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Original Article

Effect of the partial substitution of mango and ground chia on the antioxidant capacity in the elaboration of nectar based on sachatomate

Efeito da substituição parcial de manga e chia moída na capacidade antioxidante na elaboração de néctar à base de sachatomato

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Abstract

The consumption of products with high nutritional value and antioxidant capacity has increased notably in recent years. Due to health problems such as triglycerides and cardiovascular problems, its use is becoming reduced. So that, chia (*Salvia hispánica*) and sachatomate (*Cyphomandra betacea*) have gained interest as an alternative to develop nutraceutical products, compared to conventional products. The objective of the study was to determine the effect of the partial substitution of mango (*Mangifera indica*) and ground chia (*Salvia hispánica*) on the antioxidant capacity in the elaboration of nectar based on Sachatomate. The physicochemical characteristics were determined where sample 11 complies with the established parameters: 13.4° Brix, pH 4.323, 0.354 of C_6-H_8-O_7 and viscosity 3967.3 mPas, according to the NTP 203.110 standard. Regarding the antioxidant capacity, sample 12 was the most optimal, according to the DPPH method, it has been determined 104.3 micromoles Trolox equivalents; according to the ABTS method, it was determined with an antioxidant content of 187.4 micromoles Trolox equivalents. Regarding the proximal chemical evaluation, sample 12 was determined to be the most suitable with a moisture percentage of 87.45%, ash 0.32%, crude fiber 0.09%, fat 0.10%, protein 0.45% and carbohydrates 11.59%. Concluding that substituting sachatomate and ground chia significantly influences the antioxidant capacity, increasing to 104.3 and 187.4 micromoles Trolox equivalents, determined by both methods, indicates that nectar consumption can be used to improve the health of consumers.

Keywords: antioxidant capacity, chia, mango, sachatomate, DPPH, ABTS, nectar.

Resumo

O consumo de produtos com alto valor nutricional e capacidade antioxidante tem aumentado notavelmente nos últimos anos. Devido a problemas de saúde, como triglicerídeos e problemas cardiovasculares, seu uso está cada vez mais reduzido. Assim, a chia (*Salvia hispanica*) e o sachatomato (*Cyphomandra betacea*) têm ganhado interesse como alternativa para o desenvolvimento de produtos nutracêuticos, em comparação aos produtos convencionais. O objetivo do estudo foi determinar o efeito da substituição parcial da manga (*Mangifera indica*) e da chia moída (*Salvia hispanica*) na capacidade antioxidante na elaboração de néctar à base de Sachatomate. As características físico-químicas foram determinadas onde a amostra 11 atende aos parâmetros estabelecidos: 13,4° Brix, pH 4,323, 0,354 de C6-H8-O7 e viscosidade 3967,3 mPas, conforme norma NTP 203.110. Quanto à capacidade antioxidante, a amostra 12 foi a mais ótima, de acordo com o método DPPH, foram determinados 104,3 micromoles equivalentes de Trolox; de acordo com o método ABTS, foi determinado um teor antioxidante de 187,4 micromoles equivalentes de Trolox. Em relação à avaliação química proximal, a amostra 12 foi considerada a mais adequada, com percentual de umidade de 87,45%, cinzas 0,32%, fibra bruta 0,09%, gordura 0,10%, proteína 0,45% e carboidratos 11,59%. Concluir que a substituição do sachatomato pela chia moída influencia significativamente a capacidade antioxidante, aumentando para 104,3 e 187,4 micromoles equivalentes de Trolox, determinados por ambos os métodos, indica que o consumo de néctar pode ser utilizado para melhorar a saúde dos consumidores.

Palavras-chave: capacidade antioxidante, chia, manga, sachatomato, DPPH, ABTS, néctar.

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1. Introduction

The sachatomate originates from the Puno jungle (Sandia), mostly known in terms of its consumption and industrialization, since they are mostly used naturally, for which, the sachatomate would be a new alternative to transform, innovating at an industrial, commercial and entrepreneurial level (Yager-Elorriaga et al., 2022). The consumption of nectars made from (*Cyphomandra betacea*) with partial substitution of (*Salvia hispanica*) and (*Mangifera indica*) is not common, due to ignorance of its nutritional properties and lack of innovation of industrial processes. The sachatomate has a high content of vitamins, essential minerals and its antioxidant activity (Encina et al. 2017). Furthermore, chia (*Salvia hispanica*), is an excellent alternative to make by-products with nutraceutical character for its content of antioxidants and omega 3 (Jaramillo, 2013; Obregón-La Rosa et al., 2023), and mango (*Mangifera indica*) is a fruit rich in magnesium, in pro vitamins A and C, and has high concentrations of carbohydrates, as well as has a sweet taste (Peralta, 2004; Yahia et al., 2023). Hence, its use will be intended to increase its degree of acceptability of nectar production.

