EFFECTS OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON PHYSICAL CHARACTERISTICS OF CHOCOLATE BEVERAGE POWDERS

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ABSTRACT

Chocolate beverage powders (CBPs) were produced from alkalized cocoa powder (ACP) at 10-30% and soy lecithin (SL) at 0-4%. Response surface methodology (RSM) was used to determine the optimum level of ACP and SL on sedimentation, wettability, bulk density, despersibility, moisture content and flavor acceptability. SL was effective on wettability, and it also showed an optimum level for sedimentation and bulk density, while ACP was found to be significant for all physical properties. For sensory evaluation, flavor was acceptable at 20% ACP level soy taste was detected by panelists in CBPs with high SL and low ACP contents. It was found that as the ACP content was increased the soy taste of CBPs decreased. For overall physical characteristics, the optimum levels of 20% of ACP and 2-4% of SL were selected.

INTRODUCTION

High content of cocoa powder in chocolate beverages will develop high chocolaty taste, but it may affect the physical properties such as increasing sedimentation of cocoa particles and decreasing their wettability and dispersibility due to its cocoa butter content. The three important physical defects in chocolate milk are sedimentation of cocoa particles (forming a densely packed layer at the bottom of the packages), formation of large flocs, and formation of a light and a dark colored layer (Van Den Boomgaard *et al.* 1987). Chocolate beverage powders face some physical problems, i.e., poor wettability, low dispersibility and

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sedimentation of cocoa particles after reconstitution (Gutcho 1977). These are more pronounced when cows' milk is used as the solvent. Cocoa powder particle size influences flavor, mouthfeel, color, texture, viscosity and solubility (Duxbury 1986).

Emulsifiers must be used in chocolate milk products to stabilize the oil in water emulsion. They are used more often in combination with stabilizers in chocolate drinks (Anon 1992) and dissolved in butter oil for spraying on full-fat milk powders (Pisecky 1978b). According to Pisecky (1978b), wettability of whole milk powders can be improved by agglomeration and treatment with surfactants. Lecithin has been widely used as a surfactant in whole milk and in chocolate beverage powders to increase their wettability. Lecithin is usually the surfactant of choice for chocolate beverages. Vogt *et al.* (1990) described a process for manufacturing an agglomerated chocolate powder using lightly defatted cocoa powder (20-22% fat) along with a high content of lecithin (0.5-1%, preferably 0.9%) together with sucrose, glucose, lactose and NaCl. Many other researchers have used lecithin in making chocolate powders (Slowinski 1971; Vogel and Moeschl 1979; Kniel 1993).

Soy lecithin is prepared by degumming crude soybean oils and drying the hydrated gums (Schofield 1981). Addition of large quantities of SL to the chocolate powders increases their wettability but imparts a beany off-flavor.

The objective of this study was to determine the effect of alkalized cocoa powder (ACP) and soy lecithin (SL) on sedimentation, wettability, bulk density, dispersibility and moisture content of spray chocolate beverage powders (CBPs), and flavor acceptability of chocolate drinks made from them.

METHODOLOGY

Preparation of Cocoa Beverage Solution for Spray Drying

The cocoa beverage solution was prepared by mixing alkalized cocoa powder (ACP), soy lecithin (SL), nonfat dry milk (12.00%), sugar (5.00%), salt (0.60%), vanillin (1.00%), carboxylmethyl celullose (0.30%), corn syrup (10.00%), and water (39.10 -57.58%). A flow sheet for preparing the solution is shown in Fig. 1.

Spray Drying Parameter

The cocoa beverage powders were prepared using a mini spray dryer (Buchi 160) with inlet temperature at 165C, outlet temperature at 90-100C and flow rate of 9-10 mL/min. Total volume of cocoa beverage solution being spray dried for each batch was 1200-1300 mL.

Experimental Design

ACP and SL were obtained from Koko Malaysia Inc. and Damah Trading, respectively. The level of ACP and SL used are listed in Table 1. A Central Composite Rotable Design (CCRD) consisting of 13 design points (9 formulations with 5 replications) was used to calculate the combination of the two variables (ACP and SL). The two variables were codated as: -1.414, -1, 0, I and 1.414. This design was based on response surface methodology as described by Cochran and Cox (1957).

