanent US residents for at least 10 years; and be available and willing to participate in all the testing sessions.

Test procedure: On the test dates panelists came to the sensory laboratory for tests scheduled and conducted hourly between 11:30 am and 3:00 pm for a total of two days within two consecutive weeks. At the first session, panelists were welcomed by a greeter and given a brief overview on how to operate the signal light buttons in the booths. The panelists were then asked to read and sign two copies of a consent form approved by the University of Georgia Institutional Review Board. Upon completion of the consent form, panelists were asked if they had allergies towards any of the ingredients in the product and the answers were recorded. Consumers were then asked to provide demographic information. Upon completion of the demographic questionnaire, the panelists were led to partitioned booths and asked to evaluate the samples under white incandescent light in an environmentally controlled sensory laboratory.

Approximately 60 g of each refrigerated sample (10℃) were poured into 3 oz plastic cups, pre-coded with three digit random numbers and served on a tray along with Styrofoam cup with lid for expectoration, a cup for drinking water and unsalted crackers. Consumers then rated, using pen and paper ballot, their overall liking of the sample, appearance, color, texture/mouthfeel, flavor/taste, peanut flavor, chocolate flavor as well as their purchasing behavior of each sample using a 9-point hedonic scale (Peryam and Pilgrim, 1957) with 1=dislike extremely and 9=like extremely.

2.2.7 Statistical analysis

Statistical analysis was carried out using SYSTAT® 7.0 Statistics (SPSS Inc. 1997). One-way Analysis of Variance (ANOVA) was performed with storage time as a factor. T-paired means test was used to determine each sensory attribute. Fisher's Least Significance Difference (LSD) test was performed. Regression analysis (PROC REG) was used to calculate the coefficient of correlation (r) and to develop prediction models for each dependent attribute (y) based on independent chocolate concentration (x) as well as to determine the relation between sensory attributes and overall acceptance (StatSoft Inc. 2005. STATISTICA®).

3 Results and discussion

3.1 Microbiological quality

The initial bacterial counts [standard plate count (SPC) and psychrotrophic plate count (PPC)] in chocolate-flavored peanut drink ($C_{1.5}$) were less than 100 CFU mL^{-1}. Chocolate-flavored products had lower bacterial numbers at day 8 (102.3 CFU mL^{-1} for SPC and 74.13 CFU mL^{-1} for PPC) as well. On day 14, both of the formulations had PPCs greater than 20,000 CFU mL^{-1} (Figure 2) indicating that any spoilage, which may have occurred, would probably have been caused by psychrotrophic organisms.

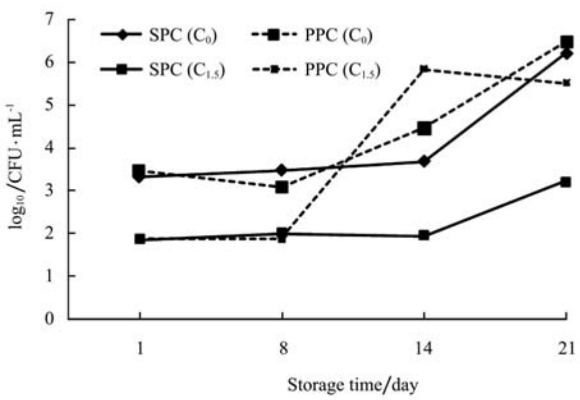

Figure 2 Microbial numbers [standard plate count (SPC) and psychrotrophic plate count (PPC)] in control (C_0) and chocolate-flavored peanut drink with 1.5g cocoa (100 g)$^{-1}$ of base formulation ($C_{1.5}$) stored at 4℃

3.2 Physicochemical properties

pH: The pH of the chocolate-flavored treatments measured only a slight change (0.3%) after 21 days of storage at refrigerated temperature (4℃) (Figure 3). There was a slight decrease in pH of C_0 (1.9%) at day 21. Analysis of Variance, ANOVA (Table 1), showed that overall the storage time did not significantly influence pH.

