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Physiochemical Properties and Sensory Characteristics of Roselle Carbonated Drinks with Different Sweeteners

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Roselle has an attractive red colour, a unique flavour and high in vitamins that makes it suitable to be a natural colour and flavour in beverage products such as carbonated drinks. However, most carbonated drinks have a high amount of sugar, leading to health problems such as diabetic and obesity. Nowadays, sweeteners are a good alternative to refined sugar in carbonated drinks. Hence, this study was conducted to evaluate the effects of different sweeteners (stevia, sucralose and combination of stevia and sucralose) in roselle carbonated drinks on the physicochemical properties and sensory acceptability. The result showed that roselle carbonated drinks with sucralose exhibited the lowest pH value, total soluble solids (TSS), and viscosity. For colour analysis, sucralose significantly ($p \leq 0.05$) reduced the brightness properties (L* values), while combination stevia and sucralose significantly ($p \leq 0.05$) reduced yellowness properties (b* values). Sample sweetened with sucralose had the most acceptability mean score in sensory evaluation and this roselle drink could provide benefits to weight and health-conscious consumers.

Keywords: Roselle, sweeteners, physicochemical and sensory

INTRODUCTION

Hibiscus sabdariffa Lin. is a scientific name for roselle, which is widely planted in many developing countries, mostly in tropical and sub-tropic regions (Riaz & Chopra, 2018). Besides, the plant also cultivated in other countries such as Central America, Saudi Arabia, Egypt, Nigeria and Sudan, (Riaz & Chopra, 2018). It has various names in different countries, such as *rosella* in Australia, *asam belanda* in Malaysia, *mei gui qie* in China, *karkanji* in Chad, *Flor de Jamaica* in Mexico, *zobo* in Nigeria, *karkade* in Sudan and *krajeap* in Thailand (Juhari et al., 2018).

Roselle is conventionally cultivated for its calyces, stem, seeds and leaves. These parts provide good nutritional sources to be used in the food and medicinal industries. (Riaz & Chopra, 2018). Roselle is rich in anthocyanins, which is a good antioxidant and other phytochemicals that may have health benefits (Juhari et al., 2018). Besides, roselle calyx consists of a rich source of dietary fiber, vitamins, minerals and bioactive compounds such as organic acids, phytosterols, and polyphenols, some of them has antioxidant properties (Abou-Arab et al., 2011). Currently, there is an interest in making extracts of roselle calyces and other fruits as ingredients in functional food development (Rosidi et al., 2021; Mohd Noor et al., 2020; Abu Hassan et al., 2019; Cid-Ortega & Guerrero-Beltrán, 2015). Fruit-based carbonated drinks are a new concept that provides nutritional properties of the fruit along with natural pigments and flavor, with carbonation effects (Masoumi et al., 2018). Carbonation is the dissolution of carbon dioxide (CO_2) gas in water by utilizing pressure and temperature. Carbonation imparts a unique taste and gives the product sparkling – effervescent – fizziness. Carbonation of juices not only enhances the natural flavor, colour and aroma but also eliminates chemical and heat preservatives to a greater extent (Abu-Reidah, 2019).

Carbonation drink is the most popular beverage, but it has been linked with health problems such as diabetes, obesity and being overweight due to high sugar content. Nowadays, consumers are more concerned about the nutritional value of food they consume and more interested in preferring healthier food products in their diet.

Alternative sweeteners are food additive, that imitate the effect of sugar on taste (Gupta, 2018). These sweeteners substitute sugar alone or in combination to improve the taste, mimicking the effect of sugar and thus provide a sweet taste in foods or beverages. The sweeteners are generally much sweeter than sucrose, and thus be used in smaller amounts. Furthermore, the sweeteners do not lead to tooth decay. It is essential to substitute sugar with other alternative sweeteners in order to develop a roselle carbonated drink. Therefore, this study aims to determine the effect of using different sweeteners on the physicochemical properties of roselle carbonated drinks. Furthermore, the sensory evaluation of the roselle carbonated drink was also carried out.

MATERIALS AND METHODS

Materials

Fresh roselle calyces were obtained from Universiti Sultan Zainal Abidin (UniSZA) farm in Besut, Terengganu. Sucrose, stevia and sucralose were purchased from local market in Terengganu.

Preparation of Roselle Extract

Fresh roselle calyces were deseeded, washed and stored in the freezer before processing.