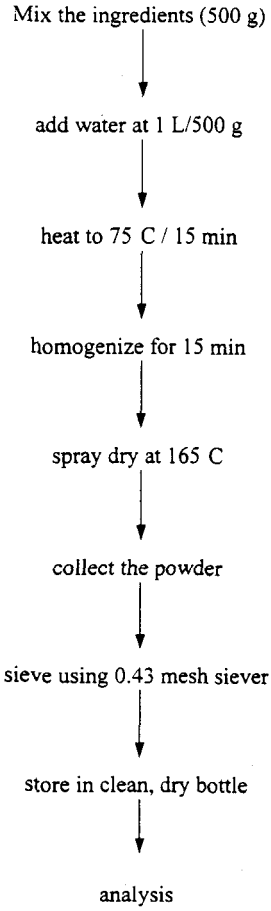

FIG. 1. FLOW SHEET FOR PROCESSING CHOCOLATE BEVERAGE POWDERS

TABLE 1.
CENTRAL COMPOSITE DESIGN (CCRD) FOR CHOCOLATE BEVERAGE POWDERS VARIABLES

Experiment	x1 (ACP)	Percent (ACP)	x2 (SL)	Percent (SL)
1	-1	12.93	-1	0.59
2	1	27.07	-1	0.59
3	-1	12.93	1	3.14
4	1	27.07	1	3.14
5	-1.414	10.00	0	2.00
6	1.414	30.00	0	2.00
7	0	20	-1.414	0.00
8	0	20	1.414	4.00
9	0	20	0	2.00
10	0	20	0	2.00
11	0	20	0	2.00
12	0	20	0	2.00
13	0	20	0	2.00

Physical Analysis

Sedimentation. Ten grams of sample were made up to 100 mL with whole milk (65C) in a volumetric flask. The solution was shaken vigorously for 5 min before pouring 10 mL into each three volumetric cylinders. After 45 min, the sedimented residue was measured and the percentage of sedimentation was calculated following the formula below:

$$\text{Percentage, of sedimentation} = \frac{\text{mL of sediment residue x 100}}{\text{volume}}$$

Dispersibilty. Dispersibility was determined using Lees method (1975). Five grams of sample were made up with distilled water to 250 mL in a volumetric flask. It was shaken frequently for about 5 min and allowed to stand overnight (12 h) then centrifuged at 2500 rpm for 20 min. Twenty-five mL of the clear liquor was pipetted into a weighed, dry stainless steel (2 cm × 4 cm IID) crucible. The residue was dried in an oven (Sartorius NLA, 300, Germany) at 105C for 3 h and weighed again. The sample was returned to the oven for another 30 min before it was cooled and weighed for the second time. If substantial alteration in weight has occurred, the sample was redried and reweighed.

Wettability. Dispersibility was determined according to the modified method of Hansen (1980). He used the method to determine the wettability of agglomerated fat in filled milk powder. One gram of sample was allowed to wet in 100 mL of water at 60C in a 250 mL beaker. The time taken to wet the sample was recorded in seconds.

Bulk Density. Bulk density was determined by filling a weighed beaker (100 mL) with sample, striking off the sample overfill, tapping for ten times and weighing the sample. This method is classified as a loose bulk density which was described by Pisecky (1978a).

$$\text{Bulk density (g/mL)} = \frac{\text{weight of final sample (g)}}{\text{volume (mL)}}$$

Determination of Moisture Content. A rapid method of moisture determination was used in order to prevent sample hydration. One gram of sample was analyzed using an oven (Sartorius MA300, Germany) at 105C.

Flavor Acceptability. Twenty trained panelists were selected to evaluate the reconstituted powders for flavor acceptability. The evaluation was carried out using 100 mm line scale (Stone *et al.* 1974); the line was anchored on the left (100 mm) and right (0 mm), respectively, with like extremely and dislike extremely. Reconstitution was done by mixing 40 g of CBPs with 50 g sugar and 100 mL hot water (100C). Each panelist was given about 15 mL of warm (60C) reconstituted CBPs samples. Warm water (about 60C) was provided for rinsing between samples.

Procedure for Plotting Three Dimensional Graphs

Analysis of variance (ANOVA) was used to determine significant differences among 13 treatment combinations. The data were analyzed by regression procedure to estimate ACP and SL effects on physical property responses. Three-dimensional graphs and contour plots generated from Statgraphics (1993) were produced from the equation data.

