

Yam addition in passion fruit juice: optimization of the consumer acceptance

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Abstract: Besides the interest in raw materials that can be used to enrich industrialized food with fiber, developing products based on tropical roots of traditional farming and crop as yam, has gained the interest of farmers and industries as it would enable the increment in the entire production chain. This study aimed to determine the best formulation of passion fruit juice added to yam through sensory tests. For this, the Central Composite Rotational Design was used as a tool to determine the best juice formulation. Results were analysed by using external preference mapping and through response surface, studying three variables (concentrations of yam, passion fruit juice concentrate and sugar) in five levels. As dependent variable the sensory characteristics of the juice (taste, texture, color, appearance, overall impression and purchase intent) were determined. Acceptance tests were conducted in laboratory with 50 consumers and the data were analysed using software Statistica version 5.0. It was observed that to achieve good acceptability (up "6-like slightly"), the product should be prepared using concentrations of yam, sugar and passion fruit juice concentrate around 10%, 6% and 18% respectively. Since the higher the concentration of yam, the greater must be the concentration of sugar and juice to obtain a better product acceptance (up "6-like slightly").

Key words: Central composite rotational design, Principal component analysis, Acceptance test.

Otimização sensorial de suco de maracujá adicionado de inhame

Resumo: O desenvolvimento de produtos tendo como base raízes tropicais, de tradição de cultivo e cultural como o inhame, além de proporcionar o enriquecimento dos alimentos industrializados com fibras, têm despertado o interesse dos produtores rurais e industriais, pois possibilitaria o incremento de toda a cadeia produtiva. O presente trabalho objetivou determinar a melhor formulação do suco de maracujá adicionado de inhame por meio de testes sensoriais. Para isso, utilizou-se o Delineamento Central Composto Rotacional (DCCR) como ferramenta para determinar a melhor formulação do suco. Os resultados foram analisados por meio de mapa de preferência externo e superfície de resposta, estudando-se três variáveis (concentrações de inhame, suco concentrado de maracujá e açúcar) em cinco níveis. Como variável dependente determinou-se as características sensoriais do suco (sabor, textura, cor, aparência, impressão global e intenção de compra) Os testes de aceitação foram conduzidos com 50 consumidores e os dados foram analisados por meio do software Statistica versão 5.0. Observou-se que para alcançar uma boa aceitabilidade (acima de "6-gostei ligeiramente"), o produto deve ser elaborado utilizando concentrações de inhame, açúcar e suco concentrado de maracujá em torno de 10%, 6% e 18% respectivamente. Foi observado que quanto maior a concentração de inhame, maiores devem ser as concentrações de suco e açúcar para obtenção de produtos com boa aceitabilidade (acima de "6-gostei ligeiramente").

Palavras chave: Delineamento central composto rotacional, Análise de componentes principais, Teste de aceitação.

Introduction

Consumption of fruit juices ready to drink has been growing in high rates, following the global trend toward consumption of healthy food and the fast pace of life in the urban society.

Fruit juices contain numerous vitamins and minerals. Soares et al. (2004) show the presence of essential mineral elements like K, Na, Ca, Mg, Fe, Zn, Cu e Mn in Brazilian fruit juices concentrated. Thus, juices are a viable alternative from the point of view of nutrition and they can be inserted in the composition of diets for various segments of the population.

Passion fruit (*Passiflora edulis*) is originated from Tropical America and it is a fruit widely cultivated in Brazil (Machado et al., 2003 & Farias et al., 2005). It is rich in vitamin C, calcium and phosphorus. The greatest economic importance of the passion fruit is in the industrialized product in the form of concentrated juice. Passion fruit can be consumed in natural or industrialized form, and its juice stands out among those produced with tropical fruits, with an excellent acceptance by consumers, representing a good percentage of juices exported Brazilian Institute of Geography and Statistics [IBGE], (2012). Brazil, Colômbia, Peru and Equador are responsible for approximately 90% of exportation of frozen concentrated juice and pulp of passion fruit (Souza et al., 2002).

In the Brazilian industry, demand for diversified flavors is large, which has led companies to develop new products to attend the demand. An alternative to the diversification of drinks is the addition of vegetables with nutritional properties, such as the yam (*Dioscorea sp.*), which, besides having large amount of carbohydrates, essential amino acids, fiber, vitamins and minerals such as calcium, phosphorus and potassium, it has low cost and wide availability (Pedralli et al., 2002 & Tavares et al., 2011).

