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Development and Evaluation of Quality Attributes, Physicochemical profile of Fruit Jam from *Avverhoa carambola* L. blended with Pineapple

K. H. A. Udani[1], K. Premakumar[1*] , S. Sahana[2]

1Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Chenkalady 30350 Sri Lanka
2Department of Biosystems Technology, Faculty of Technology, Eastern University, Chenkalady 30350 Sri Lanka
e-mail: *srisahana1992@gmail.com

Abstract: *A research was carried out to develop blended fruit jam by incorporating basic properties (nutritional and organoleptic properties) of a sub- tropical underutilized fruit in Sri Lanka with pineapple. Taking into consideration the decisions of several preliminary studies, five formulations with different combinations of star fruit and pineapple were prepared and analyzed for physico-chemical parameters inclusive of Total Soluble Solids (TSS), pH, titrable acidity, ascorbic acid content, total sugar, reducing, non-reducing sugar content, dry matter content, moisture content, and ash content and organoleptic parameters such as colour, texture, aroma, taste, and overall acceptability using Seven point Hedonic Scale. Physico- chemical analysis of star fruit blended with pine apple jam showed the increasing the trend in titrable acidity (from 0.5925 to 0.75037, as % of citric acid), TSS (from 2.93 to 7.53 Brix°), reducing sugar (from 1162 to 2517.33mg/100 ml), total sugar (from 2370.33 to 7720mg/100ml), dry matter (from 14.16 to 31.43%) and also showed the decreasing of non- reducing sugar (from 5898.33 to 1259.33 mg/100ml), ascorbic acid (from 484 to 59.40 mg/100ml, pH (from 5.67 to 4.72) , moisture content (from 85.2% to 67.63%), ash content (from 0.57% to 0.27%) due to star fruit combination of different ingredients. All sensory characters were significantly ($p<0.05$) differed in all treatments. No microbial growth (bacteria, yeast, moulds) in freshly made jams at the day of preparation. Treatment (T4) -star fruit pulp containing pine apple pulp, pectin and sugar was considered to have the strongest physicochemical and organoleptic properties and showed a strong effect on nutritional value. The jam of star fruit blended with pine apple can be included in any age group's daily diet, which can certainly improve sensory attributes and nutrient intake to sustain nutrition*.

Keywords: Star fruit, pineapple, jam, physico-chemical analysis, sensory attributes.

Introduction

In Sri Lanka, the carambola (Averrhoa carambola L.), an attractive fruit of the family Oxalidaceae, also known as the "Star fruit" had attained the status of underutilized fruits in Sri Lanka (1). *Averrhoa carambola,* tropical fruit which has the highest antioxidant properties of fighting against free radicals as well as the damage caused due to free radicals (2). Consuming theses fruits helps in the reduction in body weight, in control of cholesterol and maintain the blood pressure (3).

Carambola is rich in antioxidants, potassium, magnesium, phosphorous as well as β-carotene (4) and L-ascorbic acid (vitamin C) gallic acid, helps to scavenge reactive oxidative species (5) and is low in sugar and sodium. It also a source of both primary and secondary polyphenolic antioxidants (6) and potential antioxidants (7). The presence of antioxidants like iron, zinc and manganese in the fruits aid in strengthening the immune system (8). And also, these fruits have anti-inflammatory activity (9), anti-ulcer activity (10), hypoglycaemic activity, antimicrobial activity against *E. coli*, *Klebsiella* spp., *Staphylococcus aureus*, and *Pseudomonas aeruginosa* as well as neutraceutical properties. In addition, the availability of high quantities of fibers in fruit helps to absorb glucose and slow the diffusion of glucose into the blood stream; as a result, it helps to regulate the concentration of blood glucose (11). The consumption of Star fruit also has a hypo-cholesterolemic and hypolipidaemic effect as it improves the removal of cholesterol, lipid and bile acid through the excrement (10).

Usually, the star fruit is eaten fresh or made into a refreshing juice. The entire fruit is edible, including the slightly waxy skin. The whole fruit, including the slightly waxy skin, is edible. It is crunchy, firm, and incredibly juicy all across the flesh. Shortly after they ripen, carambolas are best enjoyed. Without being excessive, mature sweet type carambolas are sweet as they rarely have more than 4 percent sugar content. In processed types, most carambola fruits are sold. It has several benefits and is edible. The ripe fruit can be processed into fermented or unfermented beverages, jam or jelly, and can be eaten fresh or as a snack.