RESULTS AND DISCUSSION

Sedimentation

Sedimentation of cocoa particles is a common physical defect on the bottoms of the chocolate drink packages. Figure 2 shows that SL had a significant effect on the sedimentation level of CBPs. When the amount of soy lecithin was increased from 0 to 2.0%, sedimentation decreased significantly. The minimum sedimentation occurred when SL was at 2%, then it increased up to 4% SL addition. However, an increase in ACP content at that level slightly changed the sedimentation. Lecithin contains a lipophilic as well as a lipophobic moiety, therefore, it can react as a surface-active agent which reduces the interfacial or surface-tension in the emulsion system (Hamburg 1982). According to Buchanan (1972), sedimentation of cocoa particles may be controlled by reducing the cocoa

powder content. Cocoa powder is generally insoluble, heavy and has large particles (Anon 1992), thus the minimum point of sedimentation of CBPs was observed due to their low ACP content. However, when cocoa powder content increased to more than 20%, sedimentation was found to decrease. This phenomenon can be explained according to Van den Boomgard *et al.* (1987) who described a weak coagulation of protein and protein covered cocoa particles. The presence of a suitable stabilizer is a prerequisite for the formation of a stabilized chocolate milk network. In this study, carboxylmethyl celullose (CMC) was used as a stabilizer at 0.3% level, thus CMC and SL can form a network with protein and protein covered cocoa particles to prevent the sedimentation of cocoa particles. From the proximate analysis, ACP contained 22.10% crude protein. Therefore, an increase of ACP level in CBPs contributed additional protein which interacted to stabilize the cocoa particles. A large quantity of ACP in CBPs can also increase the viscosity of chocolate beverages, thus preventing the cocoa particles from settling.

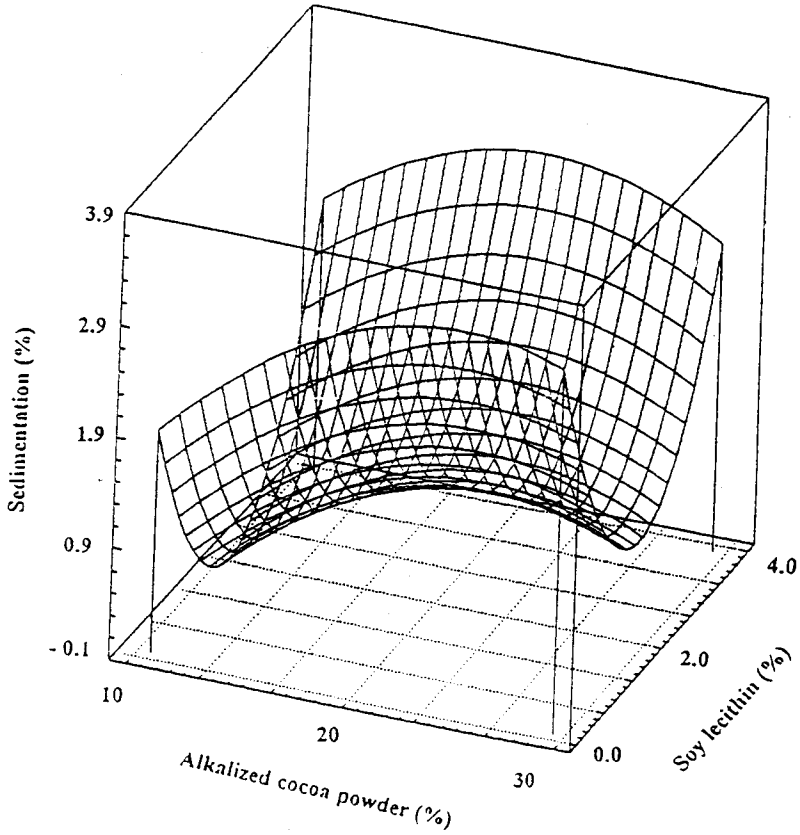

FIG. 2. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON SEDIMENTATION OF CHOCOLATE BEVERAGE POWDERS

Wettability

Cocoa powder posesses poor wetting properties because of its high fat content. When sprinkled on cold water, cocoa powder floats on the surface for some time (Hamburg 1982). Chocolate beverage powders contain cocoa powder as well as sugar, skim milk powder or nonfat milk, malt and other cereals, salt, vitamins and minerals.