As a result of this lack of knowledge, people aren't able to make use of products that have sufficient nutritional properties for consumption, which makes the development of new technologies of innovation and industrialization of fruit nectars highly significant within the food area. Nectar crafted from sachatomate (*Cyphomandra betacea*) with pulverized chia (*Salvia hispanica*) and mango (*Mangifera indica*) would be of excellent nutritional value and stand out on the market because of the vitamins and minerals they give (Sarkar et al., 2022). At present, almost all people suffer from various chronic diseases, such as obesity, triglycerides, and diabetes, these problems are generally related to metabolic syndrome (Chavez and Ortiz, 2016). Therefore, the importance of the consumption of fruits and vegetables would be an alternative to counteract various diseases that contribute to the defense of the organism, generating the consumption of the wide variety of fruits (Poljsak, 2011). As a result, consumers have an absolute need to purchase beverages that not only ensure quality and food safety but also have beneficial nutritional qualities. In addition, the tomato is a species little studied and little known in the region, so it has not been able to develop at an industrial and commercial level. In the present investigation, it was oriented to evaluate the physicochemical characteristics, antioxidant capacity, sensory and proximal chemical capacity of the nectar has been determined. Furthermore, the second objective of the study was to evaluate its nutritional properties according to current technical standards for an adequate industrialization, which guarantees the nutritional and healthy properties favorable to the consumer.

2. Materials and Methods

2.1. Experimental location

The research was carried out in the laboratories of the National University of Juliaca, chemistry laboratory of the National University of the Altiplano and laboratories of the National University San Antonio Abad of Cuzco.

2.2. Experimental treatments

Using a Box-Behnken (DBB) design, we created 15 different formulations by varying the amounts of tomato pulp, mango, and ground chia across three different levels in each treatment.

2.3. Reagents used and their collection

The raw materials, inputs and reagents used for this research were the sachatomate from the province of Sandia region of P one, ground chia from the province of Carabaya region of Pone and mango of Kent variety. Similarly, white sugar, sodium benzoate, and water were also used as active reagents. Also, the ABTS (2,2azinobis, 3-ethylbenoxthiazoline 6-sulfonate acid), DPPH (2,2-diphenyl-1-picrylhydrazil), 0.1N sodium hydroxide, 2% phenolphthalein solution, methanol and ethanol were also used and collected from the chemical laboratories of National University of Juliaca.

2.4. Processings

The raw materials were put through the standard unit processes of receiving, weighing, and selecting (badly damaged, rotten, misshapen, improperly coloured, or infected fruits were thrown away). Blanching (for 3 minutes at 80°C) and washing (using chlorine dissolved in water at a ratio of 100 ppm sodium hypochlorite) were followed by pulping (placed in the hopper of the pulper or blender). The pulp of sachatomate and mango was refined (using a screen with fine meshes of 0.5 mm) and standardized (by diluting tomato juice with water at a ratio of 1:2). After the ground chia was added, the mixture was subjected to pasteurization (heated to 90 degrees Celsius for 5 minutes), packaging (done in high-density PVC containers for food at a temperature of 70 degrees Celsius), cooling (done at a temperature of 10 to 12 degrees Celsius), and storage (done in a clean, dry, cool area away from sunlight).

2.5. Methods of analysis

In tomato, mango and ground chia, physicochemical characteristics (pH, brix, titratable acidity), proximal chemical characteristics including moisture, protein, fat, fiber, ash, carbohydrates and energy were determined by AOAC methods 925.10, AOAC 920.87, AOAC 920.85, AOAC 978.10, AOAC 923.03 respectively (Asibey-Berko and Tayie, 1999). Finally, the antioxidant capacity of tomato, mango and ground chia was evaluated by DPPH methods. Likewise, the physicochemical characteristics (pH, brix, titratable acidity and viscosity) of tomato nectar with partial substitution of mango and ground chia were determined by the potentiometer, refractometer and viscometer method respectively (Damiani and Becker, 2021). Furthermore, antioxidant capacity of the nectar was also evaluated by the ABTS and DPPH methods (Stella et al., 2011) while on the other hand the proximal chemical characteristics were also evaluated. At the end, sensory characteristics of nectar including smell, color, taste and appearance were evaluated by the method degrees of satisfaction on a scale of 1 to 9 was performed with 60 untrained judges (Barrett et al., 2010).

2.6. Statistical analysis

An analysis of variance was applied to interpret the effect of different concentrations of tomato, mango and ground chia on the variables under study physicochemical characteristics, antioxidant, proximal chemical and sensory capacity oftomato nectar with partial substitution of mango and ground chia.

3. Results and Discussion

3.1. Characterization of the raw material

In the Table 1 the results of the physicochemical analysis, proximal and antioxidant capacity of the pulp of mango, sachatomate and ground chia were shown.

The physicochemical, proximal chemical results are close to the values established by the Atasie et al. (2009). Furthermore, in comparison to the results obtained, significant differences with respect to the ash and protein of the mango pulp, and with respect to the tomato pulp has been observed. Similarly, the physicochemical and proximal results have been shown in Table 1 and presenting the significant differences with respect to ash, protein and fat. On the other hand, obtained results showed significant changes in ground chia with the chia seed (Table 1).