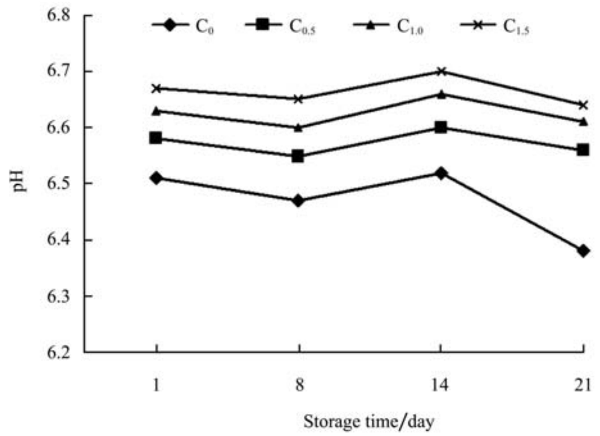

Figure 3 Effect of storage time on pH of the control (C_0) and chocolate-flavored peanut drink treatments ($C_{0.5}$, $C_{1.0}$, and $C_{1.5}$)

Table 1 Analysis of Variance (ANOVA) for effect of storage time on physicochemical properties of beverages

	F-ratio[a]			
Samples	pH	Viscosity	SSI	Lightness
C_0	7.9	89.1*[b]	2.30	1.15
$C_{0.5}$	11.1	78.2*	0.20	4.10
$C_{1.0}$	9.1	96.2*	0.90	2.30
$C_{1.5}$	13.3	35.8*	1.02	2.06

Note: [a] F – ratio has 3 and 44 degrees of freedom;
[b] Significant at 0.05 confidence level.

Viscosity: Viscosity of all four treatments increased during storage (Figure 4).

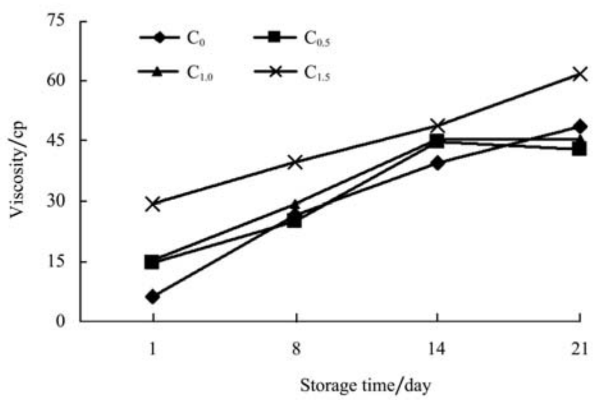

Figure 4 Effect of storage time on viscosity of the control (C_0) and chocolate-flavored peanut drink treatments ($C_{0.5}$, $C_{1.0}$, and $C_{1.5}$)

The chocolate flavored beverages were more viscous than the base formula at day 1. At day 21, $C_{0.5}$ (42.8 cp), $C_{1.0}$ (45.5 cp) were less viscous than the control (C_0) (48.4 cp). Commercial Hershey®'s low-fat chocolate milk had viscosity of 51.4 cp. Viscosity values of the formulation $C_{1.5}$ increased considerably during storage (from 29.2 to 61.6 cp). Statistical ANOVA showed the changes in viscosity were significantly affected by the storage time ($p = 0.05$) (Table1). Viscosity of the peanut drink formulations increased considerably after 21 days of storage, indicating onset of age gelation. However, no formulation of typical gel structure occurred, and the beverages had free-flowing characteristics. A possible cause of age gelation in the peanut drink beverages could be the presence of the gelling agent-Satiagel X-amp 4000. Carrageenan type stabilizers containing pure kappa or kappa and iota blends stabilize food systems by forming threadlike networks and protein-polysaccharide complexes (Modliskzewski, 1984; Hinds, Beuchat and Chinnan, 1997). This suggests that under the conditions of milk-based solution consisting of milk, peanut butter and sucrose, sucrose would form peanut protein-polysaccharide network formations and carrageenan casein micelle aggregates resulting in more viscous formulations. Stirring the beverages during the heat treatment before homogenization also increases the formation of intermolecular networks (Hinds, Beuchat and Chinnan, 1997).

