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Acidulants in Tropical Fruit Pulp: Physicochemical and Sensory Changes

Carlos Eduardo de F. Silva[a], Izabelle Caroline C. da Silva[a], Ana Karla de S. Abud[b]

[a] Technology Center, Federal University of Alagoas, Maceió, Alagoas, Brazil
[b]Food Technology Department, Federal University of Sergipe, São Cristóvão, Sergipe, Brazil.
eduardo.farias.ufal@gmail.com

The processing of pulp fruit helps to reduce the waste of raw fruits not traded, making them available in intercrop periods and in difficult access areas, ensuring quality of structure and maturation. When processed, some fruit characteristics are lost and its composition is changed due to factors such as oxidation, degradation and contamination. Because of this, Brazilian law provides the use of acidulants as flavor enhancer and pH broker, with effect on food microbiota. The study evaluated acidulants (lemon juice and solutions of citric and ascorbic acid in 1 % (m/v) proportion), with insertion of 0.1 % ($m_{acidulant}/m_{pulp}$) in the pulp, the physicochemical properties (soluble solids content (SSC), pH, acidity, total solids, total sugars and vitamin C), said identity and quality standards for fruit pulps, sensory analysis and frequency of consumption (intent consumer's purchase) to 7 pulp flavors (pineapple, acerola, cashew, caja, graviola, mango and passion fruit). The samples possessed some parameters out of the specification required by the law, being the greatest concern graviola and cashew pulps, in acidity, SSC and total solids. The sensory evaluations and the attitude test showed similarities in some acidulants choice. The pulps of passion fruit, graviola and mango, without acidulants, presented adequate sensory characteristics. The caja, cashew, pineapple and acerola pulps indicated the need for acidulants addition, such as ascorbic acid to the pulp of acerola and lemon juice or citric acid to the pineapple pulp. In the caja and cashew pulps, the presence of any from the studied acidulants, lemon juice, citric acid or ascorbic acid were important, since they presented similar results for sensory perception. The concordance coefficient in the attitude of purchasing test was relatively low due to the use of judges not trained in sensory analysis. For flavor attribute, was noticed that the samples do not differ significantly at 5% level, except for the commercial cashew pulp and with the addition of lemon juice and citric acid.

1. Introduction

The health care and the growing demand for products with fresh nutritional characteristics and sensory properties has attracted the consumers attention in the last decade (Andrés et al., 2015). The fruit importance and processed products are increasing because of the facilities provided by the offer of a ready product to be used, particularly for those who live alone, and the quality improvement of offered products (Carneiro et al., 2014).

Fruit pulps have huge importance as raw material and they can be produced in harvest times, they can be stored and processed in favorable periods or, according to the demand of the consumer market like bulk candy, jams, ices, nectars, among others. Due to the high perishability, fruits can deteriorate in a few days, turning difficult the fresh merchandising, especially for long distances. Thus, the production of frozen fruit pulps became alternative favorable to take full fruits advantage (Dantas et al., 2010). The expansion of fruit pulp industry has taken great proportions in recent years, mainly in the northeastern of Brazil. The processing units are mostly composed of small producers using traditional methods and they are usually supported by government projects or companies like Petrobras (Oliveira et al., 1999). Currently, Brazilian legislation provides limits in the physicochemical analysis for the fruit pulp quality control, through the Normative Instruction Nº 01 of January 7, 2000 (Brazil, 2000), on parameters such as acidity, pH, soluble solids content, total solids and vitamin C, setting minimum standards required for the fruit pulp.

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For food-borne products the determining factor for consumer acceptance is the appearance, in other words, the coloring, the shape and the packaging as well as the aroma, flavor and texture. Sensory analysis works synchronously with these sensory attributes, from the sight senses, smeel, taste, touch and hearing, seeking to meet the consumers and producers' needs (Pedrão and Coró, 1999). It is a used tool in the contribution of new products, raw materials control, product comparison and shelf life, measuring the acceptance and preference of consumers (Stone and Sidel, 2004). It can also supplement chemical analysis finding desirable or undesirable constituents and suggesting treatments (Amarine et al., 1965).