3.2. Partial substitution of nectar

Table 1 presenting the physicochemical results such pH as brix degrees, acidity and viscosity, of the 15 treatments obtained according to the Box - Behnken design. Regarding the °Brix of tomato nectar, values of 13.4 to 145 were obtained and the highest value of °Brix were obtained in the sample 2 that was 14.6%. Taking into account these data (Table 2), in our research it was determined that the optimal formulation for the elaboration of tomato nectar was sample 11 with 13. 4 °Brix. The pH values of tomato nectar, significantly influences the percentage of mango substitution, since in the physicochemical analysis of the raw material it can be observed that the mango has a higher percentage of pH compared to the tomato, therefore, it can be observed that the nectar is within the ranges established according to Quispe-Herrera et al. (2022), which indicates that the established pH range is less than 4.5, For our research, optimal results are deduced from sample 11, with 4.23 pH, working at a significance level of 5% (Table 2). To define as the most appropriate sample was based on the NTP, so it can be deduced that sample 4 is the most appropriate with 0.354133 C_6-H_8-O_7, since citric acid was the most abundant in almost all fruits and in greater quantity that has been found in case of tomato.

According to Mingire et al. (2016) details a viscosity of 4200 mPas, compared to our analysis, the most appropriate sample of the formulation was number 12, indicating a viscosity of 3967.3 mPas, as can be seen in Table 2. The percentages of substitution of ground chia significantly influenced the viscosity content, working at a significance level of 5%. Furthermore, more suitable representation of the substitution effect of mango and ground chia on the brix degrees of nectar has been given in Figure 1.

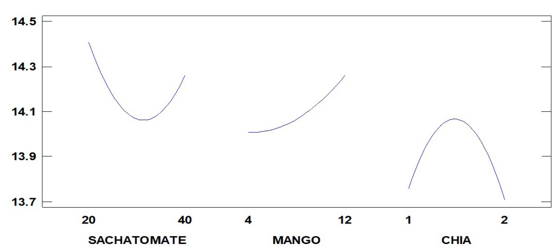

Figure 1. Graph of effects for the °brix of tomato nectar with partial substitution of mango and ground chia.

Table 1. Results of physicochemical and proximal analysis and antioxidant capacity.

Analyzed parameters	Result			Unit	Analysis method
	Mango	Sachatomate	Ground chia	--------	Potentiometer
pH	3.45	3.33	6.64	%	Potentiometer
Acidity	0.59	1.28	0.24	%	Exp. in $C_6H_8O_7$
°Brix	10.5	10.2	0.00	%	Refractometro
Ash	0.95	1.83	5.57	%	AOAC 923.03
Crude fibre	0.97	1.50	2.10	%	AOAC 978.10
Grease	3.82	0.30	28.0	%	AOAC 920.85
Humidity	79.6	85.5	3.31	%	AOAC 925.10
Protein	0.79	0.45	16.9	%	AOAC 920.87
Carbohydrates	3.55	0.94	44.2	%	----------------
Energy	51.7	8.24	492	Kcal/g	
Cap. antioxidant	23.7	50392.7	55621.7	Micr Trolox equi/100g	ABTS DPPH

Table 2. Physicochemical analysis of tomato nectar with partial substitution of mango and ground chia.

Sample Number	% Replacement			°Brix %	pH	Acidity $C_6H_8O_7$	Viscosity mPas
	S	M	CH				
1	20	4.0	1.5	14.5	4.22	1.233067	1344.6
2	40	4.0	1.5	14.6	4.19	0.308267	1609.1
3	20	12	1.5	14.4	4.24	0.301867	1291.1
4	40	12	1.5	14.1	4.14	0.354133	1229.3
5	20	8.0	1	14.1	4.18	0.314240	1542.0
6	40	8.0	1	14.2	4.15	0.307627	1417.0
7	20	8.0	2	14.1	4.20	0.330667	9342.0
8	40	8.0	2	13.6	4.21	0.289280	2884.2
9	30	4.0	1	13.4	4.18	0.294613	1905.5
10	30	12	1	14.0	4.17	0.307840	1746.5
11	30	4.0	2	13.4	4.23	0.282667	3264.2
12	30	12	2	14.4	4.16	0.309333	3967.3
13	30	8.0	1.5	14.1	4.19	0.308267	3698.0
14	30	8.0	1.5	14.0	4.13	0.290347	4457.0
15	30	8.0	1.5	14.1	4.21	0.315307	3726.0

Ranges of the brix established by different organizations which mentions that it must be located in a parameter of 12 to 18 °Brix;

In Figure 1, it indicates that lower percentages of substitution of tomato pulp showed higher values of °brix, as the percentage of substitution increases to at least 30%, the percentage of °brix decreases. This occurs may be due to the amount of substitution of tomato pulp, since the tomato pulp showed minimum percentages of degrees °brix, which was between 10.5 to 13.5 °brix.

Similarly, in Figure 2, observance of the response surface and effect of variables of tomato mango and ground chia with respect to pH. Lower percentages of substitution of tomato pulp showed higher pH values, up to at least 40% and it may be occurred due to the percentage of substitution of tomato pulp, since it contains 3.2 - 3.8% pH, as for the substitution of mango pulp at lower percentages of mango substitution higher pH values were presented up to at least 10% and as the substitution of mango pulp decreased pH values.