Addition of SL is an important step in CBPs production in order to improve wettability and absorption by water or other solvent when reconstituted. The surface of cocoa particles of CBPs is covered by free fat (cocoa butter), which makes the powder water repellent. Lechithin can be sprayed as a liquid at a temperature of approximately 60C on the heated product, or an aqueous dispersion (10%) can be added as a fine aerosol in a heatable mixer (Hamburg 1982). In this study, SL was mixed with the other ingredients prior to spray drying at 165C. The addition of SL using this method helps spread lecithin and covers other ingredients while spraying into fine particles.

Figure 3 shows the wettability of CBPs was affected by ACP and SL. As the ACP content increased at low SL content, the time for wettability increased significantly; at the minimum content of ACP (10%) and maximum content of SL (4%), wettability occurred the fastest. Minifie (1970) reported that lecithin was used at a level of 1.5-2.0% in cocoa cake before grinding to produce instant wetting properties of cocoa powder. Pisecky (1978b) reported that lecithin is a good surface active agent because of its superior functional performance, i.e., achieving of instant properties, lecithin has both polar and nonpolar groups, high surface activity and is reactive with both oil and protein, making it an excellent emulsifying agent in food systems (Cherry *et al.* 1981). These functional properties cause CBPs containing lecithin to have good wettability. In addition, poor wettability can be due to the increase in cocoa butter content when ACP was increased. According to Van Niewanhuyzen (1981), cocoa powders with low fat content possess a fat film on their surfaces. As a result, it is not possible to obtain the dispersion of powder in water or milk at temperatures below the melting point of the fat (35C). This explains the result of our study which showed the combination of 10% ACP and 4% SL to have a good wettability for CBPS.

Bulk Density

Bulk density decreased when ACP content was increased especially at 2-4% (Fig. 4). ACP contained 11.45% fat by Soxhlet method; thus inclusion of ACP in CBPs resulted in agglomerated or lumpy powders. Lumpy powders have a great volume of voids resulting in low bulk density. According to Pisecky (1978b), low bulk density milk powder can be produced by agglomeration. In this study, CBPs were produced by spray drying without an agglomeration process; however the high content of ACP induced some agglomeration (lumpiness) and hence a low bulk density powder.

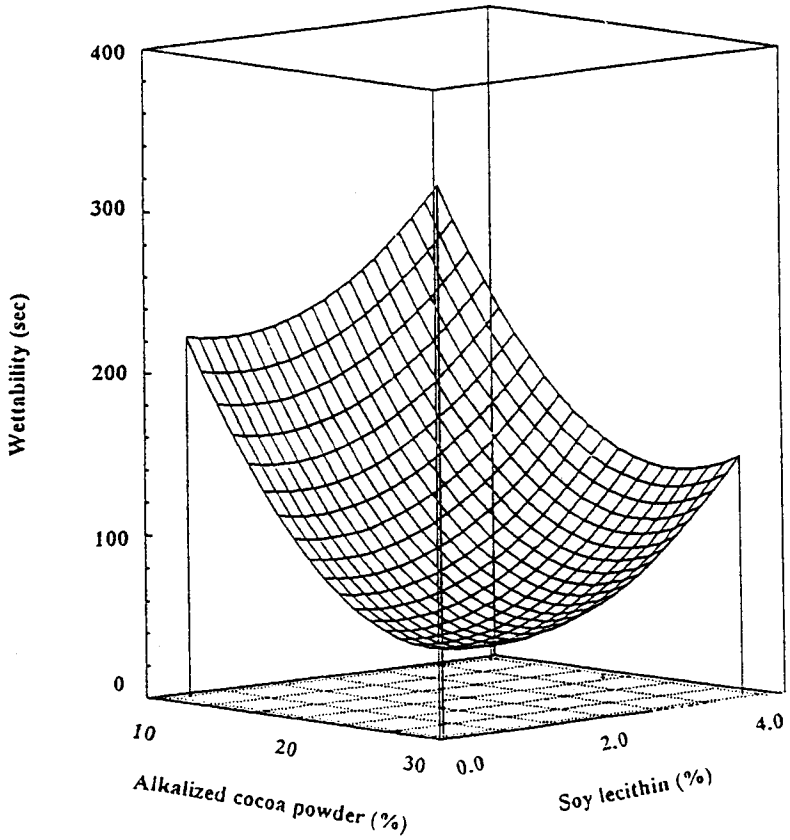

FIG. 3. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON WETTABILITY OF CHOCOLATE BEVERAGE POWDERS

SL also influenced bulk density (Fig.4). When SL content was increased up to 2.58%, the loose bulk density increased. These powders may not have been able to lump because they were covered by a thin layer of SL; as a result their bulk density increased as the volume of CBPs decreased. After the addition of more than 2.58% SL, bulk density decreased due to the excessive amount of free fat from SL itself CBPs began to lump, and increasing the volume and resulting in decreasing of bulk density to the 4.0% SL level.