The ratio of roselle calyces to water used for the preparation of roselle extract is 1:20. The frozen roselle calyces were ground with water for 1 minute by using a food blender (Panasonic MX-8015, Malaysia). In order to preserve the nutrients present in roselle extract, the mixture was heated at 60℃ for 15 minutes. Afterward, the roselle extract was filtered with a muslin cloth to remove the calyces and cooled at room temperature before it be used for carbonated drinks.

Preparation of Roselle Carbonated Drinks

The procedures used for the production of roselle carbonated drinks were adapted from Wazed et al. (2021) that studied guava carbonated drink. Four formulations of roselle carbonated drinks were developed; sucrose (Control), stevia (FSte), sucralose (FSucr) and the combination of stevia and sucralose (FSte_Sucr) as listed in Table 1. In general, 500 ml roselle drink was a mixture of 475 ml water, 25 ml roselle extract, 1 g citric acid and 0.1 g sodium benzoate. The amount of sodium benzoate and citric acid used in the formulations was below maximum limits allowed by the Food and Agriculture Organization (FAO) in Codex Alimentatius (2019). The first formulation was only added to 43 g sucrose as sugar and accepted as a control sample. FSte, FSucr and FSte_Sucr formulations were added with 1 g stevia powder, 0.05 g sucralose and 0.5 g stevia with 0.075 g of sucralose, respectively. Preliminary experiment showed that these sweeteners were adequate to give a good taste of roselle drinks.

After mixing all the ingredients, the roselle drinks was pasteurized at 90℃ for 30 seconds and rapidly cooled to room temperature by immersed them in an icy water bath. Then, the roselle drinks was chilled in refrigerator at 4°C overnight.

The chilled roselle drink was used for carbonation as the greater amount of CO_2 will be dissolved, at lower temperature (Abu-Reidah, 2019). The higher the temperature of the solution, the greater the amount of pressure needed to maintain the CO_2 in the solution (Abu-Reidah, 2019). The carbonation was done by using sparkling water express (Soda Xpress Pinnacle, Malaysia). After carbonation, the carbonated roselle drinks were filled into the sterilized plastic bottles and stored at cool and ambient temperature for further studies.

Determination of Colour

The colour measurement of roselle carbonated drinks was carried out by using a chromameter (Konica Minolta Chroma Meter CR – 400 Series Ver.1.11, Japan). The chromameter was calibrated with a standard white tile. Approximately 50 mL of roselle carbonated drinks were filled into a small container and the colour measurement was recorded at room temperature. The colour values were expressed as L* value indicate brightness or darkness, a* value measure greenness to redness and b* value represent blueness to the yellowness of the roselle carbonated drinks.

Table 1: Formulation of roselle carbonated drinks

Ingredient	Formulation			
	Control	FSte	FSucr	FSte_Sucr
Roselle extract (ml)	25	25	25	25
Water (ml)	475	475	475	475
Citric acid (g)	1	1	1	1
Sodium benzoate (g)	0.1	0.1	0.1	0.1
Sucrose (g)	43	-	-	-
Stevia (g)	-	1	-	0.5
Sucralose (g)	-	-	0.15	0.075

Determination of pH Value

The pH value of roselle carbonated drinks was determined by using pH meter (Micro Set MS 3411, India). The pH meter was standardized with buffer solutions of 4.0 and 7.0 according to AOAC method (Abou-Arab et al., 2011). 50 mL sample was poured into a beaker and the pH reading were taken at room temperature.

Determination of Total Acidity

The total acidity of roselle carbonated drinks was determined by using titration method (Tuan Azlan et al., 2020). 30 mL of each sample was titrated against 0.1N NaOH until its reach the endpoint of pH 8.2 ± 0.2 by using a pH meter. The total acidity of the sample was expressed as a percentage of citric acid. The total acidity was calculated using the equation below:

$$\% \, Acidity = \frac{N \, x \, V_1 \, x \, Eq \, wt}{V_2 \, x \, 1000} \, x \, 100\% \qquad Eqn. 1$$

where N is normality of NaOH (mEq/ mL, 1N), V_1 is volume of titrate (mL), V_2 is volume of sample (mL), Eq wt is equivalent weight of ascorbic acid (64 g) and 1000 is factor relating mg to grams (mg/ g).