At lower percentages of substitution of tomato pulp, higher acidity values are shown, as the percentage of substitution increases to at least 35%, it decreases, and above that there was a tendency to increase with respect to acidity values; On the other hand, at lower percentages of mango substitution, higher acidity values were presented up to at least 10%, and as the substitution of mango pulp increases, the acidity values decrease. Figure 3 is showing the response surface and effect of variables of tomato, mango and ground chia with respect to acidity.

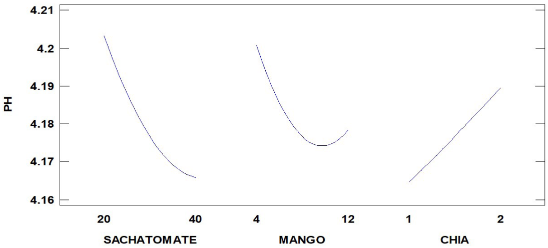

Figure 2. Effects for the pH of tomato nectar with partial substitution of mango and ground chia.

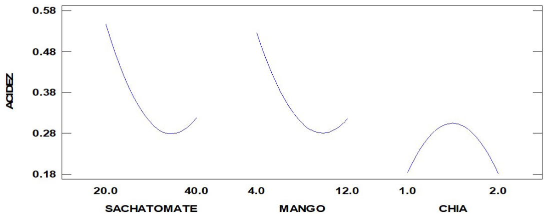

Figure 3. Effects for the acidity of tomato nectar with partial substitution of mango and ground chia

The influence of factors and response surface for tomato, mango, and ground chia on viscosity are depicted in Figure 4. The lower the percentages of substitution of tomato pulp the viscosity values were low up to at least 25%, as the substitution increases to 40% the percentages of substitution of sachatomate pulp there was a tendency to decrease the viscosity values. On the other hand, the lower the percentages of mango substitution, the viscosity values were low, and as the substitution increases to at least 8%, it positively influences the viscosity values, and above that as the percentages of mango substitution increases, there was a tendency to decrease the viscosity values. Finally, the lower the percentages of substitution of ground chia, the lower the viscosity values and as the percentages of substitution increase to at least 2% they were higher.

3.3. Evaluation of tomato nectar with partial substitution of mango and ground chia taking into account the antioxidant capacity by DPPH and ABTS

Table 3 shows the results of the antioxidant capacity of nectar, performed by the DPPH and ABTS methods of the 15 treatments obtained according to the Box - Behnken design. The following results were obtained according to the DPPH method regarding the antioxidant capacity: it is observed that formulation 12 demonstrates a greater antioxidant capacity of 104.3 micromoles equivalent Trolox. In the research of Rojas et al. (2017) an antioxidant capacity of 41.61 micromoles trolox equivalent was obtained by the DPPH method, and in the research of Bianchin et al. (2020) an antioxidant capacity of 3.4915 µmol trolox/g measured by the DPPH method was obtained. With respect to the ABTS method, formulation 12 shows a greater antioxidant capacity of 187.4 micromoles equivalent Trolox. Similarly, evaluation of proximal and sensory chemical characteristics in tomato nectar with partial substitution of mango and ground chia have been presented in Table 4 and Figure 5

Table 4 showed the results of the proximal chemical analysis in sample 11, where the percentages of moisture is 87.45%, ash 0.33%, crude fiber 0.08%, fat 0.10%, protein 0.45% and carbohydrates 11.59%; likewise, the results of proximal chemical analysis in sample 12, show percentages of moisture 87.45%, ash 0.32%, crude fiber 0.09%, fat 0.10%, protein 0.45% and carbohydrates 11.59%, compared to the research of Rojas et al. (2017).

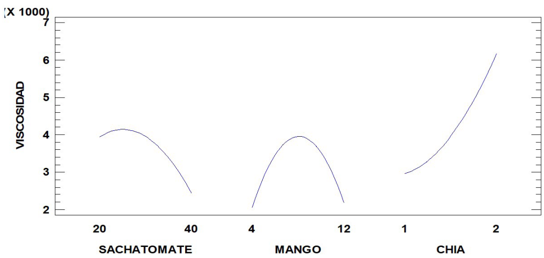

Figure 4. Effects for the viscosity of tomato nectar with partial substitution of mango and ground chia.

3.4. Evaluation of satisfaction levels of tomato nectar

Figure 6 showed the analysis of variance of the results obtained from the evaluation of degrees of satisfaction of tomato nectar with partial substitution of mango and ground chia with better physicochemical characteristics and greater antioxidant capacity (sample 11 and 12).

Tukey's multiple comparison tests were carried out, concluding that sample 12 is the one with the highest acceptability compared to sample 11, working at a significance level of 5%. According to Figure 6 indicate the percentages of acceptability of nectar samples 11 and 12; the effect of substitution of the percentages of addition of pulp and ground chia in the preparation of nectar of sachatomate was evaluated, where through the analysis of variance it was determined that this substitution significantly influences the organoleptic properties of nectar flavor, determining

Table 3. Results of antioxidant capacity of tomato nectar with partial substitution of mango and ground chia by DPPH and ABTS method.

