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Development of a fruit smoothie with solid albumen of green coconut

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ABSTRACT: *The present study aimed to develop a mixed smoothie drink using the solid albumen of the green coconut in its composition. Smoothie formulations were prepared following an experimental design, setting the solid albumen concentration at 20% and varying the contents of the acerola (Barbados Cherry), pineapple, and coconut water pulps, which corresponded to 80% of the total mass of the product. Response parameters evaluated were vitamin C content, antioxidant capacity, and overall sensory acceptance. Ten formulations were evaluated. The ones that contained higher concentrations of acerola pulp had higher values of bioactive compounds but were not the most sensorially accepted. By means of the desirability function, a final formulation consisted of 52.8% of pineapple, 27.2% of acerola, and 20.0% of solid albumen of green coconut. This new formulation was well accepted, with a grade (score) 7 ("good"). It represents a good nutritional contribution and a source of vitamin C which can contribute to add value to a co-product of the beverage industry.*
Key words: *product development, sensory analysis, tropical fruits, antioxidant capacity.*

Desenvolvimento de um *smoothie* de frutas contendo albúmen sólido do coco verde

RESUMO: *O objetivo deste trabalho foi desenvolver uma bebida mista do tipo smoothie utilizando o albúmen sólido do coco verde na sua composição. As formulações do smoothie foram elaboradas seguindo um planejamento experimental, fixando-se a concentração do albúmen sólido em 20% e variando-se os teores das polpas de acerola, abacaxi e água de coco, que totalizaram 80% da massa total do produto. Os parâmetros de resposta avaliados foram o teor de vitamina C, a capacidade antioxidante e a aceitação sensorial global. Foi observado que das dez formulações avaliadas, as que continham maiores concentrações de polpa de acerola, apresentaram valores superiores de compostos bioativos, porém não foram as mais aceitas sensorialmente. Por meio da função desejabilidade chegou-se a uma formulação final que consistiu de 52,8% de abacaxi, 27,2% de acerola e 20,0% de albúmen sólido de coco verde. Esta nova formulação teve boa aceitação, com nota igual a 7 ("bom") e representa um bom aporte nutricional, sendo fonte de vitamina C, podendo contribuir para agregar valor a um coproduto da indústria de bebidas.*
Palavras-chave: *desenvolvimento de produto, análise sensorial, frutas tropicais, capacidade antioxidante.*

INTRODUCTION

Brazil is the fourth largest producer of coconuts in the world, surpassed only by Indonesia, the Philippines, and India (FAOSTAT, 2014). In 2016, Brazilian coconut production reached a total of 1,896,124 tons (IBGE, 2016).

In the industries of bottled coconut water, the shells are generally discarded and, attached to it, the solid albumen (green coconut pulp). According to BENASSI et al. (2007), the solid albumen of the dwarf green coconut (coconut tree dwarf green variety) at 8.5 months corresponds to 3.32% of the fruit weight. Use of this pulp is an alternative to reduce the generation of residues in the coconut water industrialization process and avoid the waste of this co-product which can reach 80,000 tons per year.

SANTANA et al. (2011) characterized the green coconut pulp, which had 5.19% of carbohydrates, 92.70% humidity, 0.39% of lipids, 0.97% of protein, and 0.75% of ashes. Like coconut water, albumen also contains minerals and low fat and sugars, and can be used as an ingredient in the industry of fruit drinks.

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In this day and age, ready-to-drink smoothie beverages are sought after by consumers seeking both nutritional quality and practicality. These beverages are formulated from fruit, fruit juice, yogurt, milk or honey, have a semi-liquid consistency, and are packaged in bottles that are easy to handle. In addition, fruit smoothies contain dietary fiber, antioxidant substances, and nutrients that may contribute to reduce risk of developing chronic non-communicable diseases (NOWICKA et al., 2016).

Different fruits can be used to obtain these products which contribute to the nutritional and sensorial characteristics of the beverage. The development of smoothies with different combinations of fruits has been reported (MARKOWSKI et al., 2017). In general, fruits that are used to make a smoothie contribute to the quality of these fruits based on their original characteristics e.g. acerola which stands out for its high content of vitamin C; the banana, which adds a sweet taste to this beverage; the pineapple which is a fruit that is widely consumed and appreciated, and which can contribute to the sweet-acid balance of the smoothie; the açaí palm which is rich in anthocyanins; among other fruits.

