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PHYSICOCHEMICAL CHARACTERISTICS, PHYTOCHEMICAL COMPOUNDS AND SENSORY PROPERTIES OF HARD CANDIES MADE WITH PINEAPPLE (*Ananas comosus* L.), ORANGE (*Citrus sinensis* L.) AND PAPAYA (*Carica papaya* L.) FRUIT JUICES

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Abstract

Consumers today have a strong preference for healthy traditional foods that provide nutrients and bioactive compounds to promote good health and well-being without sacrificing taste, texture, or convenience. Hard candies are those confectionery products traditionally made with high amount of sweetening agents such as glucose syrup, which may cause various health issues. The main objective of this study was to evaluate the sensorial, phytochemical and physicochemical characteristics of hard candies made by partially substituting sucrose with pineapple (*Ananas comosus* L.), pawpaw (*Carica papaya* L.) and orange (*Citrus sinensis* L.) fruit juices. Three samples of hard candies were produced by partially substituting glucose syrup with the same amount of pineapple (HCPi), pawpaw (HCPa) and orange (HCO) juices. A subjective sensory analysis was carried out. Physicochemical analyses (Total Soluble Solid (TSS), Moisture, pH) were carried out using conventional methods. Quantifying bioactive compounds (Phenolic, flavonoid, Ascorbic Acid) were conducted via spectrophotometry and titration methods. The pH varied from 3,59 for hard candy made with orange fruit juice to 4.46, for candies made with pawpaw fruit juice. A higher value of TSS (65.3˚Bx) was found in the control sample (HCC) while hard candies made with pineapple juice concentrate had the highest value of total phenolic content (50,04 µg GAE/ml) and total flavonoid content (182,87 µg QE/ml). HCPi showed the best sensory characteristics and overall acceptability. The result of this study showed that fruit juice-based hard candies could be developed as value-added hard candies by using fruit juice. This study also suggests that the processing of fruit juice can help fighting against post-harvest losses of fruits.

Keywords: Hard candies, fruit juice concentrates, sensorial, physicochemical and phytochemical characteristic, healthier.

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1. Introduction

Hard candy, also known as boiled sweets, is a type of sugar candy made by heating sugar-based syrups to a high temperature to form a hard, often brightly colored and flavored confection. It's a sugar confectionery where the sugar solution is boiled to a high temperature and then cooled, resulting in a brittle, crunchy texture that dissolves slowly (Durani *et al.*, 2021; Ozel *et al.*, 2024). In terms of physical, textural, and sensory qualities, the ingredients used in the process of candy production can give consumers a variety of impressions. Candies are consumed globally by people of all age and have remained popular, especially among children because of its strong organoleptic indicators and inexpensive price. The high amount of sweetening agents such as glucose syrup used to make candy may cause various health issues to consumers, including teeth decay, diabetes, cardiovascular diseases, and cancer (Panghal *et al*., 2017; Samakradhamrongthai and Jannu, 2021). Consumers today have a strong preference for healthy traditional foods that provide quantitatively and qualitatively, nutrients and bioactive compounds to promote good health and well-being without sacrificing taste, texture, or convenience (Granato *et al.*, 2020).

Using fresh fruit juices to substitute glucose syrup in the process of making traditional hard candy could lead to a functional food and contribute to reduce significantly fruit post-harvest losses which represent about 40 to 50% in Cameroon (Kamda *et al.*, 2021). According to Domale *et al*., (2008) and Kohinkar *et al*., (2014), guava, papaya, pineaples, mango and orange for example are popular fruits that can be employed as functional ingredients in candy production. Fruit pulp candies are particularly nutritious since they contain most of the ingredients of the fruit from which they are made, and they are a fantastic way to take advantage of fruits that are highly perishable and cannot be preserved for a long time. Fruits such as pineapple, orange and pawpaw are cultivate throughout tropical and warm subtropical areas. They are important plant foods rich in essential vitamins, fibers, antioxidant compounds and minerals. They offer numerous health benefits, including boosting the immune system, promoting heart health, aiding digestion, and potentially reducing the risk of certain cancers. However, due to their higher content in water, they are highly perishable and cannot be stored for long period (Panghal *et al*., 2017). The causes of postharvest losses of those fruits are improper harvesting, handling and lack of storage technique especially processing and preservation techniques. Due to seasonal abundance and short market live, sometimes, their prices become low and a considerable amount is lost. But if these perishable fruits are processed into shelf-stable products, the above losses can be minimized to a great extent. Using those fruits in confectionary for example to make hard candy can be a good alternative to preserve them against post-harvest losses and to contribute to improve the health status of hard candies consumers. The main objective of this study was to compare the sensorial, phytochemical and physicochemical characteristics

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of hard candies made by partially substituting sucrose with pineapple, orange and pineapple fruit juice.