Suspension stability index: Suspension stability index values after averaging for day 1, 8, 14, and 21 were 0.93 for control (C_0) and 1.02 for two chocolate-flavored formulations $C_{0.5}$ and $C_{1.5}$. $C_{1.0}$ showed an average suspension stability index value of 0.96. The effect of storage time was not significant (Table 1). It was observed from the literature that suspension stability indices of commercial chocolate low-fat milk and chocolate drink were 1.00 and 0.96, respectively. Since the investigated liquid food system was made up of skim milk incorporated with peanut butter and stabilizer the separation of visible layers of vegetable oil-in-skim milk/water emulsions was observed immediately after preparation. That might have been caused by the creaming of relatively large fat globules with a density smaller than that of the continuous phase, clumping of small globules through interaction between absorbed macromolecules (protein naturally present and added stabilizer) to form large clusters (flocculation), and coalescence of the small globules into large units (Dickinson and Stainsby, 1988).

In our study, the protocol adopted the regimen with a moderate homogenization temperature and pressure because of the susceptibility of skim milk to proteolysis during homogenization; although, partial thermal protein denaturation can increase the emulsion stability as evidenced. Similarly, heat treatment after homogenization increased the stability of emulsions (Kinsella and Whitehead, 1988; Das and Kinsella, 1990) as noted in the present investigation.

Color: Color values *L**, *a** and *b** of various treatment formulations during storage are shown in Table 2. The effect of storage time on lightness was not significant (Table 1). Changes in lightness, *a** and *b** for treatment formulations during storage were negligible ($p \le 0.05$) (Table 2) which is also reflected in the lack of changes in chroma and hue angle. A wide range of lightness values was found varying from very light colored samples (L^*=78.69 for C_0) to dark (L^*=37.37 for $C_{1.5}$). This was comparable to commercial vanilla soy milk and Hershey®'s chocolate milk lightness values of L^*=72.6 and L^*=39.6, respectively. The color of the control (C_0) was yellowish (H = 80.25 – 79.67), whereas the chocolate flavored treatments $C_{0.5,}$ $C_{1.0}$ and $C_{1.5}$, were more reddish, (H = 49.29 – 40.70) (Table 2).

Table 2 Instrumental color measurements of peanut beverage formulations[a]

Samples	Storage time	L^{*b}	a^*	b^*	Chroma	Hue angle[c]
C_0	Day 1	77.73±2.85a	2.14±0.56a	12.14±1.43a	12.33±1.51a	80.25±0.54a
	Day 8	78.69±2.61a	2.04±0.40a	11.91±0.88a	12.08±0.88a	80.20±1.10a
	Day 14	77.81±2.30a	2.22±0.41a	12.18±0.91a	12.38±0.91a	79.67±1.24a
	Day 21	78.27±2.44a	2.30±0.44a	12.40±1.23a	12.61±0.95a	79.67±1.21a
$C_{0.5}$	Day 1	51.24±1.58a	8.32±0.57a	9.04±1.72a	12.28±1.69a	47.57±1.20a
	Day 8	51.04±1.76a	8.17±0.66a	8.88±0.97a	12.07±0.93ab	47.57±1.30a
	Day 14	54.99±2.09a	7.72±0.75a	9.05±0.73a	11.89±0.74ab	49.29±2.06ab
	Day 21	52.33±1.55a	8.39±0.45a	9.13±0.77a	12.40±1.21a	47.57±1.25a
$C_{1.0}$	Day 1	43.80±0.09a	9.73±0.08a	9.02±1.14a	13.27±0.05a	42.99±0.05a
	Day 8	42.57±0.09ab	9.60±0.15a	8.88±1.63a	13.08±0.02a	42.99±0.03a
	Day 14	44.47±1.37ab	9.50±0.05a	9.05±2.15a	13.12±0.03a	43.56±0.02a
	Day 21	41.84±0.28ab	9.75±0.48a	9.11±1.91a	13.34±0.01a	42.99±0.02a
$C_{1.5}$	Day 1	40.82±0.07a	10.15±0.08a	8.96±0.08a	13.54±0.49a	41.27±0.41a
	Day 8	37.37±1.04a	10.20±0.07a	8.83±0.01a	13.49±0.27a	40.70±0.28a
	Day 14	39.92±1.04a	10.15±0.09a	9.03±0.41a	13.58±0.17a	41.84±0.31a
	Day 21	37.70±0.42a	10.42±0.06a	9.15±0.27a	13.87±0.03a	41.27±0.44a