However, the thick consistency, similar to a "milk shake", is a determining characteristic for the acceptance or rejection of this type of beverages. Smoothies are prepared with typical ingredients. Yoghurt, frozen fruits, milk and ice are the ones most often used for making smoothies (SAFE FOOD, 2009). SANTANA et al. (2011) evaluated the functional properties of the green coconut pulp. Results of their study indicated that the ability of foam formation and emulsification, viscosity, and volume increased due to air aggregation similar to those obtained using milk, fat, and emulsifier in ice cream formulation. Considering this scenario, the present study aimed to develop a mixed smoothie drink (beverage) using the solid albumen of the green coconut in its composition.

MATERIALS AND METHODS

Raw materials (basic ingredients)

The solid albumen of the dwarf variety of green coconut and coconut water were provided by the coconut water franchise (chain store) "Rei do Coco" (Coconut King) located in Barra do Piraí, RJ, Brazil. The albumen was removed manually after water extraction, stored in flexible packages, and shipped under refrigeration to Embrapa Food Agri-industry Research Institute located in Rio de Janeiro, RJ, Brazil, where it was homogenized in a ultraprocessor (Nutri Ninja™ model BL492BR30, China).

For the initial study of the formulations, frozen pulps of acerola and pineapple (De Marchi, Jundiaí, SP, Brazil) were purchased from the Central of Supply of Rio de Janeiro State (CEASA, RJ, Brazil). For the validation of the selected formulation, we used freshly extracted pulp of fresh pineapple and acerola fruits that were purchased from the local stores in the municipality of Rio de Janeiro-RJ, Brazil. Upon receipt, the fruits were washed and sanitized. Pineapple fruits were manually peeled and sliced for pulp extraction using a horizontal fruit pulp extraction machine manufactured by Itametal, model Bonina 0,25df (Itabuna, Brazil) with a 0.6mm sieve. The acerola pulping extraction was carried out directly using a pulp machine since peeling and cutting were not required prior to the pulping of the fruit mass. All raw materials (basic ingredients) were kept (stored) in a freezing chamber at -18°C until the experimental trials were carried out. The experiments and analysis were conducted in the pilot plants and laboratories of Embrapa Food Agri-Industry.

Formulation and characterization of raw material and smoothie

Based on preliminary tests, the concentration of the solid albumen of the green coconut was set at 20% (m/m) as it provided a desirable consistency for the beverage. Contents of the three other components (acerola pulp, pineapple pulp, and coconut water) were the independent variables of the blend planning (BRANCO & GASPARETTO, 2005) which corresponded to 80% (m/m) of the product. Response parameters assessed were vitamin C content, antioxidant capacity, and overall sensory acceptability of the 10 formulations resulting from the planning (Table 1).

For the preparation of the formulations, the raw materials (ingredients) were weighed in the amounts established and were homogenized in an ultraprocessor (Nutri Ninja™, model BL492BR30, China). Formulations were pasteurized at 84°C for 40s on a scraped surface heat exchanger (FT25D, Armfield, England), packed in an ultra-clean container chamber in pet bottles with previously sanitized screw caps, and immediately cooled.

All pasteurized formulations were evaluated for the presence of pathogenic microorganisms (*Salmonella* and coliforms at 45°C) according to the American Public Health Association (APHA, 2001). Raw materials and different smoothie formulations were analyzed for physical-chemical parameters, vitamin C, and antioxidant capacity. Determination of total

Table 1 - Experimental mixing design for smoothie made with the solid albumen of the green coconut (20% m/m), with added acerola, pineapple, and coconut water.