Determination of Total Soluble Solids

Total soluble solid (TSS) is defined as the amount of sugar and soluble mineral salts that present in the fruit juice (Wazed et al., 2021). The TSS measurement of roselle carbonated drinks was measured by using a digital refractometer (Mettler Toledo Easy R40, Switzerland) at room temperature. Five drops of roselle carbonated drink were placed on the digital refractometer. The TSS values was expressed in degree Brix (°Brix).

Determination of Viscosity

The viscosity of the roselle carbonated drink was determined by using rotatable viscometer (Brookfield LV DV – 11+ Pro, USA) attached with spindle no. 61 at 100 rpm. About 250 mL of roselle carbonated drink filled into a beaker. Then, the spindle was immersed for 30 seconds in the roselle carbonated drink for equilibrium prior to the experiment. The viscosity reading was recorded when it became stable, after 10 seconds of rotation (Tuan Azlan et al., 2020). The values of viscosity were expressed in centipoise (cP).

Determination of Total Ascorbic Acid

The ascorbic acid content in roselle carbonated drink was determined by using the Folin – Ciocalteu reagent (FCR) method according to Mgaya-Kilima et al. (2014). A 20 mL of roselle carbonated drink was pipetted into 100 mL volumetric flask and followed by 2 mL of 10% of TCA solution (Mgaya-Kilima et al., 2014). Then, the solution was diluted with distilled water until 100 mL and swirled gently for 1 minute and left to stand for 1 minute. After that, the solution was filtered with a Whatman filter (no. 1). 1 mL of the solution or standard solution (3 mg ascorbic acid in 1 mL distilled water) was pipetted into a test tube and 3 mL of distilled was added into it followed with 0.4 mL of FCR. The mixture was vortexed for 30 seconds at 1500 rpm and incubated at room temperature for 10 minutes. The absorbance of the mixture was read at 760 nm by using UV – Vis Spectrophotometer (Shimadzu UVmini – 1240).

The values of ascorbic acid content were expressed as mg/ mL.

Sensory Evaluation

Sensory evaluation was carried out by 50 untrained panelists from UniSZA Campus Besut. Before evaluation, all the panelists were given written informed consent. Each panelist was served approximately 30 mL of each formulation of roselle carbonated drinks. The evaluation of roselle carbonated drinks was based on panellists' liking towards the attributes which were colour, aroma, sweetness, sourness, sparkling sensation, aftertaste and overall acceptability. They panellists were required to rate the attributes using a 7 – point hedonic scale anchored by: 1 = 'Dislike very much'; 2 = 'Dislike moderately'; 3 = 'Dislike slightly'; 4 = 'Neither like or dislike'; 5 = 'Like slightly'; 6 = 'Like moderately'; 7 = 'Like very much'.

Statistical Analysis

All the analyses were carried out in triplicates. All the result from physicochemical properties and sensory evaluation were expressed as mean values ± standard deviation. The statistical analyses were performed using IBM SPSS Statistics version 20.0 software. The results were analysed by using one – way analysis of variance (ANOVA) and the significant means separated by Duncan method ($p \leq 0.05$).

RESULTS AND DISCUSSION

Colour, pH Value and Total Acidity of Roselle Drinks

The colour of the roselle carbonated drinks is an important parameter that affects the consumers' perception and acceptability of the product. Colour of roselle carbonated showed significant ($p \leq 0.05$) different in L* values for all formulations as shown in Figure 1. Control sample exhibited slightly brighter with the highest L* value (14.34 ± 0.29) compares to other formulations. Meanwhile, FSucr showed the lowest L* value (12.99 ± 0.13) resulted darkest colour among the formulations of roselle carbonated drinks. This might due to the number of hydroxyl group present in the sweeteners that influence the stability of anthocyanin. Sucrose has eight reactive hydroxyl groups compare to sucralose and caused to the brighter of roselle drink due to instability of anthocyanin content (Queneau et al., 2007). Sucralose is derived from sugar that selectively substitutes three atoms of chlorine for three hydroxyl groups on the sugar molecule (Jolly, 2006).

There were no significant ($p > 0.05$) effect of sweeteners on the a* (indicate the greenness to redness) and b*values (indicate the yellowness) of sample. Control sample has highest a* values, 8.72, followed by FSte (8.34), FSucr (8.05) and FSte_Sucr (7.96). Meanwhile, the range of b* value from 3.44 to 3.98.