Note: [a]Means within the same column with different letters are significantly different ($p \le 0.05$);
[b] L value: 0 – black, 100 – white;
[c] Hue angle H: 0^0 - red, 90^0 – yellow.

3.3 Consumer test

The results from the microbiological assessment were too inconsistent to guarantee a safe product. It was therefore impossible to have consumers evaluate the keeping quality of the product during its storage. In accordance with the second goal of this study a consumer test for acceptance of fresh product was conducted.

3.3.1 Consumer responses on acceptance questions

The mean consumer ratings for overall acceptance, appearance, color, texture, flavor, peanut flavor, and chocolate flavor of peanut drink various formulations evaluated by American consumers (N = 30) as well as their willingness to purchase the products were determined (Table 3). The results showed that the treatments $C_{0.5}$ and $C_{1.0}$ had the highest mean ratings for all attributes evaluated in the consumer acceptance test. The significant differences of the hedonic ratings for the sensory attributes and consumers' purchasing behavior for peanut drink with different formulations are presented in Table 3.

Table 3 Mean hedonic ratings and difference between means of chocolate peanut drink samples and the panelists' willingness to purchase[a]

Samples	Overall acceptance	Appearance	Color	Texture	Flavor	Peanut flavor	Choc flavor	Willingness to purchase
C_0	5.5a	4.9c	4.4c	6.3abc	5.7a	5.6ab	4.9c	4.4a
$C_{0.5}$	6.3b	7.0ab	7.1ab	6.6ab	6.4b	6.2c	6.5b	6.0b
$C_{1.0}$	6.5b	7.2a	7.3a	6.8b	6.4b	5.9abc	6.5b	5.9b
$C_{1.5}$	5.6a	6.7b	6.8b	6.1c	5.5a	5.5b	5.9a	5.0a

Note: [a]Means within the same column not followed by the same letter are significantly different at ($p \leq 0.05$).

Overall Acceptability: Samples $C_{0.5}$ and $C_{1.0}$ were significantly higher in overall acceptance compared to the rest of the samples. Their mean ratings were 6.3 and 6.5 (like slightly) compared to samples C_0 and $C_{1.5}$, which had ratings of 5.5 and 5.6 (neither like nor dislike), respectively.

Appearance: Formulation $C_{1.0}$ was rated significantly higher in appearance acceptance compared to all other samples but similar to treatment $C_{0.5}$ while each was rated like moderately ($x = 7.2$, $x = 7.00$), whereas sample $C_{1.5}$ was rated similarly to sample $C_{0.5}$ and had a mean rating of 6.7 (like slightly). There was a significant difference among sample C_0 ($x = 4.9$, dislike slightly) and the rest of the treatments.

Color: Formulation $C_{1.0}$ was rated significantly higher for color acceptance but similar to formulation $C_{0.5}$ ($x = 7.3$ and $x = 7.1$, like moderately), whereas $C_{1.5}$ was rated as like slightly ($x = 6.8$). There was no significant difference between sample $C_{0.5}$ and either of samples $C_{1.0}$ or $C_{1.5}$, respectively. Sample C_0 was rated as dislike slightly ($x = 4.4$) and was significantly different from the rest of the formulations.