Formulation	------------Coded variables-----------			---------------------------------------Real variables-------------------------------------		
	X1	X2	X3	(%) Acerola	(%) Pineapple	(%) Coconut water
1	1	0	0	80	0	0
2	0	1	0	0	80	0
3	0	0	1	0	0	80
4	1/2	1/2	0	40	40	0
5	1/2	0	1/2	40	0	40
6	0	1/2	1/2	0	40	40
7	1/3	1/3	1/3	26.6	26.7	26.7
8	2/3	1/6	1/6	53.4	13.3	13.3
9	1/6	2/3	1/6	13.3	53.4	13.3
10	1/6	1/6	2/3	13.3	13.3	56.4

phenolic compounds was carried out only for the raw materials and for the selected final formulation. Methods are presented below.

Soluble solids were determined by direct reading in a digital refractometer (ATAGO); the pH and titratable acidity were determined in an automatic titrator (Metrohm, 785 DMP Tritino); the total solids were determined by gravimetry (AOAC, 2005). Content of vitamin C was determined by a titration method (tritrimetry) using dichlorophenol-indophenol, and results were expressed as mg of ascorbic acid per 100g of sample (SILVA, 1999). Antioxidant capacity was determined by the ABTS$^{\cdot+}$ radical capture assay (Sigma-Aldrich®, Brazil) according to RE et al. (1999) and results were expressed in µg equivalent of Trolox per gram of sample. For quantification of total phenolics, Folin Ciocalteu reagent (Sigma Aldrich®, Germany) was used according to the protocol published by GEORGÉ et al. (2005). Results were expressed as mg of gallic acid per 100g sample.

Sensory evaluation was performed in two different stages (steps) of the product development. In the first one, the global acceptability was one of the responses of the mixture planning; ten formulations were evaluated. This test was carried out in the Laboratory of Sensory Analysis of Embrapa Food Agri-Industry; 84 consumers of both sexes participated in this trial; consumer acceptance was measured by means of a hedonic scale of 9 points ranging from 1 - "strongly disliked it" - to 9 - "I liked it very much" - according to the method described by MEILGAARD et al. (1991). In the second stage, which aimed to verify the acceptance (acceptability) of the formulation selected by potential consumers, a new test was conducted at a store from the Hortifruti chain located in Recreio dos Bandeirantes neighborhood, city of Rio de Janeiro, RJ; 113 consumers of both sexes participated in this trial. In addition to the acceptability assessment based on the 9 point P & K scale (ranging from 1 - "really bad (awful)" to 9 - really good (excellent)), consumers also answered questions about consumption habits of fruit juices and nectars and consumption intentions. In both tests, samples were presented in 50ml white plastic cups coded with 3 digit numbers and served at the refrigeration temperature.

Data analysis

Results were expressed as mean values ± standard deviation of the determinations performed in triplicate and were statistically treated using analysis of variance (ANOVA) and Tukey test at 5% significance with the software Statistica 7.0 (Statsoft Inc., Tulsa, OK, USA). Coefficients and interaction among variables were observed, generating the Pareto graph. The desirability function was used in order to determine the optimal proportions of each fruit. Therefore, we were able to simultaneously optimize the different response variables to obtain the best formulation possible. Values of the function are restricted to the interval (0-1) in which 0 represents an unacceptable value and 1 is the most desirable value (DERRINGER & SUICH, 1980).

RESULTS AND DISCUSSION

Physical-chemical characterization of raw materials (active ingredients)

Table 2 presents the pulps, coconut water, and green coconut pulp. The values of pH, titratable acidity, soluble solids, and total solids determined for both acerola pulp and pineapple pulp were within the limits established by Brazilian legislation (BRASIL, 2000). These parameters are important to assess pulp quality in relation to its conservation, maturity index, and standardization (CASTRO et al., 2015).

The green coconut pulp presented a higher content of soluble solids than that of coconut water. This finding is directly related to its sugar content which is compatible with the stage of maturation (maturity) close to the seventh month (CARVALHO et al., 2006). Both the water and the pulp have low acidity which was in the pulp. As a result, its pH is higher. In this pH range, coconut water and pulp may be susceptible to the proliferation of pathogenic bacteria (bacterial pathogens) (CERESER et al., 2008). Thus, the addition of acidic fruits in the formulations of smoothies also aims to contribute to the reduction of the pH which guarantees, along with the pasteurization, the microbiological safety of beverages. The fruit mixture provides sugars (pineapple and coconut pulp) and organic acids (pineapple and acerola) to the product. It also enables the development of a fruit drink without the addition of sugars and preservatives which contributes to the sensorial characteristics of the beverage. The coconut pulp also has a significant level of total solids which contribute to the consistency of the beverage.

