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Identifying the Adequate Process Conditions by Consumers for the Pineapple Juice Using Membrane Technology

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Abstract: Hydrolyzed pineapple juices which were clarified using two different membrane systems (Plate and Frame System and Tubular System), and operating at different transmembrane pressures (TMP) were used to yield 12 samples of clarified pineapple juices to be evaluated by consumers. One hundred and four consumers evaluated the samples. The sensory tests were conducted in individual sensory booths using a nine point hedonic scale. The data were statistically analyzed through the Internal Preference Mapping (IPM) using the SAS program. The Internal Preference Mapping analysis generated a multidimensional space where the preference data variations were presented in orthogonal axes based on the consumers' liking scores for each sample. The vectors of preference were plotted yielding a multidimensional map as a function of preference data. The first and second preference dimensions explained 40.6% of the preference samples variations. The diluted commercial pineapple juice had the lowest preference and the clarified pineapple juices obtained with low molecular cut-off membranes, at low operating TMP were preferred by consumers.

Key words: Consumer, preference mapping, pineapple juice, ultrafiltration, microfiltration

Introduction

Fruit juices are liquid foods that provide vitamins, sugars, mineral compounds and water to live organisms. Brazil is considered the second biggest pineapple producer in the world, and the majority of its production is to the internal market, which is commercialized *in natura* and used by the food industry to process pineapple juice (EMBRAPA, 2000). A strong tendency has been observed in the Brazilian food and beverage market in the recent years aligned with the international tendency: the healthy, convenient and nice product (FrutiFatos, 2002 and Katz, 2000). In this scenario, the natural fruit juices in an important alternative to achieve such market.

Consumers have individual preferences by specific appearance, consistence and flavor characteristics. As a consequence, when a new product is launched in the market, many factors must be taken into account, and a sensory trial has to be carried out beforehand, to evaluate consumer preference for the referred product.

Membrane technology is an alternative to produce a juice with better nutritional characteristics because it does not destroy the vitamins as the thermal process does (Milnes *et al.,* 1986). The processed food nutrients preservation is an important aspect considered by consumers and membrane processes applied to fruit juices is an excellent alternative to make available products with improved nutritional quality. Operating at room temperature, these processes can preserve the natural characteristics of the raw materials. The sugar reactions accelerated by heat and acid conditions causing browning, which contributes to product rejection by consumers. Besides, the ascorbic acid thermal degradation also can be avoided by using the membrane technology. However, the product has to be liked by consumers.

Others important fruit's characteristics that must be take into account for the fruit juice processing are the pineapple variety, the volatile compounds present in the fruit, and the agronomic treatments of the culture. Regarding the variety, it must have high sugar and acidity levels; it is recommended that the volatile compounds found in the fruit is at optimal maturation conditions; and, finally, the soil, fertilization, irrigation, climate, and post-harvest conditions, which comprise the agronomic treatment, have also an effect on the quality of the fruit juice, and consequently on consumer's product acceptance.

Nowadays, when we need to evaluate the consumer preference for food or beverages, the Internal Preference Mapping is a valuable tool to be used (Dijksterhuis, 1997 and Chen-Tang *et al.,* 2000). The main advantage of the Internal Preference Mapping, compared to the conventional preference tests, is the fact that it does not work with means but individual consumers preference is considered in the products

evaluation. According to the Internal Preference Mapping is a graphic representation of the differences on acceptance among samples that permits an identification of each individual and his preference in relation to evaluated samples. It is based in a vectorial model and resolves a matrix with consumers liking data over the same group of samples.

Several works presented in the literature have used Internal Preference Mapping to analyze the data. Pastor *et al.* (1996) used the Internal Preference Mapping to evaluate 16 samples of peach nectars with low sugar content. The formulation consisted in peach purée (60%); aspartame contents varying from 0.082 to 0.922 g L^{-1} and guar gum from 0 to 4.0 g L^{-1}. Arditi (1997) evaluated the preference of chicken nuggets using 119 children as consumers. The tests were conducted in three steps. In the first, consumer children showed no accentuated preference for any sample. In the two last groups, the Internal Preference Mapping was introduced, and it was possible to segment children in groups according to their preferences. Children from one group preferred nuggets with plain flavor (flavor not pronounced) and products with a yellowish appearance, while children in group three preferred nuggets without chicken meat appearance.