Texture: All the mean ratings for acceptance of mouthfeel/texture were rated above 6.1 (like slightly), indicating that all of the treatment formulations were liked by consumers. The mouthfeel/texture of sample $C_{1.0}$, which had a mean rating of 6.8 was rated significantly higher but similar to the rest of the samples excluding treatment $C_{1.5}$ ($x = 6.1$) which rated similarly to treatment C_0 ($x = 6.3$).

Flavor: The treatment formulations $C_{0.5}$ and $C_{1.0}$ ($x = 6.4$, like slightly) were rated significantly higher in flavor acceptance compared to all other samples. Formulations C_0 and $C_{1.5}$ were rated as neither like nor dislike ($x = 5.7$ and $x = 5.5$, respectively). There was no significant difference among the latter two samples.

Peanut Flavor: The sample $C_{0.5}$ ($x = 6.2$, like slightly) was rated significantly higher in acceptance of peanut flavor compared to all other treatments but similar to treatment $C_{1.0}$ which had a mean ratings of 5.9 (neither like nor dislike) whereas there was no significant difference among samples C_0, $C_{1.0}$ and $C_{1.5}$.

Chocolate Flavor: Treatment formulations $C_{0.5}$ and $C_{1.0}$ ($x = 6.5$, like slightly) were rated significantly higher in acceptance of chocolate flavor compared to the rest of the samples. Sample $C_{1.5}$ ($x = 5.9$, neither like nor dislike), whereas sample C_0, which had a mean rating of ($x = 4.9$, dislike slightly), were significantly different.

Consumer Purchase Intent for Samples: Treatment $C_{0.5}$ showed the highest value ($x = 6.0$, slightly likely) closely followed by treatment $C_{1.0}$ ($x = 5.9$, neither likely nor unlikely) when consumers' willingness to purchase peanut drink was evaluated. Sample $C_{1.5}$ ($x = 5.0$, neither likely nor unlikely) and treatment C_0 ($x = 4.4$ was slightly unlikely to purchase) had no significant difference between them.

3.4 Effect of chocolate concentration on sensory attributes ratings

Regression models with a coefficient of correlation $r \leq 0.13$ and p-value <0.05 were overall acceptance, appearance, color, texture, flavor, peanut flavor and chocolate flavor as well as willingness to purchase. The calculated F-values between the significant full and reduced models indicated that a full quadratic equation model could be used to predict the responses of sensory attribute ratings from the independent variable chocolate concentration. These models are presented in Table 4 which was then used to generate regression plots. The Figure 5 is presented as an example figure for the model.

Table 4 Regression analysis of the sensory attribute variables in the four peanut drink formulations and coefficient of correlation (*r*)

Sensory attribute	Model	(*r*)
Overall liking	$y = -1.7x^2 + 2.65x + 5.475$	0.13
Appearance	$y = -2.6x^2 + 5.02x + 4.96$	0.69
Color	$y = -3.2x^2 + 6.28x + 4.49$	0.71
Texture	$y = -1x^2 + 1.42x + 6.26$	-0.17
Flavor	$y = -1.6x^2 + 2.28x + 5.69$	0.16
Peanut flavor	$y = -1x^2 + 1.38x + 5.64$	-0.24
Chocolate flavor	$y = -2.2x^2 + 3.9x + 4.95$	0.51
Willingness to Purchase	$y = -2.5x^2 + 4.09x + 4.445$	0.29