The acerola and pineapple pulps also contain bioactive compounds such as phenolics and vitamin C which are substances that contribute to the antioxidant capacity of fruits, e.g. acerola which contains high levels of these compounds and; therefore, an antioxidant capacity (51.22μmol Trolox.g^{-1}). These characteristics corroborated the use of these raw materials in the smoothie formulation.

Characterization of the mixed green coconut smoothie

The Physical-chemical characteristics of the 10 formulations are shown in table 3. The acidity of the pasteurized *smoothies* ranged between 0.25 and 0.61g.100g^{-1} (expressed as citric acid). Formulations that presented higher values of acidity were F1, F2, F4, F8 and F9 which contained higher concentrations of acerola and pineapple. As a result, these formulations had the lower pH values. In a study conducted by MATSUURA & ROLIN (2002), pineapple and acerola *blends* presented pH values between 3.42 and 3.81 and acidity between 0.71 and 0.87g of citric acid 100g^{-1}. Our findings are in agreement with their findings considering the fact that the addition of both green coconut pulp and green coconut water contribute to an increase of the pH and to a decrease of the acidity of the formulations. Soluble solid contents of the formulations varied between 6.3 and 12.0°Brix. As previously mentioned, beverages with higher contents were those that contained higher concentration of pineapple pulp due to the composition of the fruit.

Table 4 presents results of the dependent variables (vitamin C, antioxidant capacity, and sensory acceptability) of the mixture planning for the 10 formulations. As expected, it is possible to observe a link between the increase in vitamin C

Table 2 - Physicochemical characterization and bioactive compounds of the pulp of acerola, pineapple, green coconut, and coconut water.

*Parameter	Acerola pulp	Pineapple pulp	Coconut water	Green coconut Pulp
pH	3.46 ± 0.01	3.54 ± 0.01	5.16 ± 0.01	6.53 ± 0.00
Soluble solids (°Brix)	5.80 ± 0.06	12.00 ± 0.06	5.90 ± 0.00	7.50 ± 0.12
Acidity (g cítric acid 100g^{-1})	1.92 ± 0.00	0.66 ± 0.00	0.08 ± 0.00	0.06 ± 0.00
Vitamin C (mg.10 g^{-1})	773.76 ± 25.48	20.56 ± 0.20	ND	ND
Total solids (g.100g^{-1})	6.59 ± 0.18	13.12 ± 0.01	7.53 ± 0.04	10.06 ± 0.07
Total phenolics (mg gallic acid. 100g^{-1})	467.81 ± 5.04	38.18 ± 0.22	ND	18.82 ± 0.82
Antioxidant capacity (μmol Trolox.g^{-1})	51.22 ± 0.74	1.06 ± 0.07	ND	0.75 ± 0.05

*Average of 3 replicates ± standard deviation. ND - not detected.

Table 3 - Physicochemical characteristics of 10 formulations of pasteurized smoothie.

Sample/Parameter	pH	Soluble solids (°Brix)	Acidity (g cítric acid $100g^{-1}$)
F1	3.78 ± 0.02	6.3 ± 0.15	0.60 ± 0.01
F2	3.83 ± 0.00	12.0 ± 0.21	0.61 ± 0.00
F3	5.61 ± 0.00	6.0 ± 0.00	0.06 ± 0.00
F4	3.86 ± 0.01	9.3 ± 0.20	0.60 ± 0.01
F5	3.93 ± 0.02	6.4 ± 0.12	0.34 ± 0.00
F6	4.01 ± 0.01	8.6 ± 0.06	0.35 ± 0.01
F7	3.86 ± 0.00	8.0 ± 0.10	0.44 ± 0.01
F8	3.76 ± 0.00	7.3 ± 0.06	0.51 ± 0.00
F9	3.73 ±0.01	10.2 ± 0.06	0.51 ± 0.01
F10	4.19±0.01	7.2 ± 0.06	0.25 ± 0.00

*Data referring to the average of three replicates ± standard deviation.

and antioxidant capacity values and acerola pulp proportions. This fruit is the source of this vitamin and is a natural ingredient which enriches the beverage. It should be emphasized that even after heat treatment of smoothies high levels of vitamin C were still present. Correlation coefficient (R^2) between vitamin C levels and the antioxidant capacity of the formulations was 0.9963 (P<0.05). This finding confirmed the strong positive correlation between the two parameters and the contribution of this nutrient to the antioxidant capacity properties of formulated beverages.

