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ORIGINAL ARTICLE

Dehydrated mango (*Mangifera indica* L.) applied in milk chocolate development to sucrose reduction purpose: An innovative and success' case driven by sensory perspective

*Manga desidratada (*Mangifera indica *L.) aplicada no desenvolvimento de chocolate ao leite para fins de redução de sacarose: Um caso inovador e de sucesso pela perspectiva sensorial*

Marcella Benetti Ventura[1]*, Cecilia Teresa Muniz Pereira[1], Valdecir Luccas[2], Helena Maria Andre Bolini[1]

[1]Universidade de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos (FEA), Campinas/SP - Brasil
[2]Centro de Tecnologia de Cereais e Chocolate, Instituto de Tecnologia de Alimentos (ITAL), Campinas/SP - Brasil

***Corresponding Author:** Marcella Benetti Ventura, Universidade de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos (FEA), Rua Monteiro Lobato, 80, CEP: 13083-862, Campinas/SP - Brasil, e-mail: ella_mv@hotmail.com

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Abstract

The present study aimed to evaluate the sensory profile of milk chocolates, with partial substitution of sucrose for dehydrated mango, and to verify consumer liking regarding this product. Sensory analysis was performed using Quantitative Descriptive Analysis (QDA®) with a trained panel. Acceptance test and Temporal Dominance of Sensations (TDS) were performed with consumers. Descriptive analysis showed that the addition of mango did not impact characteristics such as "color", "brightness", "homogeneity", "hardness", "melting", and "adhesiveness". In Acceptance test, samples did not show a significant difference in Tukey's honestly significant difference test (Tukey HSD) ($p > 0.05$) concerning to appearance. Correlation between descriptive and hedonic data showed that descriptive terms that negatively influenced the acceptance of chocolate bars were: "acid taste", "brown sugar flavor" and "astringency".

Keywords: Spray dried fruit; Cocoa; Consumer; Trained panel; Acceptance; Indulgence food.

Resumo

O presente estudo teve como objetivo avaliar o perfil sensorial de chocolates ao leite, com a substituição parcial da sacarose por manga desidratada, e verificar a preferência do consumidor em relação a esse produto. A análise sensorial foi realizada usando Análise Descritiva Quantitativa (QDA®) com um painel treinado. Teste de Aceitação e Dominância Temporal de Sensações (TDS) foram realizados com os consumidores. A análise descritiva mostrou que a adição de manga não impactou características como "cor", "brilho", "homogeneidade", "dureza",

"derretimento" e "aderência". No Teste de Aceitação, as amostras não apresentaram diferença significativa no teste de diferença significativa de Tukey (p > 0,05) em relação à aparência. A correlação entre os dados descritivos e hedônicos mostrou que os termos descritivos que influenciaram negativamente a aceitação das barras de chocolate foram: "sabor ácido", "sabor de açúcar mascavo" e "adstringência".

Palavras-chave: Fruta desidratada; Cacau; Consumidor; Painel treinado; Aceitação; Alimento indulgente.

Highlights

- Mango addition did not impact appearance and texture characteristics
- Consumers noticed no difference in appearance
- Descriptive terms that negatively influenced the acceptance of chocolate bars were: "acidic taste", "brown sugar flavor" and "astringency"

1 Introduction

There is a growing concern of consumers looking for healthier and more sustainable foods. With increase in purchasing power, this population is willing to pay more for food that has higher quality without harming their health. This way, there has been an increase in innovations in the "guiltless indulgence" category, which incorporate products such as chocolate containing fruit or with reduced or sugar-free composition (Brasil Food Trends 2020, 2010).

Brazil stands out as one of the first countries in the world to seek to reduce sugar in processed foods (Ministério da Saúde, 2018), as sucrose is responsible not only for the flavor, but also for other very important sensory characteristics such as texture. The use of sucrose provides, in addition to sweetness, viscosity to the medium, making the product stable. Thus, for it to be replaced, it must be analyzed whether the characteristics of the final product have not been altered (Sahin et al., 2019).

Addition of dehydrated fruits in chocolate is a form of innovation that has been gaining ground in market due to the benefits that these ingredients provide to the final product (Ferreira et al., 2017; Augusto et al., 2019). In this scenario, addition of mango (*Mangifera indica* L.) to chocolate could make it possible to reduce its sucrose content and make feasible a new flavor, as mango is a fruit known for its sweetness. Also, mango is one of the most commercially important cultures in the world in terms of production, marketing and consumption (Santos et al., 2014).

In order to analyze the acceptability and characterize new products, sensory analysis is widely used as tool. Considering that sensory perception is a dynamic phenomenon (Lawless & Heymann, 2010), dynamic descriptive techniques such as Temporal Dominance of Sensations (TDS) are gaining importance (Azevedo et al., 2017; Rodrigues et al., 2016; Kiumarsi et al., 2021).

The perceived intensity of sensory attributes changes along with the transformation of food into the bolus and release of olfactory compounds during food breakdown (Sudre et al., 2012; Lawless & Heymann, 2010). Also, QDA® allows the complete sensory profile of the product in question to be traced, identify its intensities and makes association with affective analysis of consumer study, correlating more or less accepted characteristics (Muñoz et al., 1996).

Thus, this study aimed to formulate samples of milk chocolate with addition of dehydrated mango as a partial substitute of sucrose, in order to determine the sensory profile, understand the response of consumer related to the final product and correlate results found in static and dynamic tests with trained panel and consumers.