2. Material and Methods

2.1. Materials

The experiment was carried out in the Laboratory of the NGO "Food Forestry Environment Protection and Conservation Society". Fresh and sound fruits of pawpaw (red solo sechee), and lemon (smooth cayenne) were purchased from the local market of Kumba early in the morning. Fruits were washed in potable running water to remove adherent dirt. The samples were packed in polyethylene bags and stored at refrigeration temperature (5^{0}C) in airtight box at the laboratory until use.

2.2. Methods

2.2.1. Preparation of fruit juices.

The fruit juices were prepared based on the method of Pujiastuti, (2017). Fresh and clean pawpaw, oranges and pineapples were thawed at room temperature (25^{0}C) for 12 h. After washing, the papaya were peeled and the glitches were removed while pineapple were peeled and the cores and crown were removed. Then, each fruit was cut into small pieces and then blended without water using an electric blender. The mixed mass was filtered using a 20-mesh sieve and fine filtering cloth (Chung *et al,* 2017). Juices generated were put inside a container and labelled before being stored in a refrigerator until the preparation of hard candy. Sweet oranges were washed, peeled and sliced into halves with sterile knife using hand gloves during processing. The cut oranges (mesocarp) were pressed with a hand juicer squeezer to extract the juice. The juice and pulp obtained were homogenized (blended) in a sterile hand Monilex blender ®. The homogenate was clarified manually using a sterile muslin cloth to obtain a clear juice.

2.2.2. Formulation and preparation Hard candies

Three different formulations of candy were made with the same amount (40 g) of pawpaw (HCPa), orange (HCO) and pineapple juices (HCPi) and compared to a control sample (HCW). The control sample contained 69.5 g of sucrose, while for the other three samples an aliquot of 29.5 g of sucrose were used (Table 1).

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Table 1: Formula for the preparation of hard candy with addition of fruit juices

Ingredient (g)	Samples			
	HCPi (g)	HCO(g)	HCPa(g)	HCW(g)
Juice	40	40	40	00
Sucrose	29.5	29.5	29.5	69.5
Glucose Syrup	30	30	30	30
Lemon juice	0.5	0.5	0.5	0.5
Total	100	100	100	100

HCPi= Pineaple Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control

The preparation of hard candy was made by open fire cooking based on the procedure of hard candy manufacturing described by Bunce (2007) and Hartel *et al*., (2018). The following steps were used in the preparation of hard candies. Sugar and glucose syrup were first dissolved in half the quantity of fruit juice and heated while stirring up to 80°C, then the rest of the juice was added. At around 130°C the lemon juice was added and boiled up to 160°C. When the temperature of the mixture reached 160°C, the hardness was tested by dropping a small amount of the syrup in water in a bowl, the final mixture was then poured into silicone molds and cooled down to 20°C for 25 to 30 minutes (Hartel *et al.,* 2018) (Figure 1). Hardened candies removed from the molds were packaged in aluminum bags and stored in an airtight glass container to prevent contact with air until required for analysis. The final samples are shown in Figure 2.

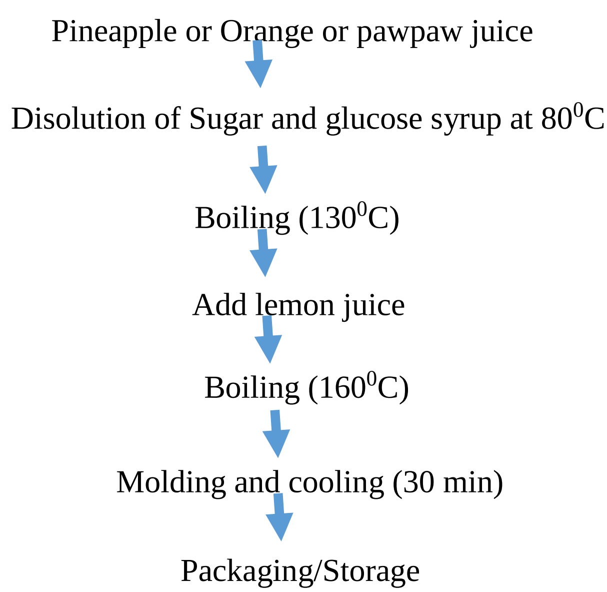

Figure 1: Hard candy preparation procedure

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(a) Sample HCW (b) Sample HCPa (c) Sample HCPi (d) Sample HCO