Sample	% Replacement			Equivalentes Trolox CI50 umol/100ml (DPPH)	Equivalentes Trolox CI50 umol/100ml (ABTS)
	S	M	CH		
1	20	4	1.5	123.3	259.2
2	40	4	1.5	122.0	246.6
3	20	12	1.5	126.7	263.8
4	40	12	1.5	126.2	250.5
5	20	8	1	120.4	226.8
6	40	8	1	142.7	275.3
7	20	8	2	143.3	274.7
8	40	8	2	132.7	258.6
9	30	4	1	133.9	258.6
10	30	12	1	142.6	272.1
11	30	4	2	112.0	210.0
12	30	12	2	104.3	187.4
13	30	8	1.5	130.0	247.2
14	30	8	1.5	126.2	243.1
15	30	8	1.5	122.0	226.2

S=Sachatomate, M=Mango, CH=Chia

Table 4. Proximal chemical analysis of tomato nectar with partial substitution of mango and ground chia (sample 11 and 12).

Parameters	Results			
	Sample 11	**Sample 12**	**Unit**	**Method**
Humidity	87.45	87.45	%	AOAC 925.10
Ash	0.33	0.32	%	AOAC 923.03
Crude Fibre	0.08	0.09	%	AOAC 978.10
Grease	0.10	0.10	%	AOAC 920.85
Protein	0.45	0.45	%	AOAC 920.87
Carbohydrates	11.59	11.59	%	---

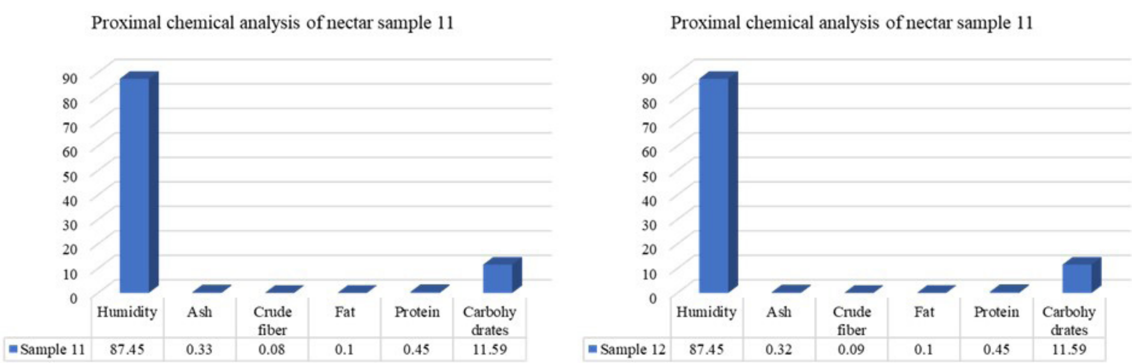

Figure 5. Determination of proximal chemical characteristics of nectar of sample 11 and 12.

that the mean of sample 11 is 7.68 and sample 12 is 8.58, whose treatments under study are different from each other.

According to Figure 7 indicant the percentages of color acceptability, where through analysis of variance it was determined that this substitution if significantly influence the organoleptic properties of nectar color, determining that the mean of sample 11 is 7.68 and sample 12 is 8.47 whose treatments under study are different from each other also indicates that the Sample 12 is the one with the highest acceptability compared to sample 11, working at a significance level of 5%.

In according with Figure 8 indicated the percentages of acceptability of odor, where through the analysis of variance it was possible to determine that this substitution if it flows significantly on the organoleptic properties of the smell of nectar, determining that the mean of sample 11 was 7.68 and sample 12 was 8.53 whose treatments under study were different. As it also indicates that sample 12 was the one with the highest acceptability compared to sample 11, working at a significance level of 5%.

Figure 9 displays the percentages of acceptability for the nectar's viscosity; using analysis of variance, we learn that the treatment differences between samples 11 and 12 have a significant impact on the organoleptic properties of the nectar's viscosity; from this, we conclude that sample 12 had a higher acceptability than sample 11, and that this effect was statistically significant.

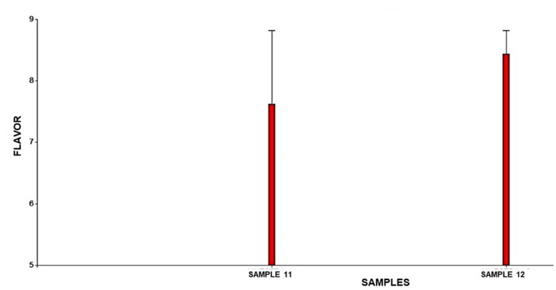

Figure 6. Analysis of variance of the flavor attribute.