The pH value of roselle carbonated drinks varied from 2.53 to 2.60, showed no significant difference ($p > 0.05$) between all formulations as presented in Table 2. FSucr and FSte_Sucr have the same pH value i.e. 2.60, followed by FSte (2.56) and Control (2.53). According to Peasura and Sinchaipanit (2022), stevia has high pH value and it is contradict with this study. It might be due to small amount of stevia were used in roselle drink sample.

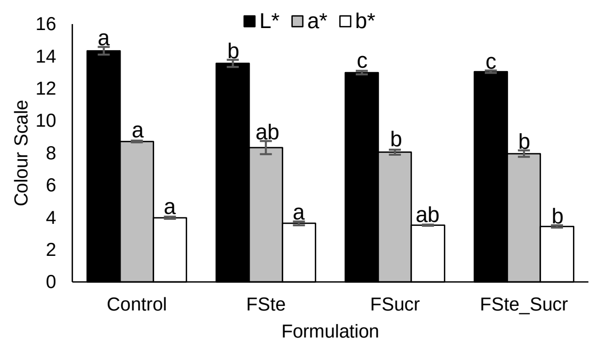

Figure 1: Colour attributes of roselle carbonated drinks with different sweeteners. Bar graph with different lower-case letters is significantly different at $p \leq 0.05$.

Table 2: pH value and total acidity of roselle carbonated drinks with different sweeteners.

Formulation	pH	Total Acidity (%)
Control	2.53 ± 0.18[a]	0.87 ± 0.12[a]
FSte	2.56 ± 0.17[a]	0.95 ± 0.15[a]
FSucr	2.60 ± 0.02[a]	1.08 ± 0.20[a]
FSte_Sucr	2.60 ± 0.04[a]	1.00 ± 0.12[a]

*Means with different superscripts within the same column are significantly different from each other ($p \leq 0.05$).

The same trend also reported for total acidity. Table 2 shows a no significant ($p > 0.05$) difference in the total acidity of the roselle carbonated drinks with different formulations. The total acidity of roselle carbonated drink within the range of 0.87 to 1.08. Based on the present study, the different type of sweeteners did not affect the colour except L* value, pH value and total acidity of roselle carbonated drinks. This is in agreement with results from in Peasura and Sinchaipanit, (2022) and Al-Dabbas and Al-Qudsi (2012) who reported that sweeteners does not significant influence on the colour, pH value and total acidity on the guava nectar and orange nectar, respectively.

Total Soluble Solid and Viscosity of Roselle Drinks

Total soluble solids (TSS) is particularly important in beverages due to its influence on both stability and sensory aspects (Alizadeh, 2014). TSS is the amount of soluble solids in liquid and it is dominated by total sugar content and a small portion of soluble proteins, amino acids and other organic materials (Kusumiyati et al., 2020). As shown in Figure 2, the roselle carbonated drink with different formulations exhibited varying degree of total soluble solids. There were significant differences (p≤ 0.05) between all the formulations of roselle carbonated drinks. Since sucrose is soluble solids (de Oliveira Rocha & Bolini, 2015), so control sample has the highest TSS (9.05 °Brix) followed by the FSte (0.78 °Brix) and a combination of stevia and sucralose (0.64°Brix). Sucrose have highest TSS because it is a disaccharide. Meanwhile the FSucr using sucralose have less total soluble solids which was 0.55 °Brix.

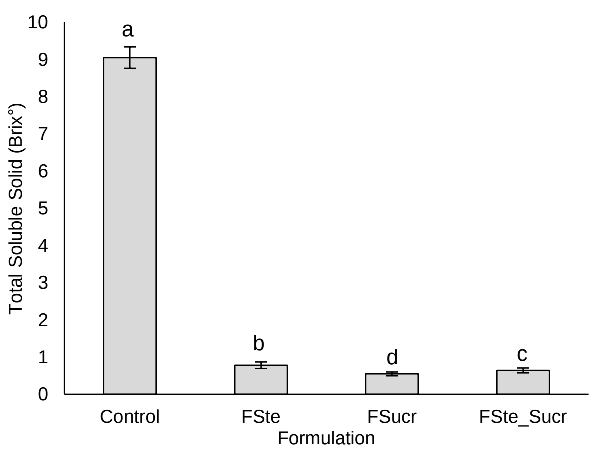

Figure 2: Total soluble solid of roselle carbonated drinks with different sweeteners. Bar graph with different lower-case letters is significantly different at $p \leq 0.05$.