Acidulants are substances added to food products with the function of intensify the sour taste of the food and beverages, as well as operating in microbiological food preservation, especially in the non-development of pathogenic bacteria due to acidic pH. They are also used to control the pH of the food, acting as a buffer during different stages of processing of food products, reducing the heat resistance of the microorganisms (Moraes, 2006).

This study evaluates the physicochemical characteristics from different fruit pulps, with or without acidulant addition, to verify required compliance by legislation. Subsequently, it was studied the impact of acidulants addition in sensory perception of untrained tasters, determining the most suitable condition for each fruit pulp flavor, aiming to produce more stable fruit pulps and higher quality products.

2. Materials and Methods

Fruit pulps were used from the same batch, in 100 g packages, collected just after the extraction in the producing unit. The fruit pulps tested were pineapple, acerola, cajá, cashew, graviola, mango and passion fruit are considered the most consumed on the market. The pulps were stored in thermal boxes and conducted to the laboratory. Besides the traditionally traded sample, three other samples were supplemented, respectively, with 1mL of ascorbic acid solution (1 %), citric acid (1 %) or lemon juice (pure).

Different examinations were performed: soluble solids content (°Brix), using a digital refractometer, pH, using a digital pH meter previously calibrated in buffer solutions pH 4 and pH 7, and the total acidity of citric acid by volumetry neutralization, using phenolphthalein as an indicator and standardized solution of NaOH. The vitamin C was determined by the AOAC (2012) method, using titration with DCPIP (dichlorophenol-indo-phenol). The total solids were determined gravimetrically from leaving the sample at 105 °C for 1 hour and weighing it after cooling in a desiccator. The results were presented as mean and standard deviation of the analysis in triplicate.

Sensory analysis tests were performed with a minimum of 25 untrained tasters and samples prepared in juice form with 100 g of fruit pulp, 200 mL of water and 2 tablespoons of commercial crystal sugar, crushed in a blender for about 1 min. The tasters were instructed about the procedure to drink different samples, interleaving with cream cracker biscuit and water to remove residual flavor of the previous sample. The hedonic scale used was 9 points, with a maximum value corresponding to "like very much", the middle to "indifferent" and the minimum to "disliked very much" (Ferreira, 2000), evaluating mainly the acceptance rate. Also, it was evaluated the attitude of consumers towards the fruit pulp consumption frequency through nine action points scale, with maximum (9) corresponding to "only drink if it is forced" and minimum (1) to "drink it whenever I have chance". Samples were interspersed randomly at the time of distribution to tasters Each sample had an identification composed of three digits, without any orders, preventing the influence of assumption by the taster. For sensory data analysis evaluation it was used the Consensor 1.1 software (Silva et al., 2010) to calculate the percentage of agreement between tasters, and the ASSISTAT software, version 7.6 beta (Silva, 2012), in which it was applied the analysis of variance and Tukey test at 5% probability.

3. Results and Discussion

Currently, the Normative Instruction Nº 01 of January 7, 2000 (Brazil, 2000) defines the limits for the quality fruit pulp control. Table 1 presents the physicochemical analysis of the pulps, where red color values indicate measures out of the range required by legislation. Cashew and graviola samples pointed unsatisfactory consumption characteristics, with discordant results of explicit by Brazilian law. These results suggest greater attention during the fruit harvesting, handling, processing and packaging, in other words, a quality control in all production stages. A practice made by some industries of processing fruit pulp is the dilution of the original pulp to decrease the content of total soluble solids content (°Brix) to the minimum required by legislation, claiming easiness about the processing. This is a mistake, since the concept, according to the legislation, says "fruit pulp is the unfermented product, not concentrated, undiluted, obtained from fleshy fruits, through a technical process, with a minimum content of total solids from the edible part of the fruit" (Brazil, 2000).