More than a nutritious food, yam can also provide beneficial physiological effects on health, such as increasing the antioxidant capacity (Hou et al., 2001, Lin et al., 2004 & Ajibola et al., 2011), reduction of triacylglycerol level and improvement of the sanguine cholesterol profile (Araghiniknam et al., 1996 & Chen et al., 2003). Thus, yam intake can contribute to the prevention of

cardiovascular diseases and disorders related to the oxidative stress, besides contribute to technological characteristics of the juice.

It is believed that adding yam to the passion fruit juice will make it more nutritious, besides enabling to obtain a more creamy juice with innovative technological characteristics. Thus, this study aimed to determine the best passion fruit juice yam adding formulation, through some sensorial attributes.

Material and methods

Experiment installation

The experiment was conducted in the Laboratory of Sensory Analysis in the Department of Food Science at Federal University of Lavras.

Raw material

For processing, the product used was the concentrated passion fruit juice, brand Maguary®, yam, crystal sugar and water. The raw materials were purchased commercially at Lavras - MG from a single batch.

Experimental design and data analysis

Central Composite Rotational Design was used as a tool to determine the best formulation of the juice according Pereira et al. (2013). Three variables at five levels were studied. The independent variables were: yam concentration (X1), juice concentration (X2) and sugar concentration (X3). The sensory characteristics of the juice were determined as the dependent variable. Results were analyzed using response surface. Different juice formulations were prepared according to the experimental design trials presented in the Table 1.

The experimental design consisted of 17 trials (Table 1). Statistical analysis was performed using the computer program Chemoface version 1.5 (Nunes et al., 2012a).

A three-way external preference mapping (Nunes et al., 2012b) was generated in order to better understand the differentiation of the formulations. This analysis enables an overall evaluation of the results and suggests what attributes or descriptors can characterize the samples. Analysis was performed using SensoMaker version 1.5 (Nunes & Pinheiro, 2012)

Processing of raw materials and preparation of passion fruit juice with yam

For the preparation of the juice formulations, yam was washed in tap water, peeled, diced and minced in a domestic blender (brand Walita®) along with the passion fruit juice, sugar and water in the proportions described in Table 1. The products were placed in a refrigerator for approximately three hours, to balance the temperature. After this period, they were conducted to sensory tests.

Sensorial evaluation

Sensory acceptance tests (Dutcosky, 2007) were conducted in the Laboratory of Sensory Analysis in the Department of Food Science at Federal University of Lavras. Tests were conducted with 50 consumers (Rodrigues et al. 2014) in three steps with intervals, and the samples were served in two groups of six and one group of five. Test was performed with proper lighting and the absence of interferences such as noise and odors (Bowles & Demiate, 2006).

Samples (around 30 mL) were served in white disposable plastic glasses identified by three-digits numbers, arranged in balanced order (Wakeling & Mcfie, 1995) at room temperature. Evaluations were made in individual cabins, at room temperature between 10-12 hours and 14-17 hours using white light.

Five attributes were evaluated: appearance, color, flavor, texture, overall impression and purchase intention. Therefore, judges were instructed to taste the samples from left to right and to indicate how they liked or disliked each attribute of each sample, using an attitude structured scale of five points to purchase intention and a hedonic scale of nine points for the other sensory aspects, according to Dutcosky (2007).

Results and discussion

The three-way external preference mapping showed the behavior of the juice formulations in relation to the sensory attributes and levels of ingredients. According to Figure 1, formulations 4, 8, 9, 12, 14 and 15 were preferred by tasters in all sensory attributes of the juices (taste, texture,