The Internal Preference Mapping was also used to investigate consumer's intention to purchase for any food. Monteleone *et al.* (1998) studied the intention to purchase regarding 12 amylaceous meals. Consumers preferred familiar amylaceous meals. The tool permitted identifying groups of consumers characterized by their preferences for these foods. More traditional consumers preferred meals with potatoes compared to other amylaceous ones and, in particular, cooked potatoes to fried ones. In contrast, there was another group that was more concerned with the nutritional aspect of the amylaceous products and preferred a diet with some of these foods (potatoes, rice, pasta).

Deliza *et al.* (1998) used internal preference mapping to evaluate flavored tofu and soy pâtés. Eighty consumers, male and female, with different ages participated in the study. The results showed that tofu flavored with onion and pâtés with ketchup flavor were preferred. Elmore *et al.* (1999) investigated the texture acceptance of puddings formulated with different contents and types of starch, milk and sodium salts using the Internal Preference Mapping. The consistence seemed to be an important attribute to consumer's acceptance of the pudding. Behrens *et al.* (1999) evaluated the Brazilian white wines acceptance by the Internal Preference Mapping and analysis of the variance. The results showed that the majority of the consumers preferred soft white wines and only a reduced number of people preferred dry white wines and demi-sec ones. Also working on alcoholic beverage, Cardello and Faria (2000) investigated consumer's liking of 11 samples of aged and not aged sugar cane brand using internal preference mapping. The results revealed that samples older than more than 24 months in oak barrel were preferred.

Until now, only few papers on juices, nectars, and fruit pulps have been written using the Internal Preference Mapping. Costell *et al.* (2000) studied the acceptance of peach nectars by internal preference mapping. The three first dimensions accounted for 91% of consumer's acceptance, segmenting them in four groups of consumers. The first dimension was related to sweetness and detection of off-flavors. The second dimension related to acidity and texture and the third one was defined by flavor and taste, peach taste and artificial flavor and cooked flavor. Based on the results, it could be established preference criteria for each consumer group.

The Internal Preference Mapping may be an useful tool for food technologists to identify the best clarified pineapple juice obtained from membrane systems, according to consumers' point of view. The main purpose of this study was to evaluate the consumer preference for clarified pineapple juices by microfiltration and ultrafiltration processes throughout the Internal Preference Mapping. The understanding of consumers' liking may help food technologists to identify processes which yield better products, according to consumers' preferences.

Materials and Methods

This study was carried out with pineapple juice obtained using Pérola cultivar pineapple, produced in São Francisco de Itabapoana, Rio de Janeiro. The experimental samples were constituted by twelve clarified pineapple juices processed in Plate and Frame, and Tubular ultrafiltration/microfiltration systems, with membranes (polysulphone, polyethersulphone and polyvinilidene fluoride) having different molecular weight cut-off, and different transmembrane pressure conditions. A commercial pineapple juice (Co) available in the Brazilian market, and prepared according to the label instructions was also used in the experiment. The 13 treatments of the study are presented in Table 1.

Sensory Evaluation

Preliminary Test: In order to identify the adequate dilution of the commercial pineapple juice as well as the clarified ones, a sensory test with 7-trained panelists was carried out. The commercial pineapple juice was prepared according to the label instructions and evaluated by the panelists to verify its adequacy in terms of sweetness and dilution. Similarly, the clarified

pineapple juices were evaluated to observe if they were ready to drink or if it would be necessary some adjustment.