2 Materials and methods

2.1 Materials

Selected ingredients for samples formulation were as follows: crystal sugar (Usina Colombo®, Ariranha, SP, Brazil); deodorized cocoa butter and cocoa liquor (Olam International®, São Paulo, SP, Brazil); whole milk powder and skimmed milk powder (Piracanjuba®, Governador Valadares, SP, Brazil); spray dried dehydrated mango containing maltodextrin (Naturex®, Bischofszell, Switzerland); liquid soy lecithin (Solec SH, Solae®, Barueri, SP, Brazil); and PGPR (polyglycerol polyricinoleate 90, Danisco®, São Paulo, SP, Brazil).

Six different samples of milk chocolate were produced, partially replacing sugar with dehydrated mango (CM0: standard sample, without addition of mango; CM3: 3% of reduction of sugar and 3% of addition of mango; CM6: 6% of reduction of sugar and 6% of addition of mango; CM9: 9% of reduction of sugar and 9% of addition of mango; CM12: 12% of reduction of sugar and 12% of addition of mango; CM15: 15% of reduction of sugar and 15% of addition of mango). Proportion ingredients of the formulations are shown in Table 1. Standard formulation with ideal sucrose concentration was defined based on previous studies of milk chocolate (Palazzo et al., 2011). Commercial chocolate has around the same percentage of sugar that represents the standard sample. Thus, percentages of substitution for dehydrated mango were made in a subtle way (from 3%). This way, differences noticed from one sample to another could be more explained according to the degree of substitution (DS).

Table 1. Formulations of chocolate samples.

Ingredients (%)	Samples					
	CM0	CM3	CM6	CM9	CM12	CM15
Sucrose	43.0	40.0	37.0	34.0	31.0	28.0
Cocoa butter	21.4	21.4	21.4	21.4	21.4	21.4
Cocoa liquor	14.0	14.0	14.0	14.0	14.0	14.0
Whole milk powder	12.0	12.0	12.0	12.0	12.0	12.0
Skim milk powder	9.0	9.0	9.0	9.0	9.0	9.0
Powdered mango	-	3.0	6.0	9.0	12.0	15.0
Soy lecithin	0.4	0.4	0.4	0.4	0.4	0.4
PGPR	0.2	0.2	0.2	0.2	0.2	0.2

2.2 Chocolate production

All chocolate samples were produced in batch (5 kg). Processing of samples was carried out at Cereal and Chocolate Technology Center (Cereal Chocotec®), at the Food Technology Institute (*Instituto de Tecnologia de Alimentos* (ITAL)) located in Campinas, in the state of São Paulo (SP), Brazil. All samples followed the same steps. Mixing stage of ingredients and conching process were carried out in a jacketed planetary mixer (INCO®, Indaiatuba, SP, Brazil). Initially powdered ingredients were mixed with liquor and part of cocoa butter, both melted. This dry stage lasted 3 hours. Total fat content of the dough was maintained at approximately 20%, in order to obtain a dough of plastic consistency.

After mixing, conching was carried out lasting 24 hours at 60 ºC. After 3 hours of the beginning of conching, leftover of fat was added. Dough was then refined in a mill made up of steel balls (Caotech®, Wormerveer, Netherlands), so that particles were between 20 and 25 µm of size. This measurement was carried out through a digital micrometer (Mitutoyo®, Suzano, SP, Brazil).

Tempering was performed in a compact JAF® tempering machine (Tambaú, SP, Brazil). Heating, cooling and reheating temperatures were set at 42 ºC, 28 ºC and 32 ºC, respectively. Cooling rate of approximately

2 ºC per minute was followed. These parameters were adjusted through the degree of tempering (tempering index between 4 and 6) using a *Chocometer* temperimeter brand Aasted® (Farum, Denmark).

Pre-crystallized mass was deposited in polyethylene rectangular forms of 5.4 x 12.6 x 0.6 cm, divided into 18 pieces of 1.8 x 2.1 x 0.6 cm and 4 g each. After molding, molds were vibrated to remove bubbles, then chocolates were cooled in a Siaht® cooling tunnel with temperatures ranging from 14 ºC to 17 ºC in extremities and between 10 ºC and 12 ºC in central portion. Chocolates were packed in an air-conditioned room in aluminum foil and stored at controlled temperature of 22 ºC, until sensory analysis was carried out.

2.3 Sensory analysis

Analyses were conducted at the Laboratory of Sensory Science and Consumer Study (*Laboratório Ciência Sensorial e Estudo do Consumidor* (LCSEC)) of the State University of Campinas (*Universidade Estadual de Campinas* (UNICAMP)). Undergraduate/graduate students and UNICAMP employees from 18 to 60 years old were recruited, without restriction, just required being a chocolate consumer. All the study participants were placed in individual booths, under white light and controlled temperature environment (22 ºC).

Presentation of samples (a 4 g square piece of chocolate), in all tests performed, was carried out on disposable plastic plates encoded with three-digit numbers, in a sequential monadic way. FIZZ Sensory Analysis Software program (Biosystems, Courtenon, France) was used to balance blocks (orders were balanced and the first 39 responses were adopted). Participants had an interval of 2 minutes between the evaluation of each sample. Also, it was served a glass of room temperature water in all analyses and instructed to participants to drink it before the evaluation of every new sample received.