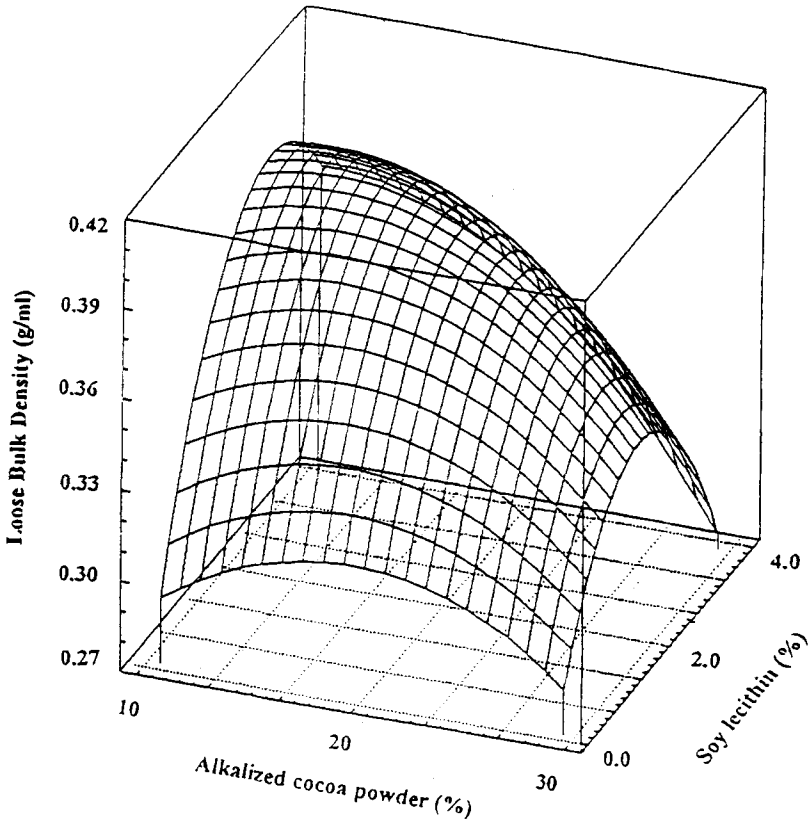

FIG. 4. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON BULK DENSITY OF CHOCOLATE BEVERAGE POWDERS

Dispersibility

Generally, ACP did not disperse easily in either cold and hot water due to its cocoa butter content. Dispersibility of CBPs was greatly affected by ACP content (Fig. 5). Increased ACP content decreased the dispersibility significantly. According to Gutcho (1977), cocoa powder itself is not easily dispersible in water because of the fat remaining therein. In this study, dispersibility of ACP itself was analyzed and found to be 34.4%. Dispersibility of ACP was considerably lower than that of CBPs which had been mixed with sugar and corn syrup, and ranged in dispersibility from 58 to 71% (Fig. 5). Lees and Jackson (1973) reported that, alkalization of cocoa powder prior to final grinding increased the dispersibility

slightly in the ranges between 19-25% dependent on the conditions of production. While SL did not significantly affect the dispersibility of CBPS, it did function as an emulsifier and wetting agent.