Figure 2: Samples of candies in molds: a) HCW=Control; HCPa=Pawpaw hard candy; HCPi= Pineapple Hard Candy; HCO=Orange hard candy

2.2.3. Physicochemical characteristics

Determination of Moisture Content

The moisture content of candies was determined using a standard method developed by the Association of Official Analytical Chemists (AOAC, 2012). Sample (5 gm) was taken in a clean, dry and pre-weighed petridish and weighed using an analytical balance. Then the petridish with sample was transferred to the oven and dried at 105°C for 24 hours. After that it was cooled in a desiccator and weighed. Moisture content was calculated by following formula:

$$\textbf{Moisture content} = \frac{(\mathbf{W2} - \mathbf{W1})}{\mathbf{W}} * \mathbf{100}$$

where, W1(g) = Weight of sample with petridish; W2(g) = Weight of dried sample with petridish;

W (g) = Weight of sample.

Total Soluble Solids (brix value)

A Homogenous syrup of 10°Brix was formulated by grinding 10 g of formulated candied using mortars pestle. Then 10gm ground sample were added to distilled water to make it 100 ml. By using Abbe's refractometer, a drop of the homogenous syrup sample formulation was gently loaded on the prism. The reading of the Brix scale was recorded to ambient temperature. The process was repeated a minimum of three times and the average reading was recorded as the final "Brix reading" (Mohanta *et al*., 2021).

pH

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The pH of candy samples was recorded at ambient temperature condition using a digital pH meter (PHT- 01 ATC). The solution of hard candy was prepared by diluting 1 g of hard candy with 10 ml of distilled water. The sample was put in a 50 ml beaker, thoroughly stirred, and the electrodes of pH meter immersed in the juice samples. The pH values were read from the screen of the pH meter. The process was repeated a minimum of three times and the average reading was recorded as the final "pH reading" (Lamptey, 2019).

2.2.4. Phytochemical compounds

1. **Phenolic compound content**

Phenolic compounds were determined spectrophotometrically using the methodology proposed by Singleton & Rossi (1965). The absorbance was read at 725 nm (Jenway 6700, Jenway, Spain). Quantification was based on the establishment of a standard curve, which yielded a straight-line equation: y = 0.0046 x + 0.0004 µg/mL. The results were expressed in mg equivalents of garlic acid in 100 g of fresh weight (FW).

2. **Flavonoids content**

Sample (0.1 g) was extracted with 5 ml of 80% aqueous ethanol by centrifuging at 6000 rpm for 30 min. Then 0.25 ml of the extract was taken in test tube, to which 1.25 ml distilled water and 0.75 ml of 5% sodium nitrate were added. After allowing to stand for 5 min, 0.15 ml of 10% aluminum chloride was added and then the mixture was further allowed to stand for 6 min. Next, 0.5 ml of 1 N NaOH and 0.275 ml distilled water were added to the test tube and absorbance was measured at 510 nm using a spectrophotometer. Blank was prepared by taking 80% ethanol instead of extract and the same procedure was followed as mentioned above. The total flavonoid content was expressed in milligrams of catechin equivalents (CE) per gram of the extract. All the determinations were carried out in triplicate (Samatha et al., 2012).