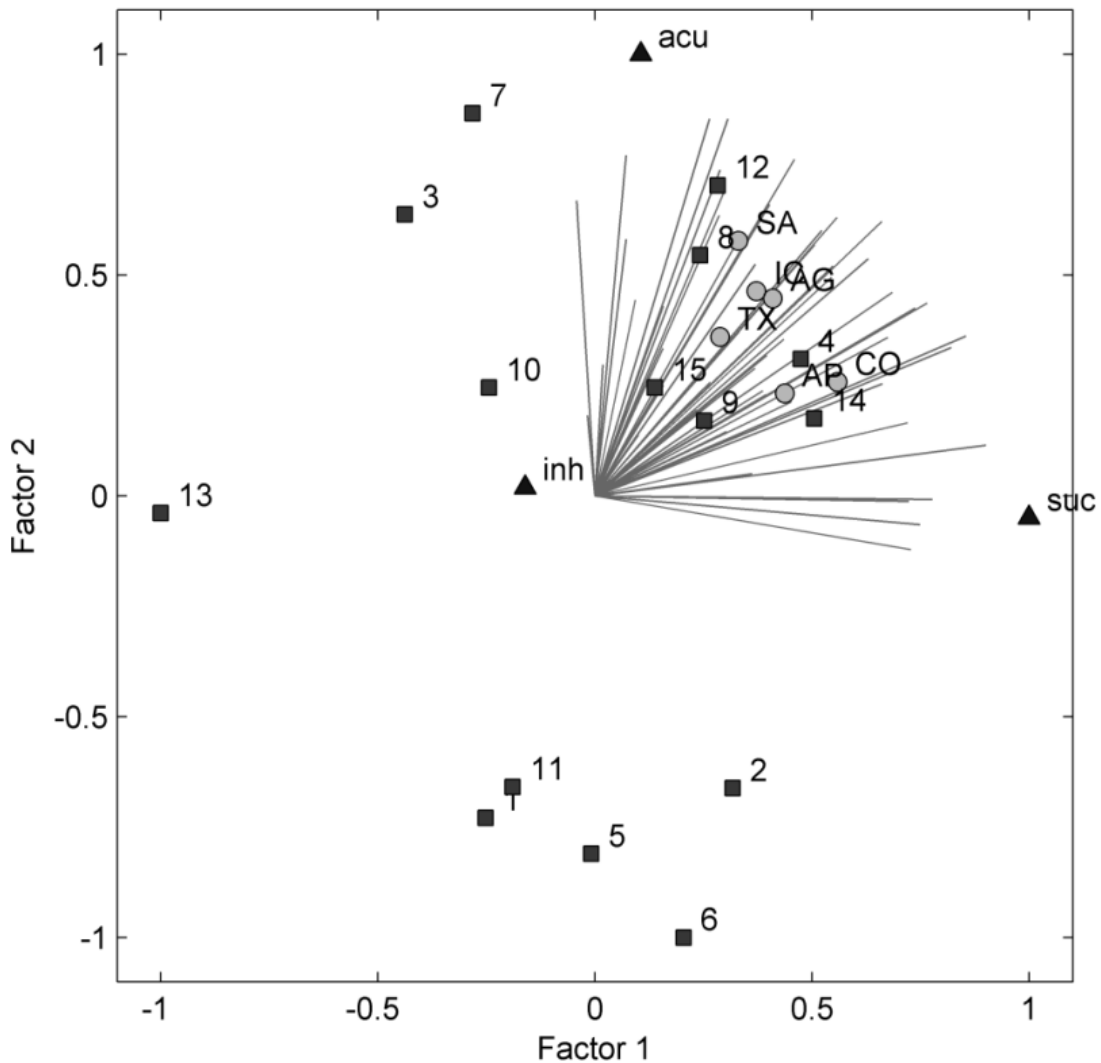
color, appearance, overall impression and purchase intent). Through the external preference mapping, it can be inferred that generally the preferred formulations have higher concentration of passion fruit and sugar and, lower levels of yam. Continuing investigate the optimal concentrations of sugar, passion fruit juice and yam, which resulted in a better acceptance of the juice, we used a Central Composite Rotational Design (DCCR). As Figure 1 and the average grades showed that all sensory attributes had similar behavior in choosing the preferred samples, the overall impression was chosen to evaluate the optimal concentrations of juice, passion fruit and yam, which determined the preference of the evaluators. Furthermore, according to Oliveira (2010), the different attributes that make up the sensory quality of food are integrated in the brain as a global print quality, even though they individually perceived by human senses. It is believed that the overall impression of a particular food product reflects the acceptance of the food, based on all the sensory characteristics (appearance, color, taste, texture) Rodrigues et al. (2014a) and Rodrigues et al. (2014b) observed this in their studies.