Similar results were obtained by Dantas et al. (2010) and Paglarini et al. (2011), where more than 50% of fruit pulps analyzed (pineapple, acerola, caja, cashew, mango and passion fruit), especially in the aspects of soluble solids content (°Brix), vitamin C content and acidity, were rejected, as they presented physicochemical unsatisfactory characteristics according the specifications required by law.

Table 1: Physical and chemical characteristics of the pulps.

Pulps		SSC (°Brix) (20°C)		pH			Acidity (g citric acid.100 g^{-1})		Vitamin C (mg.100 g^{-1})		Total Solids (g.100 g^{-1})	
		Result	NI Min	Result	NI Min	NI Max	Result	NI Min	Result	NI Min	Result	NI Min
Pineapple	WA	12.5	11.0	3.86	-	-	0.47 ± 0.02	0.3	19.86 ± 4.00	-	12.4 ± 0.16	-
	L	12.8		3.74			0.53 ± 0.02		21.62 ± 1.21			
	C	12.7		3.85			0.50 ± 0.01		21.09 ± 2.28			
	A	12.5		3.85			0.50 ± 0.01		26.48 ± 1.89			
Acerola	WA	5.6	5.5	3.19	2.8	-	0.78 ± 0.04	0,.8	829.7 ± 0.91	800	5.69 ± 0.02	6.5
	L	5.5		3.15			0.89 ± 0.03		997.1 ± 324.7			
	C	5.7		3.22			0.82 ± 0.04		1063.5 ± 4.29			
	A	5.8		3.19			0.83 ± 0.10		1330.1 ± 1.08			
Caja	WA	9.2	9.0	2.59	2.2	-	0.80 ± 0.05	0.9	8.24 ± 1.43	-	9.01 ± 0.15	9.5
	L	9.6		2.53			0.85 ± 0.02		10.61 ± 1.51			
	C	9.4		2.55			0.81 ± 0.03		10.38 ± 0.58			
	A	9.0		2.55			0.83 ± 0.02		13.58 ± 0.76			
Cashew	WA	8.1	10.0	4.20	-	4.6	0.21 ± 0.03	0,3	87.83 ± 2.25	80	8.05 ± 0.03	10.5
	L	8.4		3.75			0.24 ± 0.01		79.68 ± 2.65			
	C	8.3		4.15			0.20 ± 0.01		79.99 ± 2.66			
	A	8.5		4.16			0.20 ± 0.01		97.61 ± 2.64			
Graviola	WA	9.0	9.0	3.66	3.5	-	0.44 ± 0.02	0.6	15.60 ± 1.56	10	9.86 ± 0.01	12.5
	L	9.0		3.50			0.52 ± 0.05		14.65 ± 0.87			
	C	8.6		3.61			0.44 ± 0.02		16.73 ± 2.23			
	A	8.3		3.63			0.44 ± 0.02		20.07 ± 1.12			
Mango	WA	10.3	11.0	3.69	3.3	-	0.39 ± 0.04	0.3	28.68 ± 3.55	-	10.2 ± 0.04	14
	L	10.4		3.59			0.46 ± 0.01		41.92 ± 4.68			
	C	10.4		3.68			0.45 ± 0.03		32.56 ± 3.39			
	A	10.2		3.70			0.42 ± 0.03		38.23 ± 4.90			
Passion fruit	WA	11.2	11.0	2.82	2.7	3.8	3.24 ± 0.01	2.5	21.43 ± 1.61	-	11.0 ± 0.23	11
	L	11.3		2.75			3.32 ± 0.02		21.21 ± 1.41			
	C	11.3		2.81			3.25 ± 0.01		15.69 ± 1.43			
	A	11.2		2.79			3.25 ± 0.02		26.45 ± 1.35			

NI = Normative Instruction, Min = minimum, Max =maximum, WA = without acidulants (normal), L = lemon juice, C = citric acid, A = ascorbic acid

It was observed that the acidulants slightly increased the acidity, reducing the pH. However, there was a greater preservation of vitamin C in the samples, with a significant increase over the original without adding any acidulants. The acidity and the pH measurement in certain foods provide an indication of the degree of deterioration, confirmed by the acidity or alkalinity developed (Dantas et al., 2010).