3. **Ascorbic acid content:**

This was determined using 2,6-dichlorophenolindophenol dye. Sample (10 g) was extracted in 3% m-phosphoric acid and titrated with dye to pink colour end-point. Results were expressed as milligrams per 100 g of and calculated using the formula (Ranganna 2016)

$$Ascorbic\ acid = \frac{Titre\ X\ dye\ factor\ X\ volume\ made\ up\ X\ 100}{Aliquot\ of\ extract\ weight\ of\ volume\ of\ sample}$$

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2.2.5. Sensory evaluation

Hard candies made of pineapple, pawpaw and orange fruits were subjected to sensory evaluation of the 4 types of samples through a consumer acceptance test. Scoring was given to 25 untrained panelists (students) of both sex who were all consumers of candies, on different parameters to assess. Each of the untrained panelist was presented with samples of the different candies to taste and give his opinion about the candies. The panelists rinsed their mouth with potable water after tasting each of the samples to enable correct results. The following characteristics were evaluated: taste, flavor, color, texture, appearance, and overall acceptability. Structural sensory questionnaires were used to obtain views of respondents on the organoleptic properties of the different samples and their overall acceptability. The candy parameters were categorized using 5 points Hedonic scale method as described by Larmond (1997) where scores ranging from highest point 5 to lowest point 1 which represents like very much to dislike very much respectively. The evaluations were conducted in a well-lit room with white fluorescent lights.

2.2.6. Statistical analysis

Treatments and physicochemical analyses were performed in triplicate. The data were expressed as means ± standard deviations. The physicochemical analysis data were subjected to analysis of variance (ANOVA) and, in the case of significant difference, Tukey's test was used for post hoc comparisons ($p \leq 0.05$). The 95% confidence interval was calculated for comparison among storage periods within each candy formulation. One-way ANOVA was conducted in IBM SPSS version 25, Armonk, NY, while Principal Component Analysis was performed using XLSTAT (2007) software.

3. Results and Discussion

3.1. Presentation of Findings

The results of the physicochemical analysis of hard candies are presented in Table 2 below. A significant difference ($p<0.05$) was observed between the different pH values and the TTS. However, no significant difference ($p>0.05$) was observed for the moisture of different hard candy samples**.** The moisture content of samples HCO, HCPi, HCPa were higher than the control and HCW. Hard candies made with orange (HCO) and those made with pineapple (HCPi) had the lowest pH values of 3.59 and 3.86 respectively. The value of the TSS of the control sample (HCW) was highest (65,81° Brix).

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Table 2: Physicochemical characteristics of candy samples

Candy samlples	Parameters		
	PH	Brix index	Moisture (%)
HCO	**3,59±0,34[a]**	**52,68±2,17[a]**	**12,86±1,98[a]**
HCPi	**3,86±0,14[a]**	**55,53±2,03[a]**	**13,47±2,96[a]**
HCPa	**4,46±0,10[b]**	**56,69±2,78[ab]**	**13,03±1,71[a]**
HCW	**5,03±0,27[c]**	**65,81±2,97[b]**	**9,35±1,57[a]**

Different letters in the same column indicate significant differences between the samples, based on Tukey's test (p < 0.5). .HCPi= Pineapple Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control

Table 3 below shows the content of various phytochemicals and ascorbic acid in candy samples. A significant difference ($p<0.05$) was observed between the phenolic compounds, flavonoids and ascorbic acid content of the different samples analyzed. The control (HCW) which was carried out without fruit juice, does not have any phenolic compounds, flavonoids or ascorbic acid detectable by the methodology implemented. The total phenolic compound content of hard candies made with fruit juices ranges between 46.92 µg GAE/ml in the HCPa sample to 50.04 µg GAE/ml in the HCPi sample. The highest levels of flavonoids (182.87 ug EQ/ml) and vitamin C (8.26 mg/100 g) were recorded in the HCPi and HCPa samples, respectively.

Table 3: Phytobiochemical compounds and ascorbic acids of candy samples

Candy samlples	Parameters		
	Phenolic compounds (µg GAE/ml)	Flavonoids ug QE/ml	Ascorbic acid (mg/100 g)
HCO	48,58±2,15[bc]	174,56±3,29[c]	5,41±2,14[c]
HCPi	50,04±1,72[c]	182,87±5,63[d]	2,49±1,92[b]
HCPa	46,92±1,81[b]	154,83±3,91[b]	8,26±2,66[d]
HCW	**0.00**±0.00[a]	**0.00**±0.00[a]	**0.00**±0.00[a]

Different letters in the same column indicate significant differences between the samples, based on Tukey's test (p < 0.5). HCPi= Pineapples Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control

Table 4 below shows the average scores for the sensory attributes given by panelists following the preference test on the various samples of hard candies produced. This shows that, with the exception of the appearance and color of hard candy, produced with orange (HCO), the sensory attributes of all the other products received average scores of over 3 (neither like nor dislike). The average scores attributed to texture (4,68), flavor (4,88), color

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(4.54) and overall acceptability (4.78) were higher for hard candy made with pineapple fruit juice (HCPi). Hard candy made with pawpaw juice (HCPa) received the highest average score for appearance (3.88).