Pineapple also increases digestion, controls stomach acidity, helps in the process of detoxification and neutralization of free radicals and blood clots, as well as aids in the treatment of rheumatoid arthritis, reduction of symptoms of sciatica, development of collagen and management of weight and in the treatment of albuminuria (12).

By keeping in view, the significance of this underutilized fruit attempts has been made to evaluate the nutritive composition and to develop food products for the benefit of the society. Combination of this underutilized star fruit with highly demanded fruit, pine apple can be a solution for having new

jam product in local market with different consumer preference. The purpose of this study to identify the suitability of star fruit jam blended with pineapple and to study its quality, stability and nutritional properties and thereby evaluating the shelf life of prepared star fruit jam. Therefore, this research study was undertaken with the objective of finding out the suitability of star fruit for jam preparation with or without pineapple.

Materials and Methods

This Research Study was undertaken at the Food Science Laboratory, Department of Agricultural Chemistry, Eastern University, Vantharumoolai, Sri Lanka. Sound fresh, good quality, pest and disease-free, and well ripened pine apple and star fruits were purchased from the local market. The fruits were sorted, graded and washed to eliminate adhere dirt etc. under warm tap water. For their physicochemical studies, the fruit was analyzed. Visual appearance was used to determine the basic parameters of fruit colour, flesh colour and shape. Using vernier caliper, physical methods viz., length and width of the fruit were evaluated. The weight of the fruit was measured using electronic weighing balance.
Firstly, fruits were chopped into small pieces, blended and homogenized using electric blender to obtain the fine and homogenous star fruit pulp. Then, star fruit and pineapple pulps at different ratios selected from several preliminary studies were added with sugar and pectin were heated to boiling with occasional stirring until the final TSS reaches 68.6% using refractometer (Model RHB-90 ATC). Then prepared jam formulation was then hot-filled into a sterilized glass container and allowed to cool to room temperature of 28±1˚C. The jam was developed with following combination of different ingredients as treatments as follows.

- T1: Star fruit + without pectin + sugar
- T2: Star fruit + with pectin + sugar
- T3: Star fruit + with gelatin + sugar substitute (Aspartame)
- T4: Star fruit + pine apple + with pectin + sugar
- T5: Star fruit + pine apple + gelatin + sugar substitute

Proximate and Physico-chemical Analysis

Proximate analysis of the samples, which include moisture content, ash was determined (13). Freshly made jam formulations were analyzed for the chemical quality parameters such as Total Soluble Solids (TSS), Titrable Acidity (TA), pH, ascorbic acid content, total sugar, reducing sugar and non-reducing sugar following the standard AOAC (2019) methods (13).

Sensory evaluation

On day of preparation, a sensory evaluation was conducted to evaluate organoleptic attributes such as colour, aroma, taste, texture and overall acceptability by a panel of twenty semi trained and trained panelists. Seven-point Hedonic scale in which 1 indicates extremely dislike and 7 denotes like extremely was used to evaluate organoleptic parameters. Sensory evaluation was conducted between 9. 00a.m and 12.00pm. Each panelist was asked to evaluate every sample arranged randomly.

Statistical Analysis

Data of the chemical analysis and storage study were analyzed by Analysis of Variance (ANOVA) ($\alpha = 0.05$) and mean separation was done with Duncan's Multiple range Test (DMRT). Both chemical and organoleptic analysis was done through Statistical Analysis System (SAS) software statistical package.

Results and Discussion

pH

The pH value of the star fruit was 3.783±0.23154. pH value decreased significantly ($p<0.05$) with the presence of star fruit blended with pineapple showed the lowest (4.72) pH (Table1). It might be due to the presence of pineapple attributed by citric acid as well as ascorbic acid with star fruit led to provide more acidity in the sample. A similar pH increase (2.65-2.87) in the production of mandarin jam from fresh mandarin fruits was observed by Aksay, Tokbas, Arslan, and Cinar (14). The study also suggested that pH value may be an effective predictor that could assist in maintaining sufficient gelled consistency.

Total Soluble Solids (TSS)

Formulations had non-significant TSS values. Low TSS content with respect to low star pulp concentration complemented with higher pineapple pulp concentration resulted in minor change in TSS among star fruit formulations and it was found to be non-significant. However, T4 formulation had highest value (Table 1) and T1 formulation had lowest value (3.05). Both star fruit and pine apple contained high amount of TSS. In this analysis, the TSS of the star fruit needed to produce the jam was 9.867±1.03655 of soluble solids (Brix).

Table 1: The pH and TSS of freshly made star fruit jam with different ingredients.