Carbonated drinks usually have low viscosity and are free flowing. The sweeteners used affect significantly (p ≤ 0.05) on the viscosity of roselle carbonated drink as shown in Figure 3. Finding showed that control sample has higher viscosity, 21.6 cP compare to others sweeteners, followed by the FSte (19.7 cP). FSucr (16.3 cP) and FSte_Sucr (15.3 cP). This can be explained due to high amount of sucrose in control sample. According to Maher and Jamil, (2012), increased the particle-sugar interactions and reduced the water activity of syrups, may increase the specific viscosity of a colloidal dispersion of solids in syrups. Sugar not only adds flavour, taste, aroma, and texture, it also adds beneficial physical qualities such as viscosity and consistency, which influence food preference (Quitral et al., 2019).

From the Figure 4, it shows that type of sweeteners used in roselle carbonated drinks formulation had a significant influence (p ≤ 0.05) on the total of ascorbic acid content. Small amount of ascorbic acid has been detected in the roselle carbonated drinks. This might due to the degradation of ascorbic acid that influenced by light, higher temperature and oxygen (Zainudin & Fadhilah Suib, 2021).

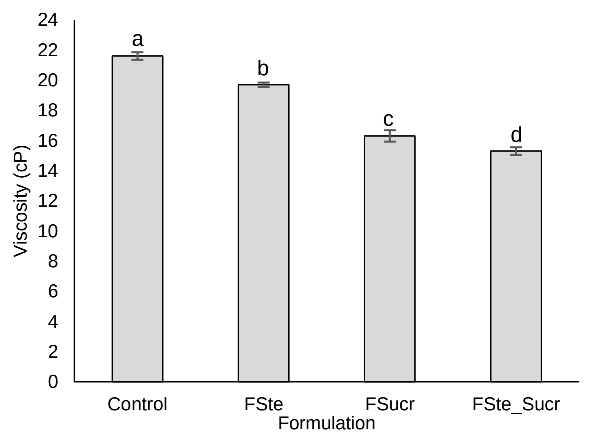

Figure 3. Viscosity of roselle carbonated drinks with different sweeteners. Bar graph with different lower-case letters is significantly different at $p \leq 0.05$.

The highest content of ascorbic acid being observed in combination of stevia and sucralose 0.0151 mg/ ml. This is might due to the presence of stevia that could probably be attributed to synergistic interactions between ascorbic acid and other constituents present in the natural sweetener, stevioside (Scrob et al., 2022). Stevioside might give protective effect on the degradation of ascorbic aicd (Scrob et al., 2022). However, for stevia as sweetener alone, has the lowest content of ascorbic acid (0.0107 mg/ ml) compare to other sweeteners.

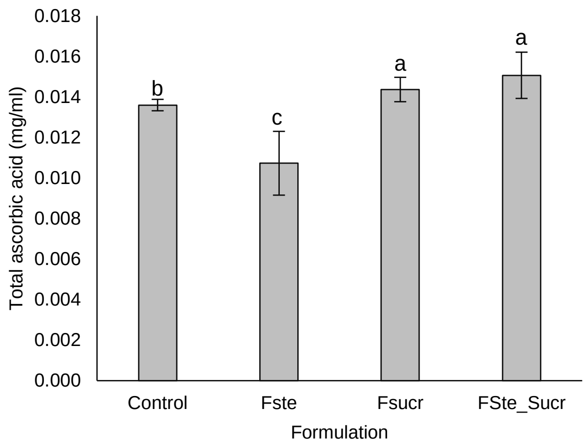

Figure 4. Total ascorbic acid of roselle carbonated drinks with different sweeteners. Bar graph with different lower-case letters is significantly different at $p \leq 0.05$.

Sensory Evaluation of Roselle Carbonated Drinks

Results of sensory evaluation on colour, aroma, sweetness, sourness, sparkling sensation, aftertaste and overall acceptability for roselle carbonated drinks has been shown in Figure 5. The mean sensory scores obtained for all the formulations of roselle carbonated above 4.5 for all attributes. Based on the statistical analysis, there was a significant effect ($p \leq 0.05$) between FSte with other samples on all attributes except for colour, aroma and sweetness. The panelists gave FSte the lowest mean score for all attributes, included overall acceptability.