Table 4: Phytochemical compounds of candy samples

Parameters	Candy samples			
	HCO	HCPi	HCPa	HCW
Taste	3.4±1,29[a]	4,2±1,25[b]	4,28±0,89[b]	3,52±1,38[a]
Texture	3,08±1,32[a]	4,68±1,22[b]	3,4±1,22[a]	3,8±1,19[ab]
Flavor	3,48±1,53[a]	4,88±1,30[c]	4,64±1,46[b]	3,56±1,41[ab]
Appearance	2,8±1,44[a]	3,76±1,16a[b]	3,88±0,97[b]	3,84±1,34[b]
Color	2,88±1,50[a]	4,54±1,27[b]	3,94±1,43[b]	4,16±1,10[b]
Overall Acceptability	3,36±1,07[a]	4,78±0,86[b]	3,96±0,78[a]	4.00±0,91[a]

Different letters in the same line indicate significant differences between the samples, based on Tukey's test (p < 0.5).
HCPi= Pineapples Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control

Figure 3 below shows the overall acceptability of hard candy samples made by panelists. Candy made with pineapples (HCPi) had the highest score (4.78), followed by the control sample (HCW) with a value of 4.00. With a value of 3.36, candy made with orange had the lowest score of overall acceptability. A significant difference was observed between the sensory attributes of all analyzed samples ($P<0.05$). Taste and colour are the main contributors to general acceptance while texture and appearance are the sensory attributes that had a negative impact on overall acceptability.

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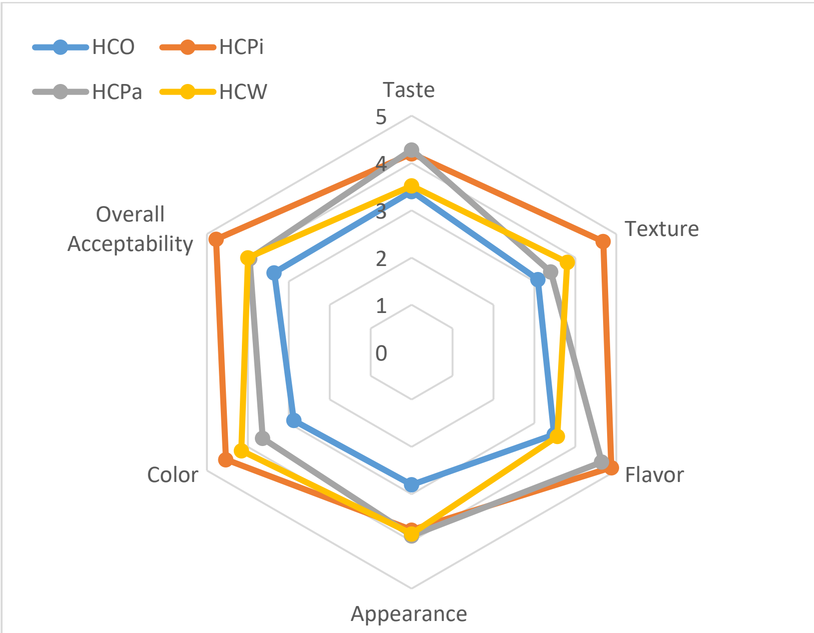

Figure 3: Overall acceptability of hard candies.
HCPi= Pineapple Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control

3.2. Discussion

The observed TSS values range from 52.68 in the sample "HCO" to 65.81 in the control sample. These values are lower than those of commercial candies that range from 74 to 80° Brix (Ge, *et al*., 2020). According to Lees and Jackson (1992), the TSS measures all substances soluble in water. In the specific case of candies, it is the sugar presence. The difference in TSS observed between the samples would be due to the difference of fruits used as ingredients. The orange, papaya and pineapple juices that were used at 40% have respectively the TSS values of 11.95, 11.5 and 17.53% respectively (Akusu *et al*, 2016). The higher value of TSS on the control and samples can be explained by the amount of sucrose they contain (69.5 % for control and 29.5 % for those of fruit candies). The reports by Bhat *et al*., (1982) with the aonla candy also showed an increase of TSS content of candies.