Pareto diagram (Figure 2A) was used to evaluate the significance and the type of effect (synergistic or antagonistic) on the overall impression. According to the data in Figure 2A, all variables and the interaction between the concentrations of yams and sugar, were significant ($p= 0.05$) in the taster decision on the preferred juice sample. Concentration of yam was the variable that most influenced the acceptability of the product. Its main effect was negative therefore; increasing the concentration of yam, the scores for overall impression of the juice is reduced. However, as the interaction between the sugar concentrations and yam was synergistic, it can be expected that the negative effect of the yam can be corrected by increasing the concentration of sugar. Regarding the isolated effect of other variables, both had positive effect. Thus, higher concentrations of passion fruit juice and sugar improve the final acceptability of the product. The quadratic model was one that best describes the relationship between the juice formulation and sensory parameters investigated (Table 2). The percentage of explained variance (R^2) for the model was satisfactory ($R^2 = 0.8152$), indicating good agreement between values

experimented and predicted by the model. According to the contour lines (Figure 2 B, C and D), the juice sample preferred by the panelists is characterized by a yam concentration of 10%, sugar between 6 to 8% and passion fruit juice

between 14 to 18%. Therefore, it was observed that it is possible to add up to 10% of yam to enrich nutritionally the passion fruit juice, without harming the overall impression of the juice, which remains with a note around 6.5, indicating that the panelists liked the drink moderately.

Figure 1 - Three-way external preference mapping obtained for samples of passion fruit juice with yam (IC-purchase intention; SA-flavor; TX -texture, PA-appearance, CO- color and AG-overall impression; acu-sugar concentration , inh- yam concentration; suc- passion fruit juice concentration; square-samples;sphere-attributes; triangle-variables).



Branco et al. (2007) have found that it is possible to enrich certain fruit juices with vegetables, which have functional properties, since the standard formulation is optimized, i.e., it is necessary to change the concentration of the

ingredients, to obtain a better sensory acceptance. Frata et al. (2006) evaluated the relationship between consumer preference and attributes of orange juice samples (full and reconstituted) and orange nectar, finding that the

sweet taste was one of the main attributes that have contributed to a better acceptance of these drinks. These results corroborate the information found in this study, where it was possible to reduce the negative effect of yam with the addition of higher concentrations of sugar. Despite the

high nutritional value of the yam and the convenience of preparation, the best juice formulation had a high sugar level. Thus, other studies as in Marcellini, Chainho e Bolini (2005) and Brito e Bollini (2010), using sweeteners is indicated to elaborate a healthy drink with the alternative to enrich nutritionally the daily diet.

Table 1- Design matrix and the responses (overall impression) for the formulations of the experiment. Design matrix and responses of the formulations of passion fruit juice with yam and sugar