Figure 1 presents the acceptance rate of each fruit pulp compared to the traded product (without acidulants) or presence of various acidulants. It can be seen that for the pulps of passion fruit and graviola, the samples with higher acceptance rate did not have the presence of acidulants. The passion fruit, for being a very naturally acidic fruit, worse sensory perception with adding more acidulant. The graviola, which has its own identity as the fact that it is a very sweet fruit, avoids pattern characteristics patterns of its juice to make it more acidic. The addition of citric acid was optional for the cashew and mango pulps, while ascorbic acid did not cause differences in caja and acerola pulps. The pineapple pulp was more favorable with the use of lemon juice.

Citric acid is a widely acidulant widely used in fruit juices, when the natural acidic pH is not enough to ensure the long term microbial stability. It also has high solubility in water, it is a neutralizing sweet taste agent and it has acidifying effect on the flavor and is widely used in the beverage industry and food in general, where it is applied to reduce pH, microbial control, flavor growth, mask the unpleasant taste of saccharin, chelating action and healing. Ascorbic acid is also often used as an antioxidant in juices (Shui and Leong, 2002).

It is emphasized that the acceptance rate among samples of pineapple, caja, cashew, mango and graviola pulps, without and added acidulants were similar. This has its positive side, because the consumer could not see significant changes. Considering the product as commercial, Dutcosky (1996) mentions that the acceptance rate needs to be above 70%. This shows the need to work on the processing characteristics of passion fruit and acerola pulps, which possessed lower acceptability to be viable for the market. In particular, the passion fruit samples mixed with fresh lemon juice and ascorbic acid and acerola without acidulants or in citric acid. In acerola's case, addition of acid content increased its acceptance.

In Figure 1 is also displayed the evaluation as the frequency of consumption of prepared juices. The best results were acerola pulp with ascorbic acid, passion fruit without acidulants, mango without acidulants or with ascorbic and citric acids, graviola without acidulants, mainly, but any optional addition of acidulants with a small loss of sensory quality.

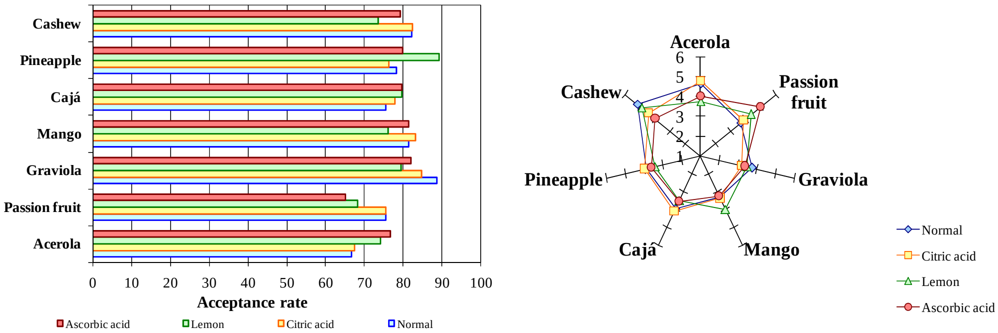

Figure 1: Acceptance rate (AR) and consumer attitude (CA) of fruit pulps in the presence and absence of acidulants.