Table 1: Pineapple juice samples used in the study

Sample code	identification (MWC – TMP)
Co	Commercial pineapple juice
A2	0.45μ - 4.0Bar
A3	50KDa – 7.5Bar
A4	50KDa – 6.0Bar
A5	0.3μ - 3.0Bar
A6	0.3μ - 1.5Bar
A7	0.1μ - 3.5Bar
A8	0.1μ - 4.5Bar
A9	0.1μ - 5.5Bar
A10	100KDa – 7.5Bar
A11	100KDa – 6.0Bar
A12	30-80KDa – 1.5Bar
A13	0.45μ - 3.0Bar

Consumer Test: The test was conduct with 104 fruit juice consumers (36 men and 68 women) from different social and economic backgrounds, with ages varying from 18 to 60 years. They were requested to express their preference based on the overall sensory characteristics perceived and to rate each sample using a nine-point hedonic scale varying from " dislike extremely" to like extremely". The design was balanced for order and carry over effects according to MacFie *et al.* (1989). Consumers were presented with four samples per session (first and second sessions) and five samples in the third session to complete the 13 juices of the experiment. Samples were served to consumers at 8°C in 50 mL transparent glasses. Tests were carried out at EMBRAPA Food Technology in individual sensory booths under white light. Consumers were provided with mineral water to clean the palate between samples.

Sweetness and Dilution: The dilution and sweetness are important fruit juice attributes which may drive consumer preference. The identification of adequate levels for such parameters may contribute to good results during the product development. The dilution was evaluated by consumers thought the relative to ideal scale (Deliza, 1996), varying from "too diluted" (score 1) to "too concentrated" (score 9), passing by the ideal point (which was scored as 5). Similarly, the sweetness was evaluated from "not sweet enough" (score 1) to "too sweet" (score 9) passing by the ideal point (score five).

Data Analysis: The data were submitted to Analysis of Variance (ANOVA) with samples and consumers as effects. The means of the pineapple juices were calculated. The significance of these effects was tested with F test at a significant level of 5%. The relative to ideal data were analyzed using the *t*- test ($H_a \neq 5$, two-sided alternative). Internal Preference Mapping was performed on the preference scores in order to examine discrimination between samples and identify different subgroups among consumers. In this study, the internal preference mapping was performed using a SAS procedure developed at the Institute of Food Research, UK (Wakeling, 1996).

Results and Discussion

Sensory Evaluation

Preliminary Test: The panel recommended that the commercial pineapple juice dilution was adjusted to one part of juice to two parts of water, with the addition of 16 g of commercial sugar/100 mL.It was not necessary to diluted the clarified juices samples since they were considered suitable to drink by the trained panel.

Mean Preference Scores for Pineapple Juices: The mean preference scores for the pineapple juices are

Table 2: Preference[§] means and standard deviations (SD) of pineapple juice samples

Sample	Mean	SD
Co – Control (Commercial)	3.9^{c}	
A1 – 0.45μ - 4.0Bar	5.6^{a}	1.88
A2 - 50KDa - 7.5Bar	4.9^{ab}	1.88
A3 - 50KDa – 6,0Bar	5.6^{a}	1.76
A4 – 0.3μ - 3.0Bar	5.1^{ab}	1.81
A5 – 0.3μ - 1.5Bar	5.0^{bc}	2.01
A6 – 0.1μ - 3.5Bar	4.5^{ab}	1.94
A7 – 0.1μ - 4.5Bar	5.1^{ab}	1.96
A8 – 0.1μ - 5.5Bar	5.2^{ab}	1.84
A9- 100KDa - 7.5Bar	5.6^{a}	1.77
A10 - 100KDa - 6.0Bar	5.5^{a}	1.91
A11 - 30-80KDa - 1.5Bar	5.5^{a}	1.84
A12 - 0.45μ - 3.0Bar	5.6^{a}	1.78

*§ Evaluated in 9-point hedonic scale. Different letters mean significant differences at 5%

given in Table 2. No difference was found in terms of preference among the clarified samples, however, consumers disliked the commercial juice (Co). The problem with univariate analysis for this type of data is the implicit assumption that all participants exhibit the same behavior, and that a single mean value is representative of all consumers. In order to overcome this problem, the data were analyzed using Internal Preference Mapping, and the results are presented below.