The research was approved by the Research Ethics Committee of UNICAMP under number CAAE: 78682817.6.0000.5404. An Informed Consent Form (ICF) was given to each participant.

2.3.1 Pre-selection and survey of descriptive terms

Fifteen assessors were pre-selected through Wald's sequential analysis (Amerine et al., 1965), performing triangular tests with the objective of select candidates with good ability to discriminate the samples. Then, assessors were surveyed the sensory descriptive terms of all chocolate samples using the RGM method (Repertory Grid Keily's Method - Moskowitz, 1983) through the evaluation form. All participants were invited to participate on a meeting to discuss terms quoted by everyone in the evaluation forms, terms that best described similarities and differences among samples evaluated were selected for Quantitative Descriptive Analysis (QDA®).

2.3.2 Training of the sensory team

After the selection, and the definition of references for descriptive terms, sensory team conducted training in five sessions of 1 hour. Food products defined as references for each descriptive term were placed on a table with the six samples. Thus, assessors had contact with all references and samples in order to form the sensory memory.

References and samples were served in controlled temperature (22 ºC) during training sessions. Food products were portioned according to samples size, 4 g of each one. Water was also served and given the instruction of drinking it before the ingestion of every different sample or reference.

2.3.3 Final selection of assessors and QDA®

Assessors were selected according to their power of discrimination among samples (p of $F_{sample} < 0.5$), repeatability (p of $F_{repetition} > 0.05$) and consensus with the team in relation to each descriptor (Damásio & Costell, 1991; Stone et al., 1974). SAS Statistical Analysis System Program (2008) was used for data analysis.

Thirteen assessors were selected to perform the Quantitative Descriptive Analysis®. Samples were evaluated in triplicate using FIZZ Sensory Analysis Software program (Biosystems, Courtenon, France).

2.4 Temporal Dominance of Sensations (TDS)

The principles of the test were explained to 74 consumers, as well as the use of the FIZZ Sensory Analysis Software program (Biosystemes, Courtenon, France). The total duration of the test was 60 seconds. Participants were required to put the entire chocolate sample in their mouth and select from a list of randomized attributes related to flavor which was the term that most called their attention at each interval during the proposed time. There was also the option "none" among the terms for when the consumer did not feel anything else. These attributes were defined before, using the RGM method (Moskowitz, 1983) for QDA® (Pineau et al., 2012; Ares & Jaeger, 2015).

Temporal dominance curves of the chocolate's sensations were constructed using FIZZ Sensory Analysis Software program (Biosystemes, 2009) following the methodology proposed by Pineau et al. (2009). Two lines were drawn in the TDS graphical display, defined as "chance level", and "significance level". The first one is related to the dominance rate that an attribute can be obtained by chance. The second indicates the minimum value that the dominance rate should equal to be considered significant (Pineau et al., 2009).

2.5 Acceptance test

The acceptance test was carried out with 126 consumers from the UNICAMP community, (none of them TDS participant), using the FIZZ Sensory Analysis Software program (Biosystems, Courtenon, France). It was requested to the consumers to select a spot in an unstructured scale of 9 cm anchored in the extremities, on the left with "I disliked it a lot" and, on the right with "I liked it a lot", concerning to the hedonic attributes: "appearance", "aroma", "flavor", "texture" and "overall liking" for all the six samples (Schutz & Cardello, 2001).

2.6 Statistical analysis

QDA® and Acceptance test results were analyzed by analysis of variance (ANOVA), followed by Tukey's honestly significant difference test (Tukey HSD). With Acceptance test results, an External Preference Map was constructed, and also multivariate statistical analysis of Partial Least Square Correlation (Partial Least Square - PLS) to determine the correlation among descriptive attributes (QDA®) and factors in the presented samples that were positively valued and negatively valued by consumers (Tenenhaus et al., 2005), using XLSTAT Program (2012). All statistical analyses were performed at a 95% significance level.

3 Results and discussion

3.1 Quantitative Descriptive Analysis (QDA®)

Nineteen descriptive terms were defined with their respective definitions and references (Table 2). Spider graph (Figure 1) illustrates the profile of the samples in relation to their characterizing attributes. Curves that are overlapping each other represent products with greater similarity to each other.

Regarding aroma, sweet aroma did not differ between the sample without added fruit and the sample with the greatest addition of mango and, in consequence, the greatest reduction of sucrose. It varied among intermediate samples, following the same pattern in the spider graph. Similar results were found by Augusto et al. (2019), where samples of white chocolate that contained fruit dehydrated by spray-dryer (açaí) showed greater intensity of sweet aroma.

Table 2. Descriptors, definitions and reference samples used in QDA®.