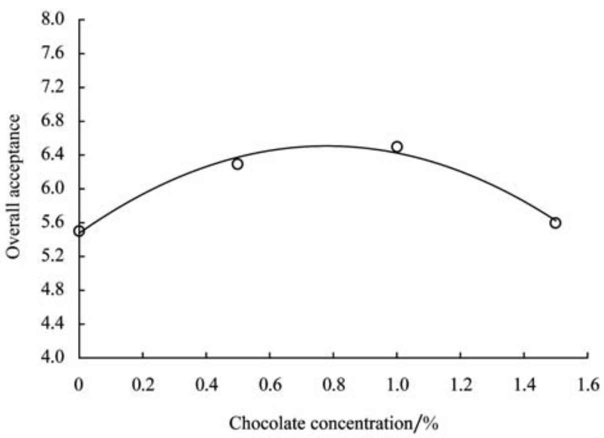

Figure 5 Regression line showing effect of chocolate concentration on hedonic ratings for overall acceptance

Regression models developed to predict the responses of sensory attributes ratings from the independent variable level of chocolate concentration indicated that $0.23 < x < 1.33$ chocolate resulted in an overall acceptance of 6 (Figure 5). Optimum appearance was obtained with $0.24 < x < 1.69$ chocolate, optimum color was obtained with $0.28 < x < 1.68$, and optimum texture was obtained with $-0.16 < x < 1.58$. To have a rating of 6 for flavor, peanut flavor and chocolate flavor; the chocolate concentration used should be $0.15 < x < 1.27$; $0.35 < x < 1.03$ and $0.33 < x < 1.44$, respectively. The optimum range for chocolate concentration for willingness to purchase should correspond to $0.60 < x < 1.03$. The prediction models demonstrated consumer acceptance decreases when you are above the level of: 0.78 for chocolate concentration for overall acceptance (Figure 5), 0.96 for appearance, 0.98 for color, 0.71 for texture and flavor, 0.69 for peanut flavor and 0.89 for chocolate flavor. For chocolate concentration greater than 0.82, willingness to purchase also diminishes.

3.5 Relationship between overall acceptance and sensory attributes

There was a relatively strong relationship between overall acceptance and sensory attributes ($R^2 = 0.83$). The coefficient of multiple regressions between overall acceptance and sensory attributes (Table 5) showed appearance, color and flavor significantly affected overall acceptance.

Table 5 Regression coefficients between overall acceptance and sensory attributes

Parameters	Overall acceptance estimate
Intercept	0.38 ns
Appearance	0.31 *
Color	0.14 **
Texture	0.06 ns
Flavor	0.38 **
Peanut flavor	0.06 ns
Chocolate flavor	0.003 ns

Note: ns-nonsignificant; *-significant at 0.05, **-significant at 0.01.

4 Conclusions

Changes in the physicochemical properties of the treatment formulations stored at refrigerated temperature (4℃) were minimal for storage up to 21 days. No reduction in pH, suspension stability and color occurred through the entire period of storage. SSI values (0.94 for C_0, 1.02 for $C_{0.5}$, 0.97 for $C_{1.0}$ and 1.02 for $C_{1.5}$) were similar to that of commercial chocolate low-fat milk (1.0) and chocolate drink (0.96). Viscosity increased with time in all treatments but resulted in viscosity values (48.39 cp for C_0, 42.8 cp for $C_{0.5}$ and 45.5 cp for $C_{1.0}$) comparable to that of commercial Hershey®'s low-fat chocolate milk (51.4 cp). However, microbiological stability only remained high for 8 days at refrigerated storage. Results of PPC on day 14 (>20,000 CFU mL^{-1}) indicated that contamination of the product at some stage during the processing with psychrotrophic bacteria is the most critical factor that influences keeping quality of the beverages. Further work will be done to improve the microbiological stability of the product.

The consumer panel rated chocolate flavored peanut drink treatment $C_{1.0}$ (1.0% cocoa powder) as the best product. It received the highest consumer ratings for overall acceptance, appearance, color and texture followed closely by treatment $C_{0.5}$ (0.5% cocoa powder). The formulation $C_{0.5}$ showed the same values as formulation $C_{1.0}$ for flavor and chocolate flavor but received higher consumer ratings for peanut flavor and purchase intent. Main differences were observed in appearance and chocolate flavor for treatment C_0 (no added cocoa powder). C_0 was the least preferred peanut drink. A chocolate flavored peanut drink has a market potential among consumers that are looking for a nutritious flavored milk alternative who might be apt to choose a peanut based beverage similar to the chocolate peanut drink.