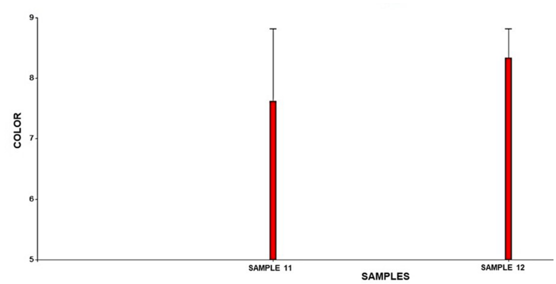

Figure 7. Analysis of variance for the color attribute.

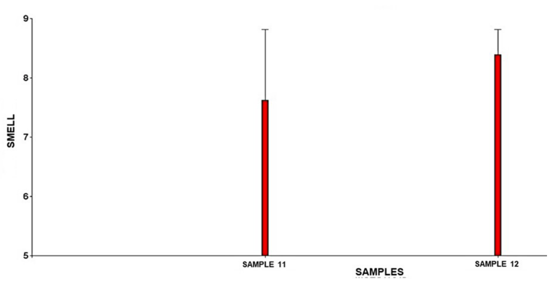

Figure 8. Analysis of variance for the odor attribute.

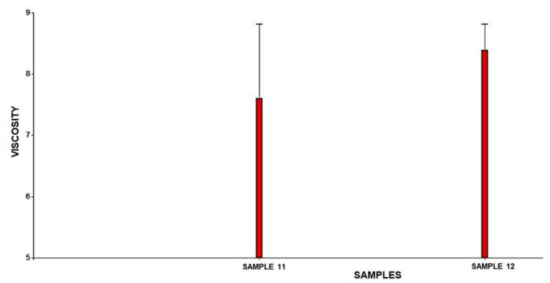

Figure 9. Analysis of variance for the viscosity attribute.

4. Discussion

The antioxidant capacity in the pulp of mango, sachatomate and ground chia, showing that the pulp of sachatomate and mango was lower with respect to ground chia. In addition, the antioxidant capacity was quite significant with respect to the study carried out by Tabart et al. (2009) and this variation is due to the origin of the raw material used. Tabart et a. (2009) considered that for the elaboration of tomato nectar the °Brix must vary between a maximum of 14 °Brix and a minimum of 12 °Brix. In comparison to mango nectar with chia addition according to Mingire et al. (2016), it indicates a high value of °Brix with 15.23. Since a higher percentage of mango pulp was added and on the other hand, Hoque et al. (2018) in mango and passion fruit nectar with tarwi substitution, stood out as an optimal treatment at 13.1 °Brix. In the research of Hoque et al. (2018) a value of 3.92 pH was obtained, which meets the parameters. This occurs may be due to the amount of substitution of tomato pulp, since the tomato pulp showed minimum percentages of degrees °brix, which was between 10.5 -13.5 °brix. According to Ramos (2021), the values of °brix degrees increased as mango pulp was substituted at higher and higher rates, suggesting that mango pulps have a high percentage of soluble solids. Lower percentages of substitution of tomato pulp showed higher pH values, up to at least 40% and it may be occurred due to the percentage of substitution of tomato pulp, since it contains 3.2 - 3.8% pH , as for the substitution of mango pulp at lower percentages of mango substitution higher pH values were presented up to at least 10% and as the substitution of mango pulp decreased pH values; According to Chong, (2022), in their research, a pH of 3.8 was observed, this indicates that it significantly influences the percentages of substitution of mango pulp for the elaboration of nectar, finally the lower the percentages of substitution of ground chia, the pH values decrease as the substitution of ground chia increases. According to the research of Rojas et al. (2017), an antioxidant capacity of 42.98 Trolox equivalent micromoles was obtained by the ABTS method, and in that of Zhou et al. (2017), 4.0555 µmol trolox/g measured by the ABTS method was obtained. Compared to our research, a higher content of antioxidant capacity can also be observed, due to the percentages of substitution of tomato and ground chia significantly influences the antioxidant capacity, working at a significance level of 5%. Zhou et al. (2017) protein is higher by 0.24% is higher as well as carbohydrates is higher by 4.09%; according to Mingire et al. (2016), you can see lower percentage of carbohydrates 7.33%, lower fiber percentage 0.74. Also, various other researcher mentions that protein is very similar to our Research, carbohydrates was found in 17.4, therefore it followed that they were within the optimal parameters.

5. Conclusion

It was found that the percentages determined for pH, brix, acidity, and viscosity, all fall within the ranges established by NTP 203.110 (INDECOPI, 2009), indicating that the addition of mango and ground chia had a significant impact on the elaboration of nectar. It was determined that Sample 11 had the optimal brix and pH levels, whereas Sample 12 had the optimal viscosity, at 3967.3 mPas. With a citric acid value of 0.354133, treatment 4 was the optimal acidity level. Tomato nectar sample 12 had a higher antioxidant capacity when measured using the DPPH method, with 104.3 micromoles equivalent Trolox, and the ABTS method, with 187.4 micromoles equivalent Trolox, because ground chia was used to partially replace some of the tomato nectar. Sample 12 included 87.45% humidity, 0.32% ash, 0.09% crude fibre, 0.10% fat, 0.45% protein, and 11.59% carbs; these were the proximal chemical features of the nectar of sachatomate in which mango and pulverized chia were used as partial substitutions. Sample 12 performs better than the rest when it comes to pleasing the senses.