Citric acid was well accepted in almost all flavors of fruit pulps, except for the pineapple flavor. Rodrigues et al. (2010) noticed a great acceptance of *topping di mirtilo* by using citric acid as acidulant and xanthan gum as a thickener, against acids such as tartaric and ascorbic. Ascorbic acid also possessed good acceptance, probably because it is a quite natural acid present in tropical fruits, serving, in some cases, as the default identity and quality in juices like cashew, graviola, acerola. Scherer et al. (2008) observed the natural presence of acidulants in cashew pulp, acai and acerola, mainly ascorbic acid in cashew and acerola. Andrés et al. (2015), in juices from orange, lemon, pear, passion fruit, acerola, pineapple, grape, apple, etc., with 7-50% of fruit pulp, added to milk and soy beans (3-10%), additives as citric acid, sodium citrate, trisodium citrate, calcium citrate and sucralose, and it was found that citric acid was the most abundant organic acid (from 0.41 to 5.05 $g.L^{-1}$). There were no significant differences between the addition of citric acid or any of its salts as acidulants.
Table 2 presents the best formulations obtained from the acceptance rate (AR) and the consumer attitude (CA), i.e., the best sensory evaluations, receiving the approximate concept of "frequently drink" by 25 analysts. There were differences and similarities on choices by hedonic scale between the acceptance rate and the attitude test to define the best acidulant adapted to each type of fruit. Similarities, such as passion fruit, graviola and mango without acidulants, being with adequate sensory characteristic, became optional the use of acidifiers indicated, unless it is necessary for the purpose of adjustment and maintenance. In the juices of caja, cashew, pineapple and acerola was necessary the addition of acidulants. To acerola, ascorbic acid; for pineapple pulp, lemon juice or citric acid; for caja and cashew pulps, lemon juice, citric or ascorbic acids.

Table 2: Formulations more appropriated by acceptance rate (AR) and consumer attitudes (CA) of the prepared fruit pulp juice.

Fruit Pulp	Without acidulants	Lemon Juice	Citric Acid	Ascorbic Acid
Pineapple	-	AR and CA	-	CA
Acerola	-	-	AR	AR and CA
Caja	-	AR and CA	AR	AR and CA
Cashew	AR		CA	AR and CA
Graviola	AR and CA		CA	AR and CA
Passion fruit	AR and CA	-	AR	-
Mango	AR and CA	-	AR and CA	AR

Table 3 presents the concordance coefficient (CC), for the attitude purchasing test of fruit pulps prepared and evaluated in sensory analysis. It is observed greater acceptance in graviola juice with added citric acid, lemon juice with pineapple and cashew with addition of ascorbic acid.
The CC values relatively low are explained by the fact that the use of untrained tasters, which is in part a positive point to evaluate the acceptability of a product, making it necessary to also consider different opinions aiming to simulate a real field consumer. Carneiro et al. (2014) also had low CC between pepper jam sample and cambuci, with the average being less than 50%, and Silva et al. (2010) evaluated custard apple juice with added milk (0-50%). In the analysis of variance (ANOVA), the flavor attribute showed greater divergence from the other attributes, as coloring, appearance and odor to the prepared drinks, proving to be a determinant factor in the choice of this type of product. These results are presented in Table 4.

Table 3: CC (%) for the consumer attitudes test (CA) of the prepared beverage.

	Pineapple	Acerola	Caja	Cashew	Graviola	Passion Fruit	Mango
Without acidulants	26.35	14.14	23.40	31.62	25.76	36.45	36.78
Lemon Juice	41.90	26.93	30.77	21.06	27.66	28.57	26.00
Citric Acid	31.62	22.36	29.67	32.74	42.26	28.89	33.37
Ascorbic Acid	36.09	24.00	31.83	41.04	29.45	18.90	37.36

Table 4: ANOVA parameters for all the attributes evaluated in the sensory analysis of the prepared drinks.