For sourness attributes, roselle carbonated drinks with addition of stevia and sucralose (FSte_Sucr) attained significantly ($p \leq 0.05$) higher acceptability score than FSte. This is because sucralose has more sweet intensity than sucrose and stevia, which can cover the sourness of roselle. Besides, stevia has been reported to have a compound that contributes to bitter aftertaste which cause the sweetness that cannot fully cover sourness of roselle extract. Meanwhile, there were no significant differences between FSucr and control samples in sourness attributes. The addition of carbon dioxide in beverages can modify the taste and flavour perception such as carbonation, bite, burn, numbing and astringency of carbonated drinks, and thus gives sparkling sensation characteristics. This sensation produced by these carbonated drinks could be due to a chemogenic origin that comes from carbonic acid formation. The sensation characteristics may also due to a mechanical origin, from the capability of carbon dioxide bubbles to stimulate the tongue receptors. For sparkling sensation, FSte attained a significantly ($p \leq 0.05$) lower acceptability mean score than other samples. This is might due to stevia is natural noncaloric sweetener that does made up from glucose, therefore the taste of sparkling sensation in FSte may be strong compared to other samples. The tingling and irritation sensation produced by carbonated drinks may be suppressed when high amounts of glucose.

There was a significant effect ($p < 0.05$) on the aftertaste attributes between FSte with other sweeteners in roselle carbonated drinks. FSucr has the highest acceptability mean score, (5.560 ± 0.9510) compared to other formulations. This is because sucralose has a high sweet intensity which is 600 times sweeter than sucrose and does not have bitter aftertaste, unlike stevia (Gupta, 2018). Meanwhile, among the formulations, the roselle carbonated drink with stevia (FSte) has the lowest acceptability mean score (4.84 ± 1.4337).

The current sensory evaluation also demonstrated no significant ($p > 0.05$) differences in the level of colour acceptability mean score of roselle carbonated drinks with a different type of sweeteners. The colour for control and FSte_Sucr samples have the most acceptability mean score (6.02 ± 1.0784 and 6.02 ± 1.0593 respectively). Besides, for aroma attributes, no significant difference ($p > 0.05$) was observed between the samples, thus different sweeteners had no effect on the aroma of roselle carbonated drinks. Similar results were observed in the study of passion fruit juice (Oliveira Rocha & Bolini, 2015).

Figure 5 also shows no significant ($p > 0.05$) difference for the level of sweetness acceptability mean score for roselle carbonated drinks. Carbon dioxide gas might reduce sweetness perception and the differentiation between natural and artificial sweeteners. This makes the perception of non-caloric sweetener similar to the caloric sweetener and the carbonation might favour the consumption of low calorie diet beverages (Sternini, 2013).

For overall acceptability, FSucr showed highest means score of acceptability (5.62 ± 0.8053), while FSte exhibited loweest mean score of acceptability values (5.00 ±1.3248). This can be explained by the sourness, aftertaste and sparkling sensation being significantly lowest ($p < 0.05$) in the roselle carbonated drink with stevia.

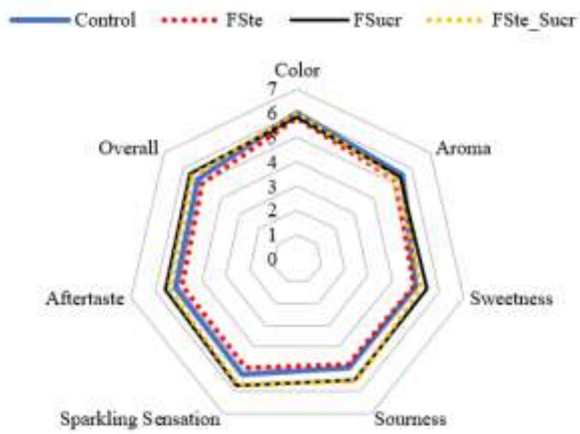

Figure 5. Sensory evaluation of different formulations of roselle carbonated drink.

CONCLUSION

Stevia and sucralose were shown to have great potential as sugar replacers in producing roselle carbonated drinks. Generally, these alternative sweeteners affect the physicochemical properties of roselle carbonated drinks especially total soluble solid and viscosity. All the produced roselle carbonated drinks with alternative sweetners exhibited significantly lower total soluble solid and lower viscosity than the control sample. All the produced roselle carbonated drinks) were considered acceptable products as they received a mean score higher than 4.5 for all attributes

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

IK and WMFWM planned and managed the study, performed the experiment, collecting and analysis the data, write the manuscript; WAFWM and RA interpreted the data and write the manuscript; AA, NH and HJ designed the research methodology and checked the manuscript. All authors read and approved the final version.

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