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References

ASIBEY-BERKO, E. and TAYIE, F.A.K., 1999. Proximate analysis of some under-utilized Ghanaian vegetables. *Ghana Journal of Science*, vol. 39, pp. 91-96. http://dx.doi.org/10.4314/gjs.v39i1.15862.

ATASIE, V.N., AKINHANMI, T.F. and OJIODU, C.C., 2009. Proximate analysis and physico-chemical properties of groundnut (Arachis hypogaea L.). *Pakistan Journal of Nutrition*, vol. 8, no. 2, pp. 194-197. http://dx.doi.org/10.3923/pjn.2009.194.197.

BARRETT, D.M., BEAULIEU, J.C. and SHEWFELT, R., 2010. Color, flavor, texture, and nutritional quality of fresh-cut fruits and vegetables: desirable levels, instrumental and sensory measurement, and the effects of processing. *Critical Reviews in Food Science and Nutrition*, vol. 50, no. 5, pp. 369-389. http://dx.doi.org/10.1080/10408391003626322. PMid:20373184.

BIANCHIN, M., PEREIRA, D., ALMEIDA, J.D.F., MOURA, C.D., PINHEIRO, R.S., HELDT, L.F.S., HAMINIUK, C.W.I. and CARPES, S.T., 2020. Antioxidant properties of lyophilized rosemary and sage extracts and its effect to prevent lipid oxidation in poultry pátê. *Molecules (Basel, Switzerland)*, vol. 25, no. 21, pp. 5160. http://dx.doi.org/10.3390/molecules25215160. PMid:33171894.

CHAVEZ, C. and ORTIZ, K., 2016 [viewed 11 August 2023]. *Efecto del consumo de jugo de tomate de árbol sobre indicadores bioquímicos en el personal administrativo de La Universidad Técnica del Norte. Ibarra. Periodo 2014-2015* [online]. Ibarra, Ecuador: Universidad Técnica del Norte, 51 p. Tesis Ciencia de los Alimentos. Available from: http://repositorio.utn.edu.ec/bitstream/123456789/6114/1/06%20NUT%20180%20TRABAJO%20GRADO.pdf

CHONG, W.Y., 2022. *Physicochemical, phytochemical and sensorial quality of gummy candies produced from mango (mangifera indica) peels with different types of fruit sweeteners*. Kampar, Perak: UTAR. 108 p. Doctoral dissertation.

COMISIÓN DE NORMALIZACIÓN Y DE FISCALIZACIÓN DE BARRERAS COMERCIALES NO ARANCELARIAS – INDECOPI, 2009 [viewed 11 August 2023]. *NTP 203.110-2009 Jugos, Nectares y Bebidas de Fruta* [online]. Peru: INDECOPI. Available from: https://www.scribd.com/document/426832568/NTP-203-110-2009-JUGOS-NECTARES-Y-BEBIDAS-DE-FRUTA/

DAMIANI, C. and BECKER, F.S., 2021. *Inserção de coprodutos na produção de alimentos: alternativa para redução do lixo orgânico*. Curitiba: Editora Appris.

ENCINA, C., GALLEGOS, D., ULLOA, A., LUMAN, M., MOENA, B., CANALES, T., ROJAS, J., DÍAZ, C. and SAAVEDRA, L., 2017. Concordancia entre la percepción materna y el estado nutricional de sus hijos antes y después de una intervención educativa. *Revista Chilena de Nutrición*, vol. 44, no. 4, pp. 318-324. http://dx.doi.org/10.4067/S0717-75182017000400318.

HOQUE, M.I., CHOWHAN, S. and KAMRUZZAMAN, M., 2018. Physiological changes and shelf life of mango (Mangifera indica L.) influenced by post harvest treatments. *SAARC Journal of Agriculture*, vol. 15, no. 2, pp. 219-226. http://dx.doi.org/10.3329/sja.v15i2.35164.

JARAMILLO, Y., 2013 [viewed 11 August 2023]. *La chía (salvia hispanica L.), una fuente de nutrientes para el desarrollo de alimentos saludables* [online]. Antioquia, Colombia: Corporación Universitaria Lasallista, 43 p. Especialización en Alimentación y Nutrición. Available from: http://repository.unilasallista.edu.co/dspace/bitstream/10567/1043/1/La_chia_salvia_hispanica_L_desarrollo_alimentos_saludables.pdf

MINGIRE, S.S., DHAWALE, K.N., TALANE, S.M. and SAVVASHE, A.Y., 2016. Evaluation of mango (Mangifera indica L.) varieties for nectar product processing on the basis of organoleptic parameters. *Environment and Ecology*, vol. 34, no. 3B, pp. 1311-1314.

OBREGÓN-LA ROSA, A.J., CONTRERAS-LÓPEZ, E., JUÁREZ, E.F., BARRÓN, Ú.G., MUÑOZ, A.M. and RAMOS-ESCUDERO, F., 2023. Nutritional and antioxidant profile of the Physalis fruit grown in three Andean regions of Peru. *Roczniki Panstwowego Zakladu Higieny*, vol. 74, no. 1, pp. 49-57. PMid:37010381.