	Attributes	Definitions	References
Appearance	Brown color (BROW)	Milk chocolate brown color	Minimum: Milk chocolate Talisman® (Dum Dum, Capivari, SP, Brazil)
			Maximum: Semisweet chocolate Garoto® (Vila Velha, ES, Brazil)
	Brightness (BRIG)	Characteristic of the sample reflecting light on the surface	Minimum: Milk chocolate Talisman®
			Maximum: Milk candy Toffee® (Arcor, Rio das Pedras, SP, Brazil)
	Homogeneity (HOMO)	Uniform, characteristic of what is composed of parts of the same nature	Minimum: Homemade "brown sugar"
			Maximum: Milk chocolate Hershey's® extra creamy
Aroma	Sweet (SWEE)	Characteristic aroma of sweet products	Minimum: Semisweet chocolate Garoto®
			Maximum: Aerated chocolate Sufflair® (Nestlé, Caçapava, SP, Brazil)
	Cocoa (COCO)	Characteristic aroma of cocoa that went through roasting process	Minimum: 10 g Olam® brand (São Paulo, SP, Brazil) diluted in heated water for 1 min in the microwave. Proportion 1:60
			Maximum: 11 g Olam® brand cocoa liquor
	Milk (MILK)	Aroma associated with milk powder	Minimum: Powdered solution of the brand Piracanjuba® diluted in water in the ratio 1:200
			Maximum: Powdered milk solution of the brand Piracanjuba® diluted in water in the proportion 1:10
	Cocoa butter (COBU)	Aroma associated with cocoa fat that has been separated by pressing	Minimum: 10 g of Olam® brand cocoa butter diluted in warm water for 1min30s in the microwave. 1:20 ratio.
			Maximum: 10 g of Olam® brand cocoa butter
	"Brown sugar"/ Fruity (BRSU)	Aroma associated with brown sugar + fruit that went through drying process	Minimum: Water
			Maximum: Homemade "rapadura"
Flavor	Sweet (SWET)	Typical flavor of sucrose solution	Minimum: Semisweet chocolate 53% cocoa Arcor®
			Maximum: White chocolate Laka® (Lacta, Curitiba, PR, Brazil)
	Milk (MILT)	Characteristic taste of powdered milk	Minimum: Whole milk powder Piracanjuba® diluted in water at a ratio of 2%
			Maximum: Whole milk powder Piracanjuba® diluted in water at a ratio of 10%
	Cocoa butter (COBF)	Flavor associated with cocoa fat that has been separated by pressing	Minimum: 10 g of Olam® brand cocoa butter diluted in warm water for 1min30s in the microwave. 1:20 ratio.
			Maximum: 10 g of Olam® brand cocoa butter
	Brown sugar (BROS)	Typical flavor of brown sugar, "rapadura" in Brazil	Minimum: Milk chocolate Garoto®
			Maximum: Homemade "rapadura"
	Cocoa (COCF)	Bitter taste from cocoa liquor associated with bitter chocolate	Minimum: Milk chocolate Garoto®
			Maximum: Semisweet chocolate 60% cocoa Hershey's® (São Paulo, SP, Brazil)
	Bitter (BITT)	Primary taste produced by aqueous solutions of bitter substances	Minimum: Milk chocolate Garoto®
			Maximum: Semisweet chocolate 60% cocoa Hershey's®
	Acid (ACID)	Taste associated with acetic acid, such as vinegar	Minimum: Nothing
			Maximum: Cocoa liquor Olam®
	Astringent (ASTR)	Flavor associated with the tying sensation of the mouth	Minimum: White chocolate Laka® (Lacta)
			Maximum: Semisweet chocolate 60% cocoa Hershey's®
Texture	Adhesiveness (ADHE)	Force required to remove material adhered to the palate during chewing process	Minimum: Semisweet chocolate 53% cocoa Arcor® (Rio das Pedras, SP, Brazil)
			Maximum: Dadinho® (São Paulo, SP, Brazil) peanut butter traditional
	Melting (MELT)	Sample capacity to melt being pressed between tongue and palate	Minimum: Semisweet chocolate 53% cocoa Arcor®
			Maximum: Milk chocolate Hershey's® extra creamy
	Hardness (HARD)	Force necessary to obtain a deformation between the molar teeth	Minimum: Milk chocolate Hershey's® extra creamy
			Maximum: Semisweet chocolate 53% cocoa Arcor®

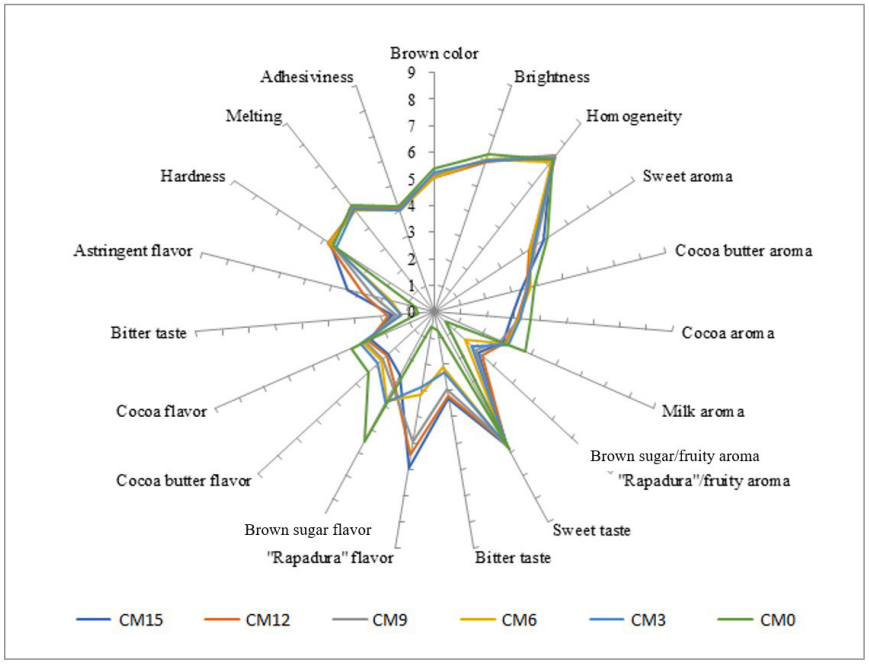

Figure 1. Spider graph of Quantitative Descriptive Analysis® attributes of chocolates. CM0: Sample without addition of powdered mango; CM3: Sample containing 3% of powdered mango; CM6: Sample containing 6% of powdered mango; CM9: Sample containing 9% of powdered mango; CM12: Sample containing 12% of powdered mango; CM15: Sample containing of 15% powdered mango.