Internal Preference Mapping: The data were also analyzed using the Internal Preference Mapping, and it is now presented. The two first dimensions of the Internal Preference Mapping of the 13 pineapple juices explained 40.4% of the total variance (dimension 1, 28.3%; dimension 2, 12.1%). Fig. 1 shows a projection of subjects scores on the two axes. The 104 consumers distribution and their preference are represented by each point on Fig. 1. In total 65 consumers (62.5%) were fitted in the model. Considering the explained variance the fit was nor especially good, however, this is expected in consumer experiments where the heterogeneity is generally high. Similar results were presented by Pagliarini *et al.* (2001) and Daillant-Spinnel *et al.* (1996). The product map of the 13 samples is presented in Fig. 2. Dimension 1 of both the consumer plot (Fig. 1) and product plot (Fig. 2) indicates that consumer preferences are clearly oriented towards samples A10, A11, A12 and A4. Moving left to right on the first dimension, the commercial sample (Co) was the least preferred, followed by the group of clarified juices A5 (0,3μ - 3.0Bar); A9 (0.1μ - 5.5Bar) and A3 (50KDa – 7.5Bar). Samples A8 (0.1μ - 4.0Bar); A6 (0.3μ - 1.5Bar) and A2 (0.45μ - 4.0Bar) were located in an intermediate position on the Internal Preference Mapping.

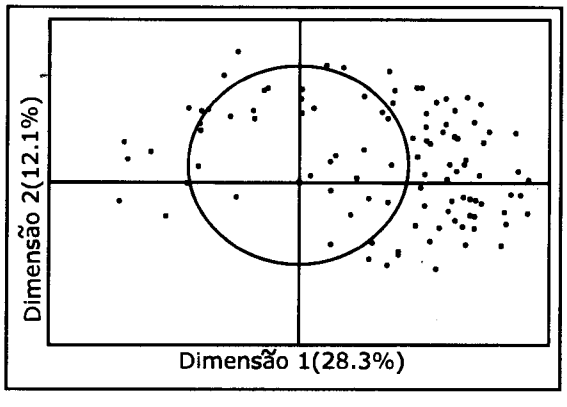

Fig.1: Internal Preference Mapping showing consumers` distribution evaluating 13 samples

Consumers were still differentiated by dimension 2, and samples A7 and A13 were separated from the others, showing little consumer's preference. Although it was possible to indicate products which were in the consumer's preference direction, the similarity among some samples could have jeopardize a better separation, in relation to consumers preference. The low mean liking scores giving by consumers to the commercial juice has to be interpreted with care. This juice dilution was according to the label instructions (1 part of juice: 3 parts of water) and it was considered watering by panelists. A new dilution (1:2) was prepared and tasted by the trained panel, evaluated by consumers and still might have been considered inadequate.

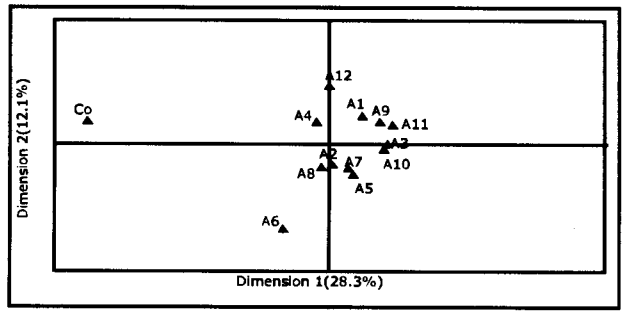

Fig. 2: Internal Preference Mapping showing 13 samples` position

In order to better understand the consumer's preference for clarified pineapple juices, the commercial product was removed from the analysis, and the data were re-analyzed using Internal Preference Mapping. The two first dimensions of the Internal Preference Mapping of the 12 pineapple juices explained 31.6% of the total variance (dimension 1, 17.3%; dimension 2, 14.3%). Fig. 3 and 4 show the consumers and sample plots, respectively. The position of 104 consumers revealed that the majority of participants was positioned in the top right of the map. It can be observed that when sample of commercial juice was excluded, the clarified juice from 0.1μ membranes - 3.5Bar treatment was considered the least preferred by consumers.