PERALTA, M., 2004 [viewed 11 August 2023]. *Comportamiento de la demanda del mango en EEUU. Ventanas para la exportación* [online]. Piura, Peru: Universidade de Piura, 230 p. Undergraduate thesis Ciencia de los Alimentos. Available from: https://pirhua.udep.edu.pe/bitstream/handle/11042/1315/ECO_014.pdf?sequence=1&isAllowed=y

POLJSAK, B., 2011. Strategies for reducing or preventing the generation of oxidative stress. *Oxidative Medicine and Cellular Longevity*, vol. 2011, pp. 194586. http://dx.doi.org/10.1155/2011/194586. PMid:22191011.

QUISPE-HERRERA, R., PAREDES VALVERDE, Y. and ROQUE HUAMANI, J.R., 2022. Antioxidant capacity and proximal analysis of Solanum sessiliflorum Dunal and Chenopodium quinoa Willdenow nectar-based. *Agronomía Mesoamericana*, vol. 33, no. 2

RAMOS, S., 2021 [viewed 11 August 2023]. *Obtención de licor de mango (Mangifera Indica) a partir del mango de descarte con fines de aceptabilidad* [online]. Piura, Peru: Universidad Nacional de Piura, 60 p. Tesis Ciencia de los Alimentos. Available from: https://repositorio.unp.edu.pe/bitstream/handle/20.500.12676/2848/IAIA-RAM-SEM-2021.pdf?sequence=1&isAllowed=y

ROJAS, D., REPO, C. and ENCINA, C., 2017. Determination of maximum retention of bioactive compounds and antioxidant capacity in tree tomato nectar (solanum betaceaum cav.). *Revista de la Sociedad Química del Perú*, vol. 83, no. 2, pp. 174-186. http://dx.doi.org/10.37761/rsqp.v83i2.195.

SARKAR, T., SALAUDDIN, M., SHEIKH, H.I., PATI, S. and CHAKRABORTY, R., 2022. Effect of drying on vitamin, carotene, organic acid, mineral composition, and microstructural properties of mango (Mangifera indica). *Journal of Food Processing and Preservation*, vol. 46, no. 2, pp. e16237. http://dx.doi.org/10.1111/jfpp.16237.

STELLA, S.P., FERRAREZI, A.C., DOS SANTOS, K.O. and MONTEIRO, M., 2011. Antioxidant activity of commercial ready-to-drink orange juice and nectar. *Journal of Food Science*, vol. 76, no. 3, pp. C392-C397. http://dx.doi.org/10.1111/j.1750-3841.2011.02055.x. PMid:21535805.

TABART, J., KEVERS, C., PINCEMAIL, J., DEFRAIGNE, J.O. and DOMMES, J., 2009. Comparative antioxidant capacities of phenolic compounds measured by various tests. *Food Chemistry*, vol. 113, no. 4, pp. 1226-1233. http://dx.doi.org/10.1016/j.foodchem.2008.08.013.

YAGER-ELORRIAGA, D.A., GOMEZ, M.R., RUIZ, D.E., SLUTZ, S.A., HARVEY-THOMPSON, A.J., JENNINGS, C.A., KNAPP, P.F., SCHMIT, P.F., WEIS, M.R., AWE, T.J., CHANDLER, G.A., MANGAN, M., MYERS, C.E., FEIN, J.R., GALLOWAY, B.R., GEISSEL, M., GLINSKY, M.E., HANSEN, S.B., HARDING, E.C., LAMPPA, D.C., LEWIS, W.E., RAMBO, P.K., ROBERTSON, G.K., SAVAGE, M.E., SHIPLEY, G.A., SMITH, I.C., SCHWARZ, J., AMPLEFORD, D.J., BECKWITH, K., PETERSON, K.J., PORTER, J.L., ROCHAU, G.A. and SINARS, D.B., 2022. An overview of magneto-inertial fusion on the Z machine at Sandia National Laboratories. *Nuclear Fusion*, vol. 62, no. 4, pp. 042015. http://dx.doi.org/10.1088/1741-4326/ac2dbe.

YAHIA, E.M., DE JESÚS ORNELAS-PAZ, J., BRECHT, J.K., GARCÍA-SOLÍS, P. and CELIS, M.E.M., 2023. The contribution of mango fruit (Mangifera indica L.) to human nutrition and health. *Arabian Journal of Chemistry*, vol. 16, no. 7, pp. 104860. http://dx.doi.org/10.1016/j.arabjc.2023.104860.

ZHOU, T., XU, D.P., LIN, S.J., LI, Y., ZHENG, J., ZHOU, Y., ZHANG, J.J. and LI, H.B., 2017. Ultrasound-assisted extraction and identification of natural antioxidants from the fruit of Melastoma sanguineum Sims. *Molecules (Basel, Switzerland)*, vol. 22, no. 2, pp. 306. http://dx.doi.org/10.3390/molecules22020306. PMid:28218717.