Attribute	Fruit Pulp	Without acidulants	Lemon Juice	Citric Acid	Ascorbico Acid
Flavor	Pineapple	6.64[a]	6.64[a]	6.76[a]	6.64[a]
	Acerola	5.37[a]	5.27[a]	6.33[a]	6.23[a]
	Caja	6.85[a]	6.46[a]	7.08[a]	6.73[a]
	Cashew	5.76[ab]	6.60[ab]	5.40[b]	7.04[a]
	Graviola	7.00[a]	7.62[a]	6.81[a]	7.43[a]
	Passion Fruit	6.43[a]	6.17[a]	6.14[a]	6.37[a]
	Mango	7.20[ab]	7.32[a]	7.36[a]	7.44[a]
Appearance	Pineapple	7.00[a]	7.16[a]	6.52[a]	6.76[a]
	Acerola	6.06[a]	6.70[a]	6.73[a]	6.77[a]
	Caja	7.15[a]	7.38[a]	7.38[a]	7.38[a]
	Cashew	4.56[a]	6.36[a]	5.84[a]	6.48[a]
	Graviola	7.05[a]	6.86[a]	7.05[a]	7.19[a]
	Passion Fruit	6.83[a]	6.14[a]	6.68[a]	6.37[a]
	Mango	7.48[a]	7.48[a]	7.52[a]	7.48[a]
Color	Pineapple	6.84[a]	7.20[a]	6.64[a]	7.04[a]
	Acerola	6.23[a]	6.73[a]	7.06[a]	7.06[a]
	Caja	7.35[a]	7.54[a]	7.31[a]	7.58[a]
	Cashew	6.00[a]	6.60[a]	6.08[a]	6.72[a]
	Graviola	7.24[a]	7.00[a]	7.00[a]	7.33[a]
	Passion Fruit	6.97[a]	6.74[a]	6.94[a]	6.40[a]
	Mango	7.68[a]	7.64[a]	7.76[a]	7.80[a]
Aroma	Pineapple	6.96[a]	6.32[a]	6.52[a]	6.84[a]
	Acerola	6.43[a]	6.70[a]	6.33[a]	6.60[a]
	Caja	7.19[a]	7.15[a]	7.07[a]	7.57[a]
	Cashew	5.64[a]	5.72[a]	6.52[a]	6.64[a]
	Graviola	6.81[a]	7.09[a]	7.05[a]	7.24[a]
	Passion Fruit	6.43[a]	6.14[a]	6.17[a]	6.37[a]
	Mango	6.96[a]	7.04[a]	7.28[a]	7.56[a]
General evaluation	Pineapple	7.04[a]	7.13[a]	6.87[a]	7.17[a]
	Acerola	6.00[a]	6.07[a]	6.67[a]	6.90[a]
	Caja	6.85[a]	7.15[a]	6.85[a]	7.15[a]
	Cashew	5.68[b]	5.96[b]	6.64[ab]	7.12[a]
	Graviola	7.09[a]	7.14[a]	7.62[a]	7.38[a]
	Passion Fruit	6.80[a]	6.14	6.80[a]	5.86[b]
	Mango	7.32[a]	6.84[a]	7.48[a]	7.36[a]

* a, b e ab were obtained from the Tukey test using the Assistat 7.6 beta version. Same letters in the same row means that the formulations are not significantly different at 5%.

By Tukey test, it is noticed that for attributes like coloring, smell and appearance, the drinks did not differ significantly at 5%, confirming the good acceptance rate of the product. To choose a food, the first attribute appreciated by consumer is the appearance, followed by the smell and taste, the latter being the main determinant attribute of choice.

It is noticed that the evaluated criteria did not differ significantly at 5%, except for commercial cashew pulp (without acidulants) and with addition of lemon juice and citric acid, presumably due to problems during the fruit pulps processing, as they not presented any consistency values to the established by Brazilian legislation for the identity and quality standards for frozen fruit pulp (Table 1). This indicates that the vast majority of the pulps were approved in taste and acceptance rate, although noticed higher values of some other formulations.

4. Conclusions

Fruit pulp samples possessed some parameters out of specification required by the legislation, being the main concern in the graviola and cashew samples. In sensory evaluation, the acceptance rate and the attitude test showed similarities in choosing some acidulants, like the passion fruit, graviola and mango pulps. The caja, cashew, pineapple and acerola pulps indicated the need for addition of acidulants such as ascorbic acid to the acerola pulp and lemon juice or citric acid to the pineapple pulp. In the cashew and caja pulps, it is important the presence of any of the studied acidulants. It was noticed that not all pulps need this addition and that it should be linked, first, to the sensory characteristics.The values found for the correlation coefficient in the attitude of purchasing test were low, which had been expected, because it was used not trained tasters. The samples were not significantly different at 5%, except for the pulp commercial cashew (without acidulants) and with the addition of lemon juice and citric acid.

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