Samples of clarified pineapple juices from the 50KDa – 6.0Bar; 0.45μ - 3.0Bar; 30-80KDa – 1.5Bar; 100KDa – 6.0Bar; 100KDa – 7.5Bar; 0.45μ - 4.0Bar and 0.3μ - 4.0Bar treatments were grouped together in Fig. 4. On the other hand, the clarified samples from 0.3μ - 1.5Bar and 0.1μ - 4.5Bar treatments showed similar preference by consumers, but they were least preferred than the former group of juices. Juices from 50KDa - 7.0Bar and 0.1μ -5.5Bar treatments were separated by

Table 3: Relative to ideal[§] means for dilution and sweetness evaluation

Sample code	Sweetness	SD	Dilution	SD
Co - Control	2.9*	1.57	3.0*	1.91
A1 – 0.45μ - 4.0Bar	5.2	1.73	4.4*	1.57
A2 - 50KDa – 7.5Bar	4.6	1.91	4.0*	1.91
A3 - 50KDa – 6.0Bar	4.9	1.49	4.3*	1.70
A4 – 0.3μ - 3.0Bar	4.7	1.83	4.0*	1.87
A5 – 0.3μ - 1.5Bar	4.8	1.91	4.1*	1.95
A6 – 0.1μ - 3.5Bar	4.5*	2.02	3.9*	1.90
A7 – 0.1μ - 4.5Bar	4.7	1.86	4.2*	1.61
A8 – 0.1μ - 5.5Bar	5.0	1.69	4.2*	1.78
A9- 100KDa – 7.5Bar	4.9	1.66	4.2*	1.75
A10 - 100KDa – 6.0Bar	4.9	1.83	4.1*	1.60
A11 - 30-80KDa –1.5Bar	5.2	1.83	4.3*	1.59
A12 - 0.45μ - 3.0Bar	4.7	1.69	4.0*	1.62

§ Compared to "ideal point" (value 5) for the juice sweetness and dilution. *Mean statistically different ($p<0.05$) from the "ideal" value.

Table 4: Preference test media of the clarified pineapple juices

Sample Code	Media	Standard Deviation
A1 – 0.45μ - 4.0Bar	5.6[a]	1.88
A2 - 50KDa - 7.5Bar	4.8[ab]	1.88
A3 - 50KDa - 6.0Bar	5.6[a]	1.76
A4 - 0,3μ - 3,0Bar	5.0[ab]	1.81
A5 - 0.3μ - 1.5Bar	5.0[ab]	2.01
A6 - 0.1μ - 3.5Bar	4.5[b]	1.94
A7 - 0.1μ - 4.5Bar	5.1[ab]	1.96
A8 - 0.1μ - 5,5Bar	5.2[a]	1.84
A9 - 100KDa - 7.5Bar	5.6[a]	1.77
A10 – 100KDa - 6.0Bar	5.5[a]	1.91
A11 - 30-80KDa - 1.5Bar	5.5[a]	1.84
A12 - 0.45μ - 3.0Bar	5.6[a]	1.78
q	4.62	
F	3.96	

§ Compared to "ideal point" (value 5) for the juice sweetness and dilution. *Mean statistically different ($p<0.05$) from the "ideal" value.

dimension 1from the most preferred samples and the least preferred.

Although the model has not accounted for by a high value, such result is expected in consumer's studies where the variance level is generally high since non-trained individuals participate in the test (Monteleone *et al.*, 1998). The results of this study demonstrated that consumer's preference was directed towards the clarified juice obtained from smaller pore size membranes.