The pH of confectionery products is important because adding acid to fruit-flavoured products can enhance fruity flavours. The pH showed differences ($p < 0.05$) between the different samples and the control. Hard candies made with orange and pineapples exhibited the lowest pH. These results can be explained by the low pH of pineapple (pH range of 3.20 to 4.00) and orange (pH range of 3.69 to 4.34) juices used to substitute glucose syrup in the formulation of hard candies (Akusu *et al.*, 2016). Another explanation of this low pH is the use of lemon juice rich in citric acid during the preparation of hard candy (Yan, 2022). According to Søltoft-Jensen and Hansen (2005), citric acid is a tricarboxylic acid that serves antibacterial effects owing to its acidulation and indirect antioxidant by chelating metallic

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ions that catalyze oxidation. The chelating effect of citric acid can function as a preservative to prevent microbial growth (Søltoft-Jensen and Hansen, 2005). The pH values of samples HCPi and HCO are within the range of standard hard candies that are 3 to 4 (Hubbermann, 2016). pH of hard candies mixture influences the color shade of the product. pH can also drive the sucrose inversion process that occurs during the heating step of hard candy production (Ozel *et al.*, 2024). Generally, low pH accelerates sucrose inversion in combination with high temperature and high relative humidity. Inversion of sucrose to glucose and fructose alters the physicochemical properties of the samples in terms of storage stability, texture, taste and appearance (Nadaletti *et al.,* 2011).

Water affects the stability of textural properties and shelf life of the food products, and the growth of the microorganisms (Yetim and Kesmen, 2009).

In this study, the moisture content in the candy samples was within the range of that obtained by Mohanta *et al.,* (2021) on orange peel based candies. However, this moisture content was higher than the one obtained by Sharma and Ghoshal (2021) on fruit-juice sweets. The difference in method of assessment used and the use of fruit juices in this preparation, can explain this disparity. In fact, Dinesh *et al.*, (2021) reported that increasing the concentration of vegetables and fruits in formulations resulted in a rise in the moisture content of the hard candies. When fruit juices are soaked in a sugar solution, it experiences an osmotic pressure of sugar solution (Khanom *et al.*, 2015) and that pressure moves the sugar molecules on the cell wall (extra cell) of fruit until the sugar solution enter into it, as a result the water within the cells of fruit out. Water content in all samples is still relatively safe as the water content of food permitted for a maximum of 25% (Buntaran *et al.*, 2010).

According to Yan *et al*., (2020), ascorbic acid or vitamin C is a water-soluble vitamin that promotes healthy growth and improves iron absorption. The presence of vitamin C in hard candies made with fruit juices and not in the control can only be explained by the usage of fruit in the formulation. Vitamin C content is generally 38.3 mg/100g for pineapple juice, 41.2 mg/100g for orange juice and 39.3 mg/100g for papaya juice (Ellong *et al,* 2015). There is a considerable reduction in vitamin C in the final products compared to the content of this compound in fruit juices. This is in line with the work of Kumar and Kirad 2013 which observed that generally, the vitamin C content of fruits decreases considerably during the preparation of fruit-based candies. The loss of ascorbic could be consequence of oxidation of ascorbic acid in the formation of dehydro ascorbic acid in syrup (Priyadarshini and Ravindra, 2017).

According to Ahmed *et al*. (2014), phenolic compounds and flavonoids are among the most significant bioactive substances and are known for their ability to operate as strong antioxidants, hydrogen donors, reducing agents, and free radical scavengers, anti-inflammatory agents, metal chelators, and quenching singlet oxygen. Phenolic compounds

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and flavonoids are present in hard candies made with fruit juices and not in the control sample. The presence of these biochemical compounds in these samples originates from the fruits used in the formulation of these candies. Orange, papaya and pineapple have phenolic compounds in the order of 131.8, 43.5 and 73.3 mg/100g respectively (Ellong *et al*, 2015). This difference in the content of phytochemicals compounds found in fruits also explains the significant difference in the concentration of these compounds in prepared candy products. In confectionery, sensory characteristics are important for consumer perspective (Prabhat, 2011; Kour *et al*., 2021). That is because the confectionery items are ingested for enjoyment in addition to nourishment (Kurt *et al.*, 2021). The difference in sensory attributes among the samples can be explained by the difference of the fruit juices used to make these products. Hard candy made with pineapples were the most preferred product to the panelists, this is possible because the colour and the flavor of pineapples were still nice. Control sample (HCW) had the second high mean score for overall acceptability after hard candy made with pineapple juice (HCPi). This should be due to the general perception of the commercial hard candies in the market (Yan, 2022).