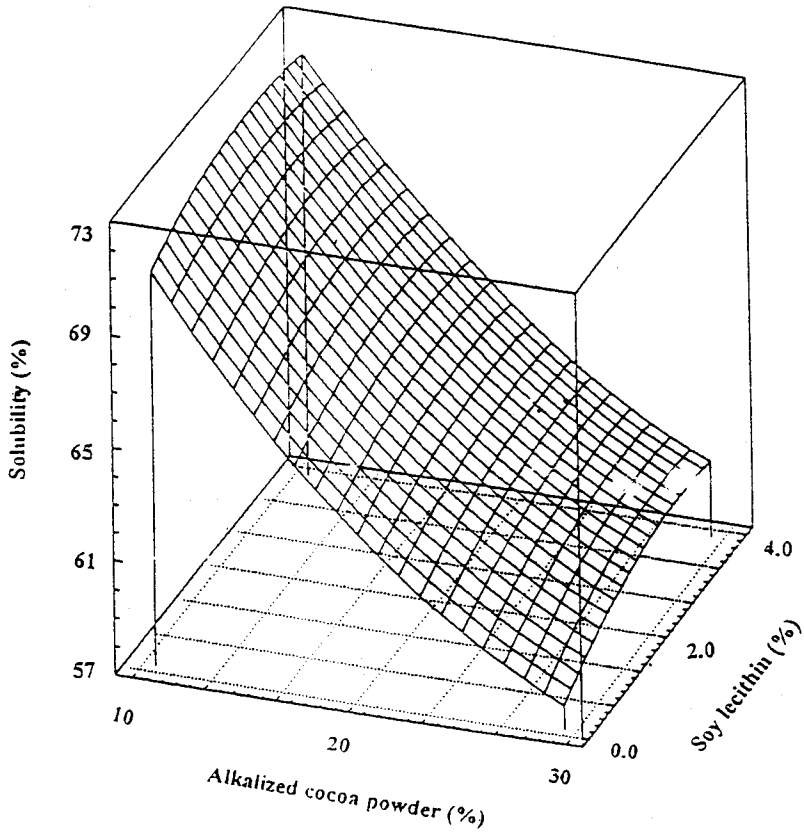

FIG. 5. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON SOLUBILITY OF CHOCOLATE BEVERAGE POWDERS

Moisture Content

Moisture content was lowest at 24.5% ACP and 2.74% SL levels (Fig. 6). I-Egh moisture content can be decreased to 3-4% by adjustment of the drying process. A high content of ACP prevents CBPs from absorbing moisture from the environment during sieving. SL did not show any significant effect on the moisture content of CBPS.