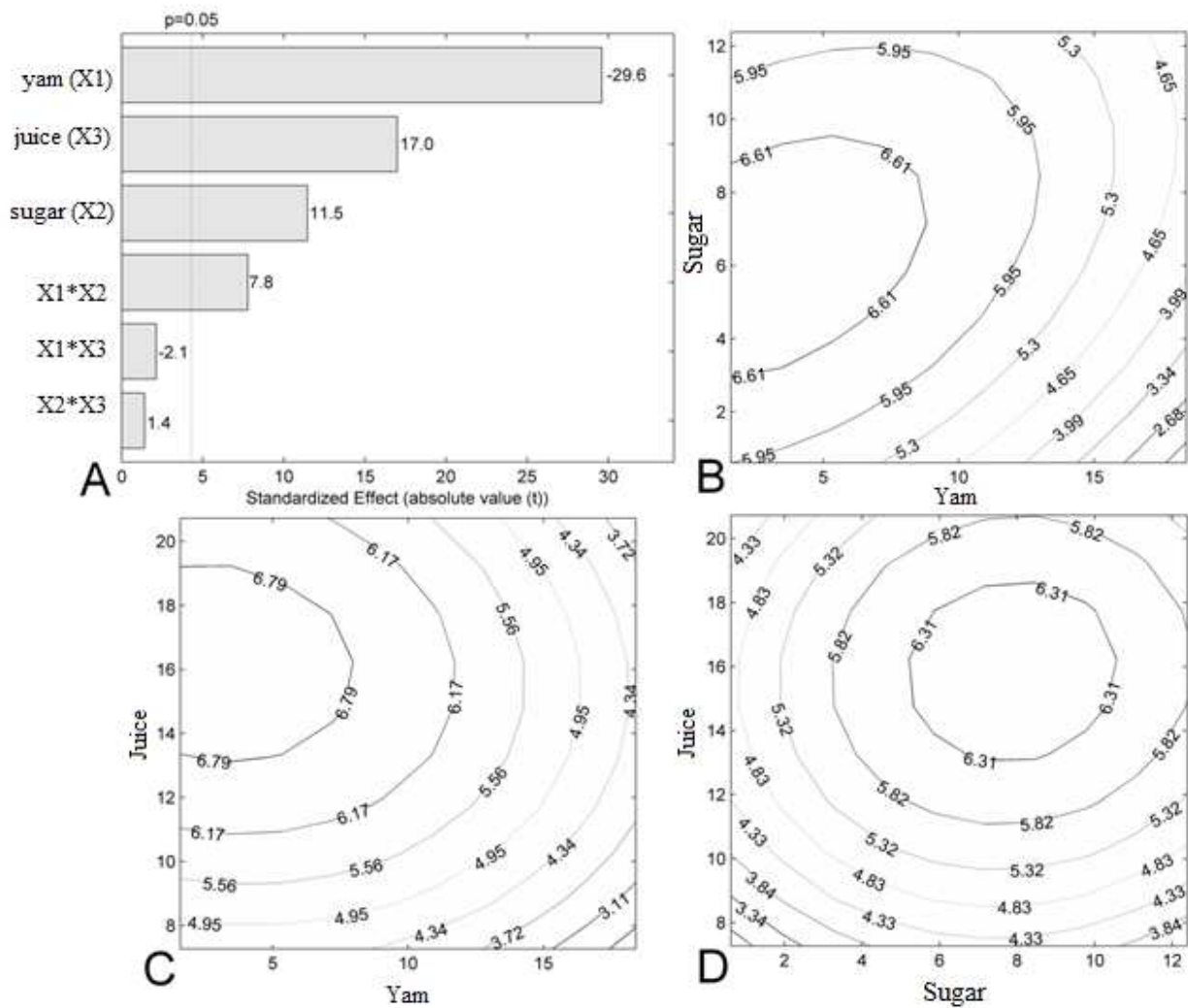
Trial	[Yam] (%)	[Sugar] (%)	[Juice] (%)	Overall impression
1	5(-1)	3(-1)	10(-1)	5.2
2	5(-1)	3(-1)	18(+1)	5.8
3	5(-1)	10(+1)	10(-1)	6.2
4	5(-1)	10(+1)	18(+1)	6.4
5	15(+1)	3(-1)	10(-1)	4.5
6	15(+1)	3(-1)	18(+1)	3.9
7	15(+1)	10(+1)	10(-1)	5.2
8	15(+1)	10(+1)	18(+1)	5.8
9	1.6(-1.6818)	6.5(0)	14(0)	6.5
10	18.4(1.6818)	6.5(0)	14(0)	4.6
11	10(0)	0.62(-1.6818)	14(0)	3.7
12	10(0)	12.4(1.6818)	14(0)	6.8
13	10(0)	6.5(0)	7.3(-1.6818)	4.2
14	10(0)	6.5(0)	20.7(1.6818)	6.4
15	10(0)	6.5(0)	14(0)	6.2
16	10(0)	6.5(0)	14(0)	6.2
17	10(0)	6.5(0)	14(0)	6.3

Table 2 - Model predicted for the overall impression of the passion fruit juice with yam

Sensory attribute	Model	R ²
Overall impression	$Y=2,34+0,03x_1+0,33x_2+1,03x_3+0,01x_1x_2-0,004x_1x_3+0,003x_2x_3-0,01x_1^2-0,03x_2^2-0,03x_3^2$	0,8152

Y= overall impression;
 x1= yam concentration;
 x2 = sugar concentration;
 x3= passion fruit juice concentration.

Figure 2 - Pareto Diagram (A) with the effect of yam concentrations (X1), sugar (X2), passion fruit juice (X3) and their interactions on the acceptability in relation to the overall impression, and contour lines for the acceptance of passion fruit juice with yam due to interactions between the variables.



Conclusions

Yam had an isolated negative effect on the passion fruit juice, but it is possible to reduce this effect by adding higher levels of passion fruit juice and sugar. Therefore, it is possible to add yam in the passion fruit juice without harming their acceptability, since the yam concentration does not exceed 10% of the formulation and levels of sugar and passion fruit juice concentrate be around 6% and 18% respectively. Despite the high nutritional value of the yam and the convenience of preparation, the best juice formulation had a high sugar level. Thus, other study, using sweeteners is indicated to elaborate a healthy drink with the alternative to enrich nutritionally the daily diet.

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