Principal component analysis (PCA) was carried out to classify the different hard candies according to their overall acceptability, their physicochemical characteristics and bioactive compounds. Figure 4 shows the correlation circle between the different variables, in particular overall acceptability, physicochemical characteristics (pH, moisture, TSS) and bioactive compounds (phenolic compounds, flavonoids). The figure shows that these variables contribute 94.58% to the formation of the (F1xF2) axis system. The F1 axis alone explains 80.23 % of the variables observed, while the second axis, F2, explains 14.35%. There is a positive correlation between overall acceptability and variables such as pH and TSS. These variables are however, negatively correlated to phenolic compounds, flavonoids and ascorbic acid.

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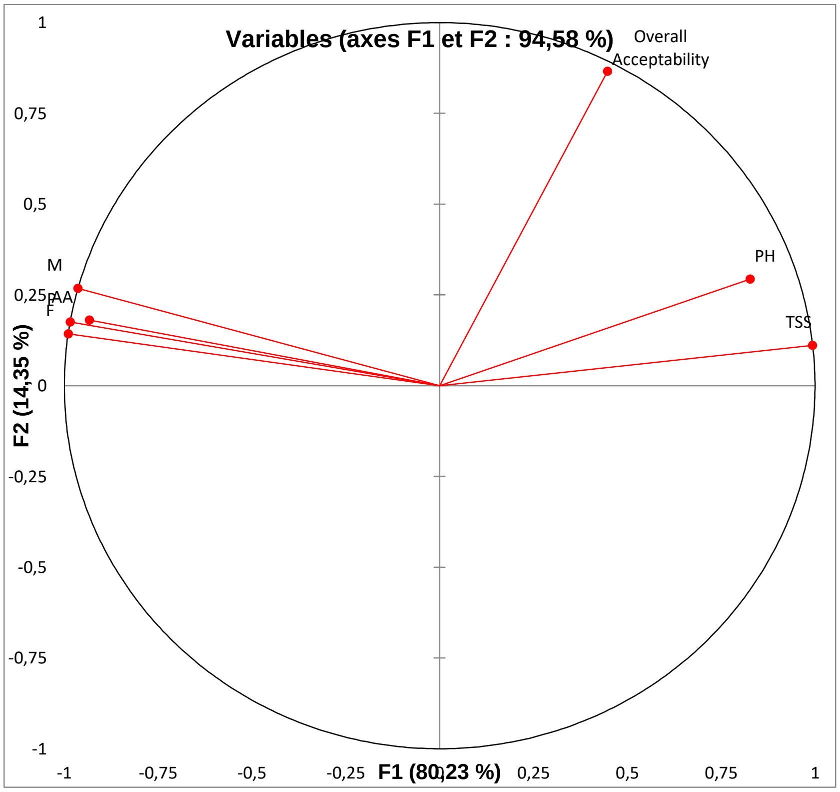
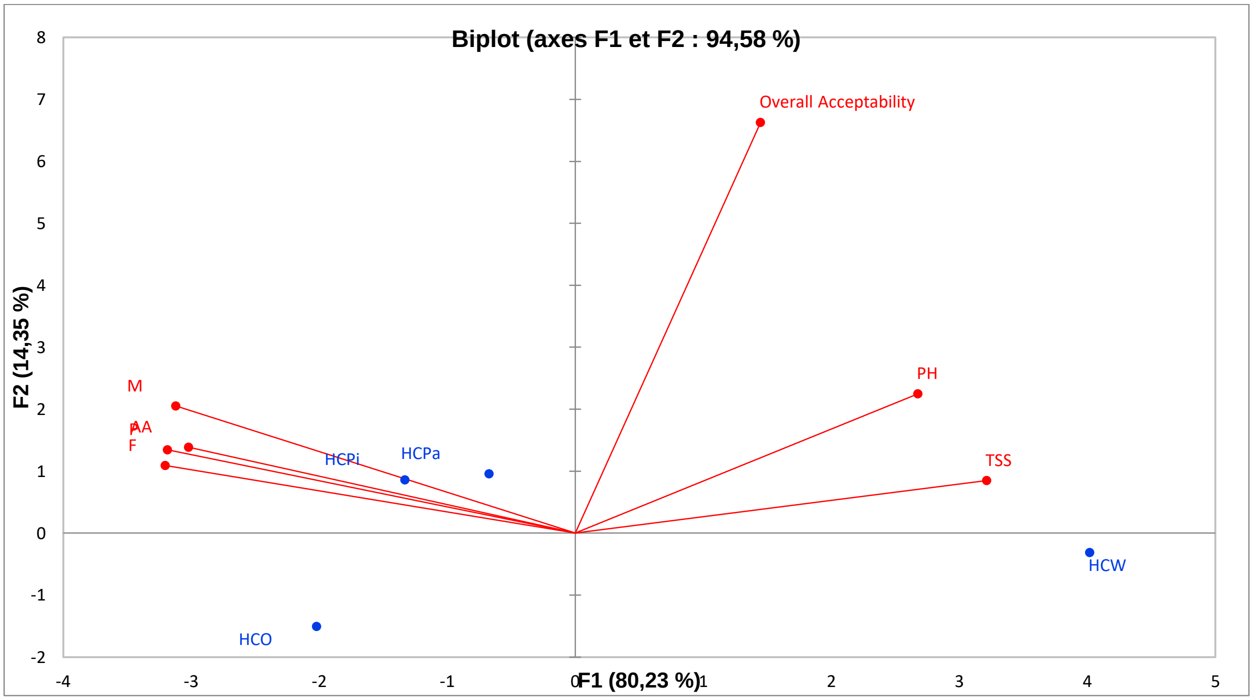