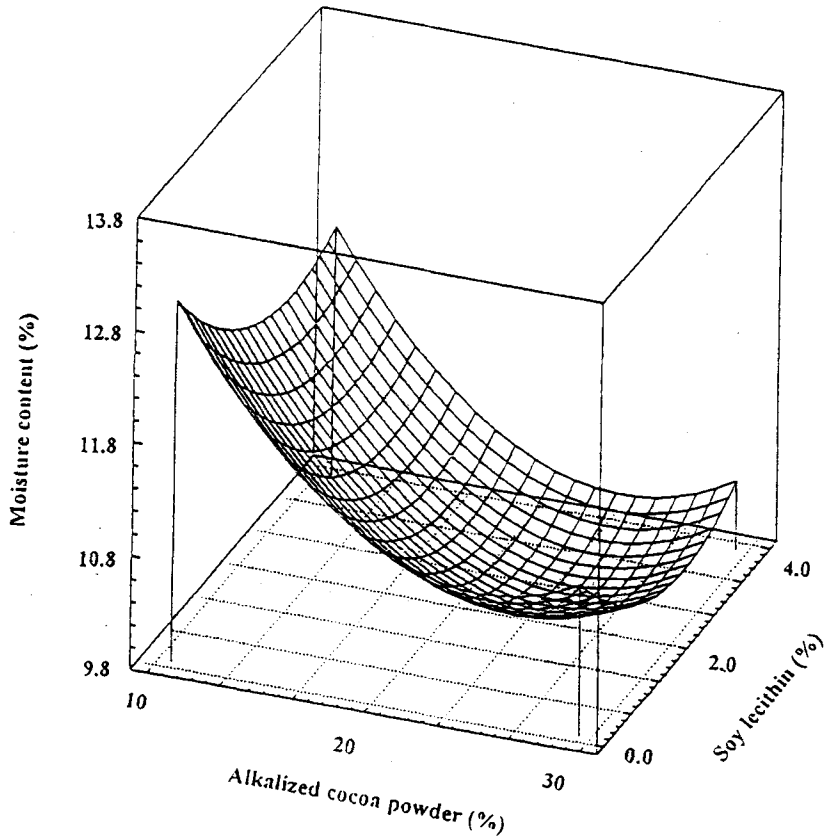

FIG. 6. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECITHIN ON MOISTURE CONTENT OF CHOCOLATE BEVERAGE POWDERS

Flavor Acceptability

A very rich and pleasant flavored drink can be prepared from cocoa powder. Figure 7 shows optimum flavor acceptability of reconstituted CBPs at 21.94% ACP and 3.80% SL. ACP had a significant effect on flavor acceptability of the reconstituted CBPs. Panelists preferred an intermediate medium level of ACP because it tasted delicious, was moderately bitter, and was comparable to commercial chocolate beverage powders. SL has been reported to have a straw-like off-flavor but it has been used in making chocolate and instant cocoa powder (Minifie 1970). Addition of SL up to 4% did not affect flavor score significantly and 20-30% ACP, but it decreased flavor acceptability when used at the 10% level.

Panelists complained about the beany or soy flavor in formulations with 10% ACP and 4% SL content. The beany or soy flavor can be reduced by increasing the ACP content in the formulation.

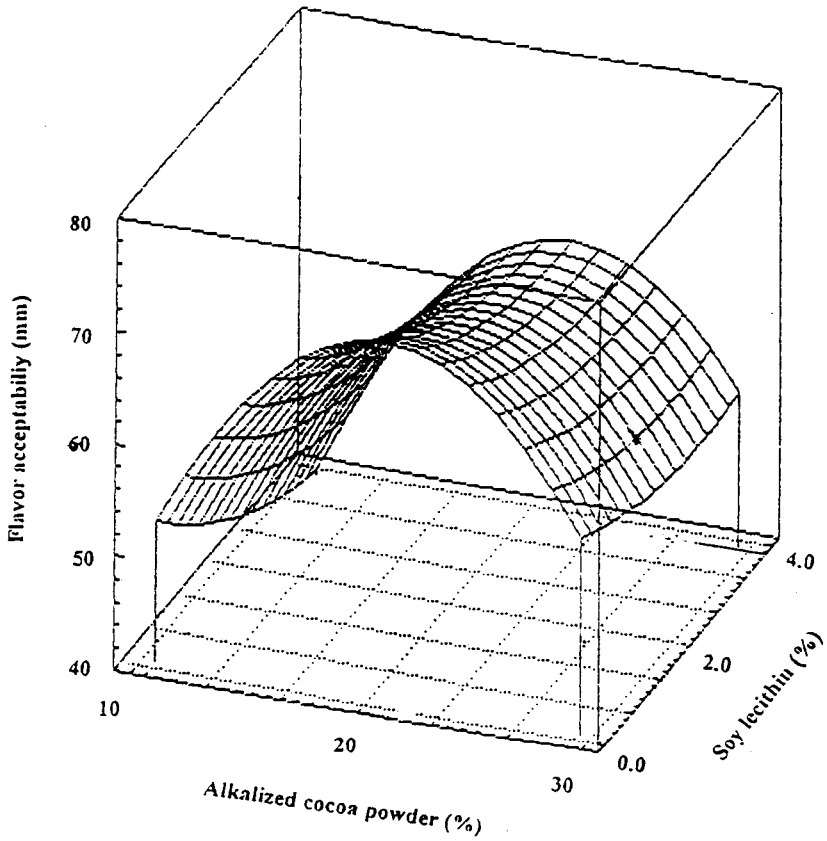

FIG. 7. THREE DIMENSIONAL PLOT ON THE EFFECT OF ALKALIZED COCOA POWDER AND SOY LECHITHIN ON FLAVOR ACCEPTABILITY OF CHOCOLATE BEVERAGE POWDERS

CONCLUSION

Sedimentation of CBPs was affected by ACP and SL. The optimum level of sedimentation was at 2% SL. At higher addition levels, SL was an effective wetting agent of CBPS. Higher levels of ACP decreased CBPs wettability. Optimum wettability occurred at 10% ACP and 4.0% SL. The optimum level of

SL (2.58%) increased bulk density and improved wettability. Solubility of CBPs was affected by ACP level due to its cocoa butter content, while SL did not affect the solubility significantly. Flavor acceptability of CBPs was optimum at 21.94% ACP and 3.80% SL. Higher SL levels produced objectional beany off-flavor which was covered up by the chocolate flavor at the higher ACP levels. It can be concluded that the overall optimum SL and ACP levels were around 2.0-4.0% and 20%, respectively.

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