Samples did not differ regarding sweet taste, something positive considering the substitution of sucrose for mango. This is because sugars present in mango become more accessible to the palate when it is in powder form (Bonneau et al., 2018).

Prolonged conching time generated a reaction among sugars present in mango similar to the caramelization process that occurs in very long cooking times to form brown sugar. This fact justifies the apparition of attributes such as "acid taste", "brown sugar flavor", "bitter taste" and "astringency", more characteristic of burnt sugar than of fruit (Verruma-Bernardi et al., 2011).

The addition of dehydrated mango did not have an impact on texture. Since sucrose plays both a sweetening and structural role in chocolates, the substitution of this ingredient must be well-planned. Powdered mango contains maltodextrin, which facilitates the replacement of part of sucrose with this ingredient without affecting texture, as adding up to 20% maltodextrin to milk chocolate does not affect its textural properties (Farzanmehr & Abbasi, 2009). Other works have also added fruit to chocolate and reported no changes in texture (Jung et al., 2017; Lončarević et al., 2018).

Refined sugar is usually processed sequentially through washing, extraction, purification, crystallization, drying, and packaging. Such a sequence and its high purity cause a low nutritional value and therefore provide empty calories (Lee, et al., 2018; Azlan, et al., 2020). In contrast, powdered mango has significant amounts of total carotenoids, which can add nutritional value to the developed chocolate (Hymavathi & Khader, 2005).

3.1.1 Principal Component Analysis

From data collected, it was possible to construct a graph corresponding to the Principal Component Analysis (PCA) shown in Figure 2. Through this graph, it is possible to observe the distance of the samples and the influence of each attribute. Principal Components 1 and 2 together explain 83.73% of the variation among samples.

Attributes "cocoa aroma", "brown color", "brightness", "sweet aroma", "cocoa butter" and "cocoa flavor"; attributes "milk flavor", "milk aroma" and "cocoa butter aroma"; and also "acid taste", "brown sugar flavor", "brown sugar/fruity aroma", "bitter taste" and "astringency" have the vectors close to each other, translating a positive correlation among them. This proximity possibly interferes positively with each one of the attributes cited, thus enhancing or improving the perception of one of those terms. The first two groups of attributes mentioned are in opposition to the third group, also expressing a negative correlation among such descriptive terms. Thus, it could be interpreted that the greater the intensity of any of the attributes, the lower the intensity of the term as opposed to this. "Homogeneity", "adhesiveness", "melting" and "sweet taste" are important in the characterization of the samples, but not in their differentiation.