Figure 4: Correlation circle between variables: overall acceptability; F (Flavonoids compounds); AA: (Ascorbic acids); M (Moisture); pH and TSS

Figure 5 illustrates the Principal Component Analysis of the hard candies with physicochemical characteristics (ascorbic acids, pH and Brix index) overall acceptability and phytochemical compounds (phenolic and flavonoids compounds; ascorbic acids). The figure shows that the hard candies samples made with fruits showed a positive correlation with the phytochemical compounds and ascorbic acids. The control, on the other hand, showed a positive correlation with TSS and pH.



4. **Figure 5: Principal component analysis of different hard candies.** *HCPi= Pineapples Hard Candy; HCO=Orange hard candy; HCPa=Pawpaw hard candy; HCW=Control, F=Flavonoids compounds; AA=Ascorbic acids; M=Moisture; TSS= Total Soluble Solids*

5. Conclusion

The main objective of this study was to evaluate the sensorial, phytochemical and physicochemical characteristics of hard candies made by partially substituting glucose syrup with pineapple, pawpaw and orange fruit juices. The incorporation of fruit juices in the formulation of hard candies decreases the pH, improves the sensory characteristics and adds the phytochemical compounds (phenolic and flavonoid compounds) of ordinary hard candy. Hard candy samples made with pineapple juice (HCPi) showed the best sensory characteristics and have the highest content of flavonoids and phenolic compounds that can be useful to improve the health of consumers. The result of this study showed that fruit juice-based hard candies could be developed as value-added hard candies. This study also suggest that the processing of fruit juice can help fight against post-harvest losses of fruits. However, more investigation is required in the future to optimize the formulations conditions.

5.1. Implications

The results of this study will have as potential consequences, an intensification of the cultivation and use of fruits in general and pineapples in particular in the manufacture of hard candies. This new approach in the formulation of confectionery products will reduce the incidence of diseases caused by an excessive consumption of sugars. It will also reduce the rate of post-harvest fruit losses.

5.2. Contributions

This study is a contribution to the knowledge of the potential use of fruits in confectionery. It also informs about the proximal composition and anti-nutritional factors likely to disrupt the assimilation of nutrients and other bioactive compounds contained in these fruits.

5.3. Recommandations

We recommend that fruit juices in general and the one of pineapple in particular be incorporated into the formulation of confectionery products so that consumers can benefit from these fruits, thus contributing to the reduction of post-harvest losses.

5.4. Suggestions for further Studies

Additional studies should be done to optimize the proportions of ingredients that go into the formulation of candies. Similar works should also be done to optimize the conditions of preparations of hard candies. Finally, this study should extend to other fruits and other confectionary products with the aim of reducing the consumption of sugars while encouraging the consumption of fruits through these products.

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