In the 10 formulations of the pasteurized smoothie, coliform counts were lower than 10 CFU/100g considering the limit of the legislation (BRASIL, 2001). *Salmonella,* which standard is its absence in 25g, was not detected in any sample tested. Based on the analysis of variance, we noticed that the formulations F2, F6, and F9 had the highest mean of acceptance (scores close to 6.0 - liked a little bit (to a certain degree)) and did not present a significant difference (P<0.05) between them. These formulations contained higher proportions of pineapple pulp which suggest that the soluble solid contents of this pulp contributed to the acceptability of the formulations as sweetness tends to influence consumer approval. A similar result was observed by NOWICKA et al. (2016). These researchers noted a relationship between the degree of sweetness and the acceptance of smoothies; those beverages with the highest proportions of apple and quince juice were the most accepted ones with a mean of scores of 8.2 and 7.5, respectively. The other smoothies, with high acidity had lower acceptability scores.

FARAONI et al. (2012) developed a mixed juice of mango, guava and acerola which achieve scores varying from 6.6 to 7.6. These marks were higher than those observed in the present study especially in formulations with a higher proportion of acerola and; therefore, higher acidity, that had lower sensory acceptability.

Based on the Pareto diagram (Figure 1), we were able to observe that these three components (ingredients) had a significant effect on the overall acceptance of the smoothie. The proportion of pineapple was the most influential variable followed by coconut water and ultimately acerola. This data shows statistically that the formulations with a higher content of pineapple pulp presented the greater acceptance among tasters.

The formulation selected based on desirability considering the balance between consumer responses contained 34% of acerola and 66% of pineapple without the addition of coconut water. Thus, the final formulation selected consisted of 52.8% of pineapple, 27.2% of acerola and 20% of solid albumen of green coconut, and presented 432.72mg.$100g^{-1}$ of vitamin C, 519.46mg of acid gallic acid.$100g^{-1}$ of total phenolic compounds, and antioxidant capacity of 27.37μmol Trolox.g^{-1}.

Acceptance of the selected formulation

Consumers profile who participated in the validation test of the final formulation that was selected

Table 4 - Vitamin C content, antioxidant capacity and overall acceptance notes of the ten formulations of pasteurized smoothie.

Sample	Vitamin C (mg 100 g^{-1})	Antioxidant capacity ABTS (µmol Trolox g^{-1})	Global acceptability score
F1	572.37 ± 3.27	52.35 ± 1.82	3.10^{e}
F2	20.29 ± 0.12	1.41 ± 0.04	6.13^{a}
F3	15.30 ± 0.07	0.67 ± 0.03	4.69^{bc}
F4	290.20 ± 2.42	27.74 ± 0.49	4.46^{bc}
F5	316.27 ± 9.14	29.08 ± 0.77	3.50^{de}
F6	19.93 ± 0.17	1.18 ± 0.04	5.96^{a}
F7	252.31 ± 10.0	19.12 ± 0.28	4.86^{b}
F8	395.56 ± 9.15	34.91 ± 0.51	4.05^{cd}
F9	132.83 ± 12.94	11.34 ± 0.49	5.80^{a}
F10	130.12 ± 4.47	9.02 ± 0.57	4.26^{bc}

Mean of three replicates ± standard deviation. [*]Means with equal letters in the column do not differ by Tukey's test ($P < 0.05$).

showed that 42% consumed fruit drinks (nectar or juice) "once in a while (occasionally)" and 30% "always" consumed this type of beverage. Based on these findings, we may infer that these individuals form a potential target audience for the beverage formulated in this study.