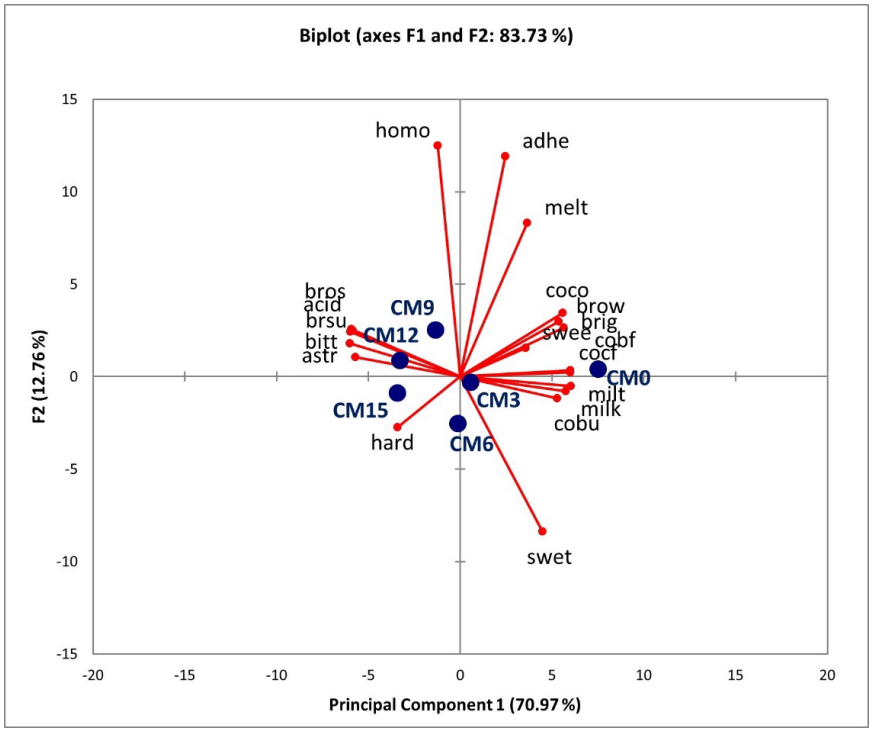

Figure 2. Bidimensional representation of Principal Component Analysis (PCA) of Quantitative Descriptive Analysis®. CM0: Sample without addition of powdered mango; CM3: Sample containing 3% of powdered mango; CM6: Sample containing 6% of powdered mango; CM9: Sample containing 9% of powdered mango; CM12: Sample containing 12% of powdered mango; CM15: Sample containing 15% of powdered mango. BROW = Brown color; BRIG = Brightness; HOMO = Homogeneity; SWEE = Sweet aroma; COBU = Cocoa butter aroma; COCO = Cocoa aroma; MILK = Milk aroma; BRSU = Brown sugar/fruity aroma; SWET = Sweet taste; ACID = Acid taste; BROS = Brown sugar flavor; MILT = Milk flavor; COBF = Cocoa butter flavor; COCF = Cocoa flavor; BITT = Bitter taste; ASTR = Astringent flavor; HARD = Hardness; MELT = Melting; ADHE = Adhesiveness.

Still, through the principal component analysis, it can be observed which descriptive terms best apply to each of the samples. CM0 and CM3 are characterized by attributes such as cocoa aroma, brown color, brightness, sweet aroma, cocoa butter flavor, cocoa flavor, milk aroma, cocoa butter aroma, and milk flavor. CM9, CM12, and CM15, on the other hand, with a higher percentage of mango added, are mainly characterized by the terms: acid taste, brown sugar flavor, brown sugar/fruity aroma, bitter taste, and astringency; CM6 is not strongly characterized by certain attributes as the others.

3.2 Temporal Dominance of Sensations (TDS)

Figure 3 shows TDS curves. In CM15, CM12, and CM9 samples, the attribute that first stands out and remains in evidence throughout the analysis is "brown sugar/fruity flavor". In CM6 and CM3 samples, the

first attribute to be perceived by consumers is "sweet taste", followed by "milk flavor", characteristics more related to traditional milk chocolate (CM0), with "brown sugar / fruity flavor" also showing up. In all samples, as the standard, there is a continuous presence of "sweet taste", except in CM15, while in QDA® they did not differ for "sweet taste" intensity ($p > 0.05$).

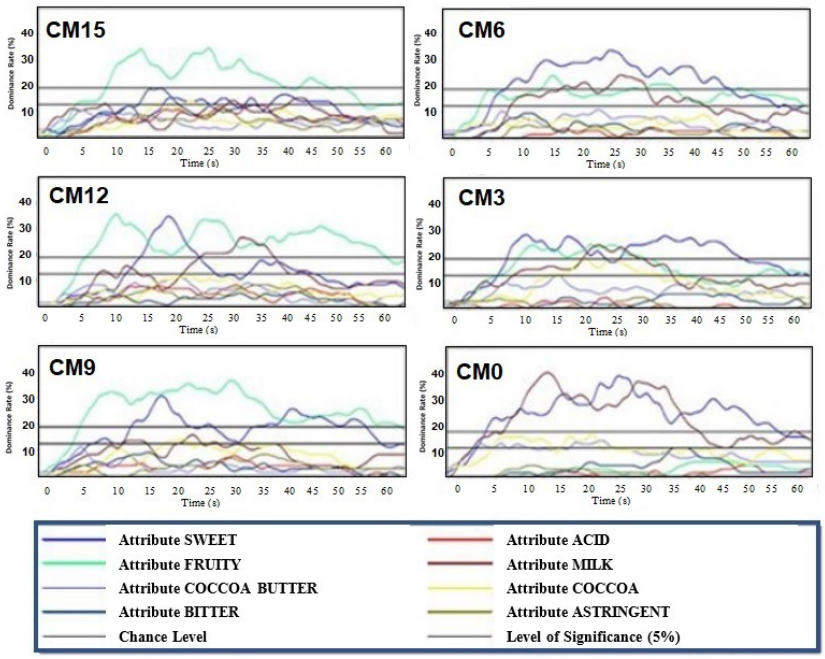

Figure 3. Graphs of the curves generated by Temporal Dominance of Sensations Analysis. CM15: Sample containing 15% of powdered mango; CM12: Sample containing 12% of powdered mango; CM9: Sample containing 9% of powdered mango; CM6: Sample containing 6% of powdered mango; CM3: Sample containing 3% of powdered mango; CM0: Sample without addition of powdered mango; N = 74; Line close to 20: level of significance (5%); Line close to 10: Chance level.

QDA® methodology assesses peak intensities of sensory attributes at singular time points, although members may consider duration and intensity when making a judgment about attribute evaluation. The unique data points collected may not take into account the nature dynamics of feeding (Oliver et al., 2018). Therefore, the use of the TDS methodology can add more data about the sensory characteristics of the product.

3.3 Acceptance test

Means of "appearance", "aroma", "flavor", "texture" and "overall liking" are shown in Table 3. The scale used was 9 cm, thus means above 4.5 revealed to be above the central indifference score and means below 4.5 represent negative scores for acceptance of the samples. Therefore, all samples obtained positive acceptance in all evaluated attributes. From data of analysis of acceptance by consumers for "overall liking" correlated with means of the descriptive terms obtained from QDA®, the external preference map was constructed (Figure 4).