The higher consumer's preference by clarified juices, according to the results of the Internal Preference Mapping, was heavily associated with the volatile compounds present in the samples. The clarified juices using smaller pore size membranes were identified as having higher amount of the referred compounds (Carvalho *et al.*, 2002 a and b). It was expected that as the membrane pore size used in the clarified juices increased, the volatile compounds in the juices increased as well. However, other factors might have affected the filtration process which contributed to an opposite result. The higher pressures used in the ultrafiltration processes might have facilitated a solute deposition on the membrane surface and, consequently, this solute could have retained a greater amount of volatile compounds in it. On the other hand, the preference by clarified pineapple juices obtained by smaller pore size membrane processes could be explained by the fact that the pressures applied allowed that low molecular weight compounds passed through the small pore first the compactation take place. The hydrolyzed pineapple juice used before the membrane processes application contained about 38 different volatile compounds. Clarified juices obtained from 50KDa and 100KDa (polysulphone) and 30-80KDa (polyvinilidene fluoride) membranes had 15 and 11

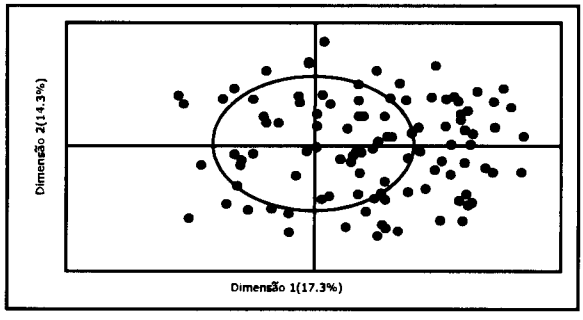

Fig. 3: Internal Preference Mapping showing consumers' distribution evaluating 12 samples

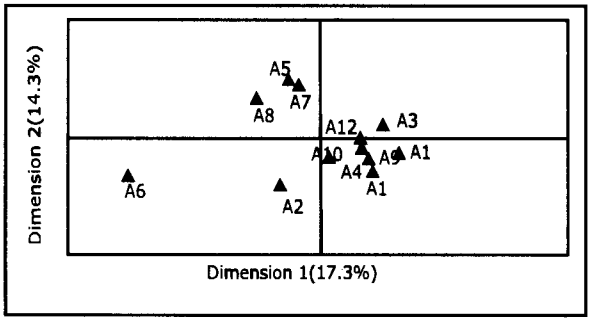

Fig.4: Internal Preference Mapping showing 12 samples' position

volatile compounds, respectively. In the clarified juices obtained from 0.45μ and 0.3μ membranes, the volatile compounds decreased to 11 and 12, respectively. Although the reduction on the number of volatile compounds was apparently not very high, it is important to consider that the 3-methyl,2,5 furanodione, the compound responsible for the pineapple aroma and flavor, was not present in juices processed in 0.45μ and 0.3μ.membranes.

Sweetness and Dilution Evaluation: All samples differed from the "ideal" point (value 5) when we focused on the dilution evaluation. It means that all pineapple juices (clarified and commercial) were considered weak by consumers. Although the greater difference between samples was observed with the commercial juice, the 12 clarified samples were rated below the "ideal" dilution reference point by consumer. Considering the sweetness results, only samples of the commercial juice and 0.1μ - 3.5Bar were considered less sweet than the "ideal" consumer reference for pineapple juice. It is a valuable information for the fruit juice producer, as it gives information about consumer perception of the juice, being an indication of the subsequent studies direction concerning fruit juice formulation.

Conclusion

The Internal Preference Mapping was an useful tool in demonstrating consumers' individual differences in terms of their preferences, and also in identifying potential clarified pineapple juice samples, which may be used as interesting alternatives to the juice producer and to consumers. The preferred clarified juices were obtained from the smallest pore size membranes (30-80KDa, 50 and 100KDa membranes) and with the application of low transmembrane pressure, exception for samples Co and 0.45μ - 3.0 and 4.0Bar treatments. It could be observed that consumers preferred the clarified juices higher in volatile compounds. The diluted commercial pineapple juice was considered the least preferred by the participants. It might have affected the preference towards the clarified juices. We suggest the use a higher scored on preference commercial pineapple juice to investigate how the clarified samples are compared to the non-clarified juice.

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