The average overall smoothie consumer acceptability score was 7 which correspond to "good". This finding indicated that the new formulation selected was well accepted by consumers. The majority of the consumers (98%) considered smoothie a healthy drink; 92% of these individuals said that regular consumption of this type of beverage might help preventing illness since it contains vitamins, minerals, and bioactive

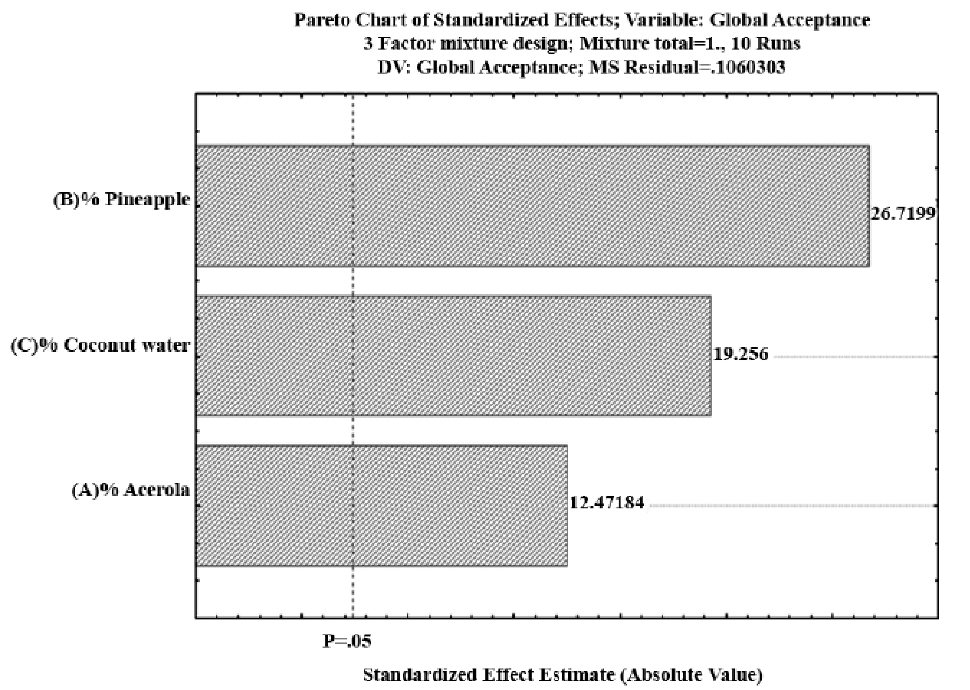

Figure 1 - Pareto diagram for the effect of the independent variables (pineapple, acerola, and coconut water) on the global acceptance of the smoothie.

compounds. More than 50% of consumers would consume this beverage both for their liking and for their potential beneficial health benefits.

CONCLUSION

Results of the present study showed that it is possible to use solid albumen of green coconut in the development of a smoothie beverage. The selected formulation had good sensory acceptability. Considering the Physical-chemical composition of raw materials used in the preparation of these soft drinks, these ingredients may contribute to the nutritional supplementation (diet) of consumers. In addition, it provides a good source of vitamins, bioactive compounds, and antioxidant capacity. The industrialization of this beverage will also contribute to minimize the disposal of this co-product from the coconut water agroindustry by at least 20% by means of value aggregation.

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BIOETICHS AND BIOSSECURITY COMMITTEE APPROVAL

We the authors of the article titled “Development of a fruit smoothie with solid albumen of green coconut” do hereby declare for all due effects (intents) and purposes that the research project that generated the data presented in this publication was already submitted for evaluation by the Ethics Committee of the Plataforma Brasil (Brazil Platform), and that we are aware of the content of Resolution No. 466 issued on December 12, 2012 by the National Health Council <http://conselho.saude.gov.br/resolucoes/2012/Reso466.pdf> if humans in research studies. Therefore, the authors take full responsibility for the data presented in this study. The authors are available for any inquiries (questions) if there is any concern or need for further clarification if these requests come from competent bodies.

DECLARATION OF CONFLICTING INTERESTS

The authors declare no conflict of interest.

AUTHORS’ CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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