Regarding appearance, no significant difference ($p < 0.05$) was found among the samples evaluated. In aroma, the only sample that showed a significant difference ($p < 0.05$) was the sample without the addition of mango, presenting a higher mean than the others. For texture, CM0, CM3, and CM6 samples did not differ, as well as CM3, CM6, CM9, and CM12 samples. However, the CM15 sample, containing the highest percentage of mango, differed significantly ($p < 0.05$) from all the others. As for flavor and overall liking, the same pattern was observed, practically all samples differed from each other, and those that obtained the

higher means were those with the lower content of added fruit. Similar results were also found by Das Virgens et al. (2020), where higher intensity of bitterness, cocoa flavour, acid taste, and astringency negatively affected the acceptance of chocolate samples.

Table 3. Results of acceptance of the six chocolate samples with regard to appearance, aroma, flavor, texture and overall liking.

Samples	Appearance	Aroma	Flavor	Texture	Overall liking
CM0	7.46^{a}	7.32^{a}	7.66^{a}	7.07^{a}	7.52^{a}
CM3	7.45^{a}	6.49^{b}	6.49^{b}	6.85^{ab}	6.79^{b}
CM6	7.51^{a}	6.52^{b}	6.48^{b}	6.71^{ab}	6.69^{bc}
CM9	7.46^{a}	6.39^{b}	5.59^{cd}	6.46^{b}	6.05^{ed}
CM12	7.38^{a}	6.60^{b}	5.96^{bc}	6.54^{b}	6.28^{cd}
CM15	7.58^{a}	6.47^{b}	5.07^{d}	5.99^{c}	5.69^{e}
MSD	0.30	0.44	0.58	0.47	0.46
SD	0.07	0.34	0.89	0.37	0.64

CM0: Sample without addition of powdered mango; CM3: Sample containing 3% of powdered mango; CM6: Sample containing 6% of powdered mango; CM9: Sample containing 9% of powdered mango; CM12: Sample containing 12% of powdered mango; CM15: Sample containing 15% of powdered mango. Means with equal letters in the same line do not differ by Tukey's honestly significant difference test ($p < 0.05$). N = 126. MSD - Minimum significant difference obtained in Tukey's honestly significant difference test ($p < 0.05$). SD: Standard deviation

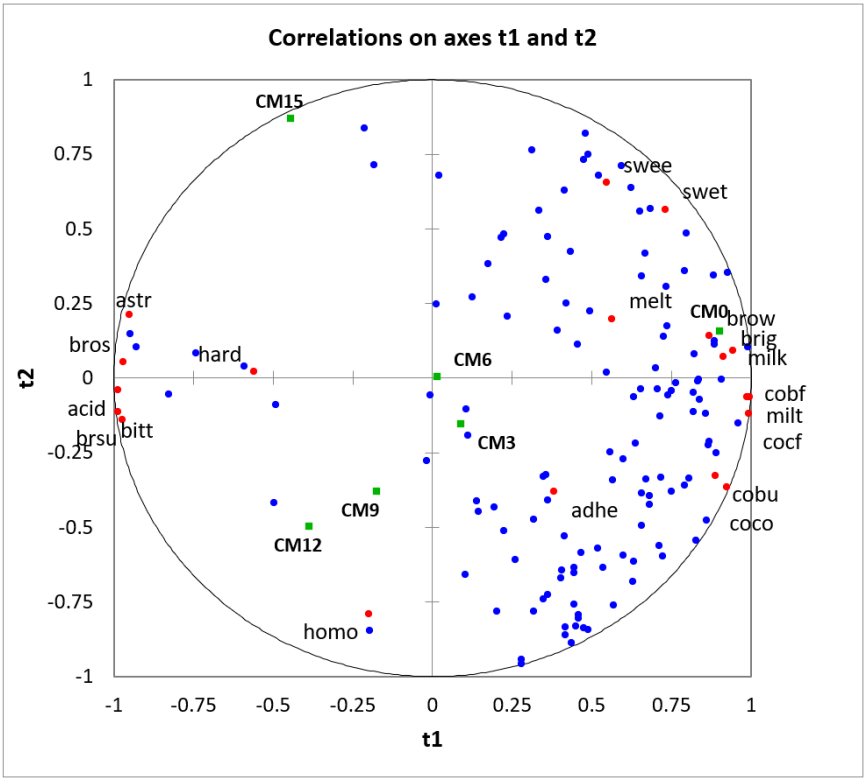

Figure 4. External Preference Map of chocolate samples. CM0: Sample without addition of powdered mango; CM3: Sample containing 3% of powdered mango; CM6: Sample containing 6% of powdered mango; CM9: Sample containing 9% of powdered mango; CM12: Sample containing 12% of powdered mango; CM15: Sample containing 15% of powdered mango. BROW = Brown color; BRIG = Brightness; HOMO = Homogeneity; SWEE = Sweet aroma; COBU = Cocoa butter aroma; COCO = Cocoa aroma; MILK = Milk aroma; BRSU = Brown sugar/fruity aroma; SWET = Sweet taste; ACID = Acid taste; BROS = Brown sugar flavor; MILT = Milk flavor; COBF = Cocoa butter flavor; COCF = Cocoa flavor; BITT = Bitter taste; ASTR = Astringent flavor; HARD = Hardness; MELT = Melting; ADHE = Adhesiveness. BLUE DOTS: Consumers; RED DOTS: Terms descriptors; GREEN DOTS: Samples.