Acknowledgements

This research was supported by the Peanut Collaborative Research Support Program of US Agency for International Development, USAID grant No DAN-4048-G-0041-00. The irreplaceable assistance provided by Mr. Glenn Farrell and Mrs. Vijaylakshmi Mantripragada in conducting pilot plant work and consumer-affective sensory test is highly appreciated.

References

Abdul, A. J. 1988. Making a natural food peanut punch. *United States Patent*. 4: 746, 530.

Coggins, P. C., A. A. Glueck-Chaloupka, M. L. Tynes, S. L. Drake, and J. A. Wilbourn. 2004. Consumer acceptance of a processed chocolate-cheese emulsion product. In *proc. IFT Annual Meeting*, July 12-16, Las Vegas, NV.

Compusense® five, version 3.8, Compusense, Inc., Guelph, Ontario, Canada.

Craven, H. M., and B. J. Macauley. 1992. Microorganisms in pasteurized milk after refrigerated storage. *The Australian Journal of Dairy Technology*, 47(1): 38-45.

Cromie, S. J. 1991. Microbiological aspects of extended shelf life products. *The Australian Journal of Dairy Technology*, 46(2): 101-104.

Das, K. P., and J. E. Kinsella. 1990. Effect of heat denaturation on the adsorption of b-lactoglobulin at the oil-water interface and on coalescence stability of emulsions. *Journal of Colloid and Interface Science*, 139(2): 551-560.

Dickinson, E., and G. Stainsby. 1988. Advances in food emulsions and foams. London: *Elsevier Applied Science*. ISBN-13: 9781851662005.

Douglas, S. A., M. J. Gray, A. D. Crandall, and K. J. Boor. 2000. Characterization of chocolate milk spoilage patterns. *Journal of Food Protection*, 63(4): 516-521.

FDA/CFSAN. 2001. *Grade "A" pasteurized milk ordinance (PMO)*. U.S. Department of Health and Human Services, Washington, D.C.

Hammarlund, R. 2002. A Study of marketing issues with Organic milk. Dept of Agricultural Economics, Kansas State University, Reviewed August.

Hinds, M. J., L. R. Beuchat, and M. S. Chinnan. 1997. Properties of a thermal-processed beverage prepared from roasted partially defatted peanuts. *International Journal of Food Science and Technology*, 32(3): 203-211.

Kinsella, J. E. and Whitehead, D. M. 1988. Emulsifying and foaming properties of chemically modified proteins. In: *Advances in Food emulsions and foams*, (edited by E. Dickinson and G. Stainsby): 163-188.

Modliskzewski, J. J. 1984. In Gum and Starch Technology, 18^{th} Annual Symposium, ed. D. L. Downing, Cornell University, Ithaca, NY: 25-31.

Peryam, D. R. and P. J. Pilgrim. 1957. Hedonic scale method for measuring food preferences. *Food Technology*, 11**:** 9-14.

SPSS Inc. 1997. SYSTAT® 7.0 Statistics. ISBN 0-13-679739-3. Version 7.0.1., Chicago, IL.

StatSoft Inc. 2005. STATISTICA®: The Small Book. Tulsa, OK.

Thompson, J. L., M. D. Yates, K. Lopetcharat, and M. A. Drake. 2004. Mapping consumer preferences of commercial chocolate milk. *IFT Annual Meeting*, July 12-16, Las Vegas, NV.

USDA Center for Nutrition Policy and Promotion. 2000. Consumption of Food Group Servings: People's Perceptions vs. Reality, October.

Zadow, J. G. 1989. Extending the shelf life of dairy products. *Food Australia*, 41(9): 935-937.