By analyzing the external preference map, it can be concluded that consumers are concentrated between the first and third quadrants, where CM0 and CM3 samples are found. In addition, in these quadrants, characteristics most related to the preferred samples are located. CM9 and CM12 samples, on the other hand, are distant from the concentration of consumers and related to the descriptive terms found in the third quadrant. CM15 sample is also far from the concentration of consumers, and it is more characterized by "astringency", "brown sugar flavor" and "hardness attributes". CM6 sample remains exactly in the center of the map, which puts it in a position not so close to consumers, but also less distant than chocolate samples with higher concentrations of fruit, characterized with all descriptive terms, but without any specific attribute predominating.

Such results observed from the external map are consistent with results found in the analysis of principal components, where samples were characterized by the same descriptive terms found in the map. According to Figure 5, it was possible to assess which terms positively and negatively influenced consumer acceptance in the acceptance test (R = 0.981).

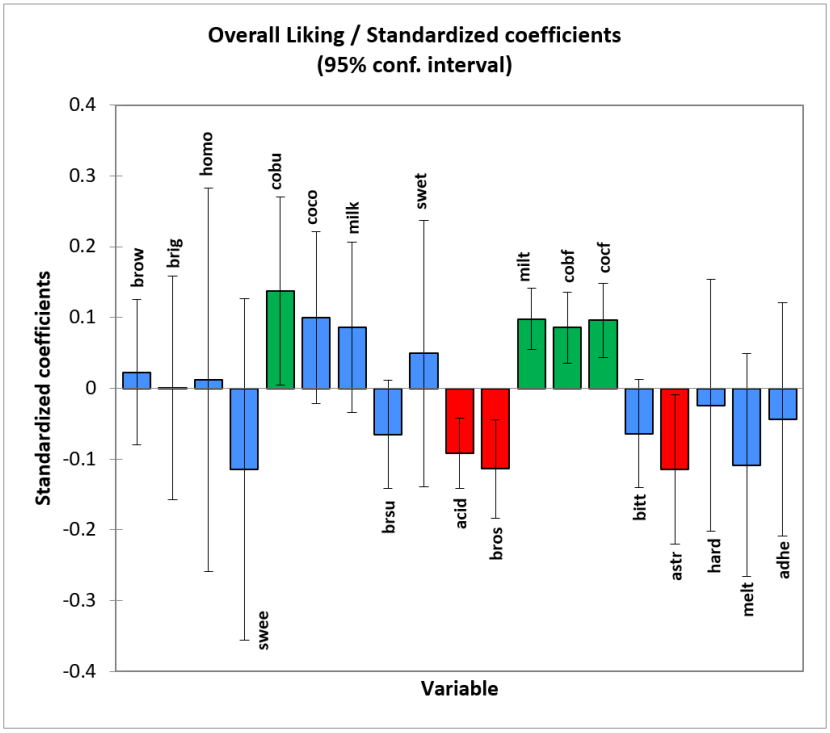

Figure 5. Standard coefficients of the Partial Least Squares Regression analysis among descriptors and means for overall liking of chocolate samples. 95% Confidence interval; BROW = Brown color; BRIG = Brightness; HOMO = Homogeneity; SWEE = Sweet aroma; COBU = Cocoa butter aroma; COCO = Cocoa aroma; MILK = Milk aroma; BRSU = Brown sugar/fruity aroma; SWET = Sweet taste; ACID = Acid taste; BROS = Brown sugar flavor; MILT = Milk flavor; COBF = Cocoa butter flavor; COCF = Cocoa flavor; BITT = Bitter taste; ASTR = Astringent flavor; HARD = Hardness; MELT = Melting; ADHE = Adhesiveness. ATTRIBUTES IN RED: Negative influence; ATTRIBUTES IN GREEN: Positive influence; ATTRIBUTES IN BLUE: Did not influence.

Descriptive terms that presented a confidence interval below 0, revealed a negative influence on the score attributed to overall liking in the acceptance test, and terms that presented a confidence interval above 0 had, a positive influence. Thus, descriptive terms that positively influenced the acceptance of chocolate bars were "cocoa butter aroma", "milk flavor", "cocoa butter flavor" and "cocoa flavor". Such attributes were associated with samples prepared with less mango according to the external preference map and QDA®. Descriptive terms that had a negative impact were "acid taste", "brown sugar flavor" and "astringency", characteristic of samples with higher percentages of mango (CM9, CM12, CM15). Therefore, the addition of powdered mango in milk chocolate at levels of 9% can have a negative impact on consumer acceptance.

4 Conclusion

The addition of powdered mango did not have an impact on texture and sweet taste in milk chocolate formulations, without significant differences among samples for these attributes ($p > 0.05$), according to QDA® results.

According to the results from TDS, the addition of powdered mango at levels of 15% in milk chocolate did not have a predominance of sweet taste, which can impact acceptance.

The sample without the addition of mango showed significantly greater acceptance ($p < 0.05$) followed by CM3 and CM6 samples, which demonstrates that the addition of dehydrated mango to milk chocolate is viable up to 6%, from a sensory point of view, considering the evaluation means given by consumers.

Overall, the present study demonstrated that partial substitution of sucrose in milk chocolate with powdered mango is possible, which is interesting due to its novelty aspect.

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