Treatment	pH	TSS
T1	5.67±0.0057a	3.05±0.0763c
T2	5.61±0.0057b	3.166±0.033c
T3	4.73±0.0144c	2.933±0.088c

T4	4.72±0.012c	7.533±0.202a
T5	4.72±0.0057c	5.200±0.0577b

Note: The values are means of triplicates ± standard error. Values with the different superscripts in lower case letters in the same column are significantly different at $p<0.05$, among the different treatments, T1-T5. (T1: Star fruit + without pectin + sugar, T2: Star fruit + with pectin + sugar, T3: Star fruit + with gelatin + sugar substitute (Aspartame), T4: Star fruit + pine apple + with pectin + sugar, T5: Star fruit + pine apple + gelatin + sugar substitute).

Titrable Acidity

Acidity is one of the variables that undermines the flavour-based classification of fruit. Acidity value is a practical magnitude in determination of stability and mean life of the product. The titrable acidity of jam samples (Figure 1) increased significantly ($p<0.05$) in the T4 jam sample which containing both pine apple and star fruit and also interpreted the highest score of 0.75%. This is because of the acid content of both pineapple and star fruit and the presence of citric acid.

Ascorbic acid

Figure 1 depicts that the increment of ascorbic acid in jam samples are non- significant ($p<0.05$) from each other. On the day of preparation, the highest mean value (484.09) was obtained for T4 whereas, the least mean value (59.4) obtained from T3 sample. This is because of higher ascorbic acid content of pineapple (22.39±0.43mg/100g). Similar findings of increase in ascorbic acid content were reported in blending of pineapple and orange juices with hibiscus (15).

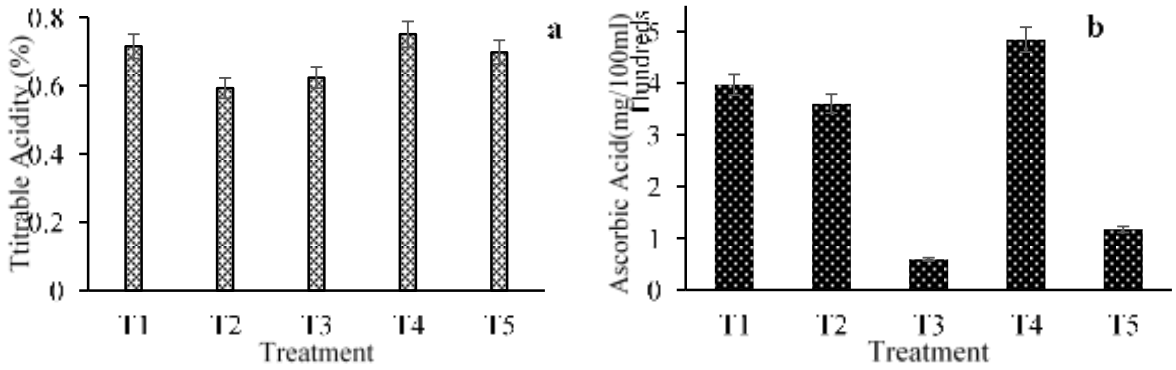

Figure 1: (a) Titrable acidity content (b) Ascorbic acid of freshly made underutilized star fruit jam blend with pineapple. The values are means of triplicates. Vertical bars indicate the standard errors of means. T1-T5. (T1: Star fruit + without pectin + sugar, T2: Star fruit + with pectin + sugar, T3: Star fruit + with gelatin + sugar substitute (Aspartame), T4: Star fruit + pine apple + with pectin + sugar, T5: Star fruit + pine apple + gelatin + sugar substitute).

Sugar Content

For sweetness, sourness and overall acceptability in jam, sugars, acids and their interactions are essential. Mean values for total sugar, reducing sugar and nonreducing sugar contents of freshly prepared fruit jam formulations are presented in Figure 2. T4 jam formulation had highest values for total sugar where the lowest values obtained from T3. It revealed both pine apple and star fruit contained high amount of total sugar content with sugar than the combinations with sugar substitute provided the lower amount of total sugar. The similar decreasing trend in reducing sugar with sugar substitutes was interpreted by Correa et al16. Same as total sugar, higher reducing sugar and non-reducing sugar contents were recorded for formulation T4. Lowest reducing sugar content, non-reducing sugar, total sugar was obtained for the formulation T3. In T4 sample contained high amount of citric acid than T3 sample. It caused for increment of non- reducing sugar due to hydrolysis of sucrose with presence of citric acid. Citric acid is a factor of increasing the inversion of sugar (17).

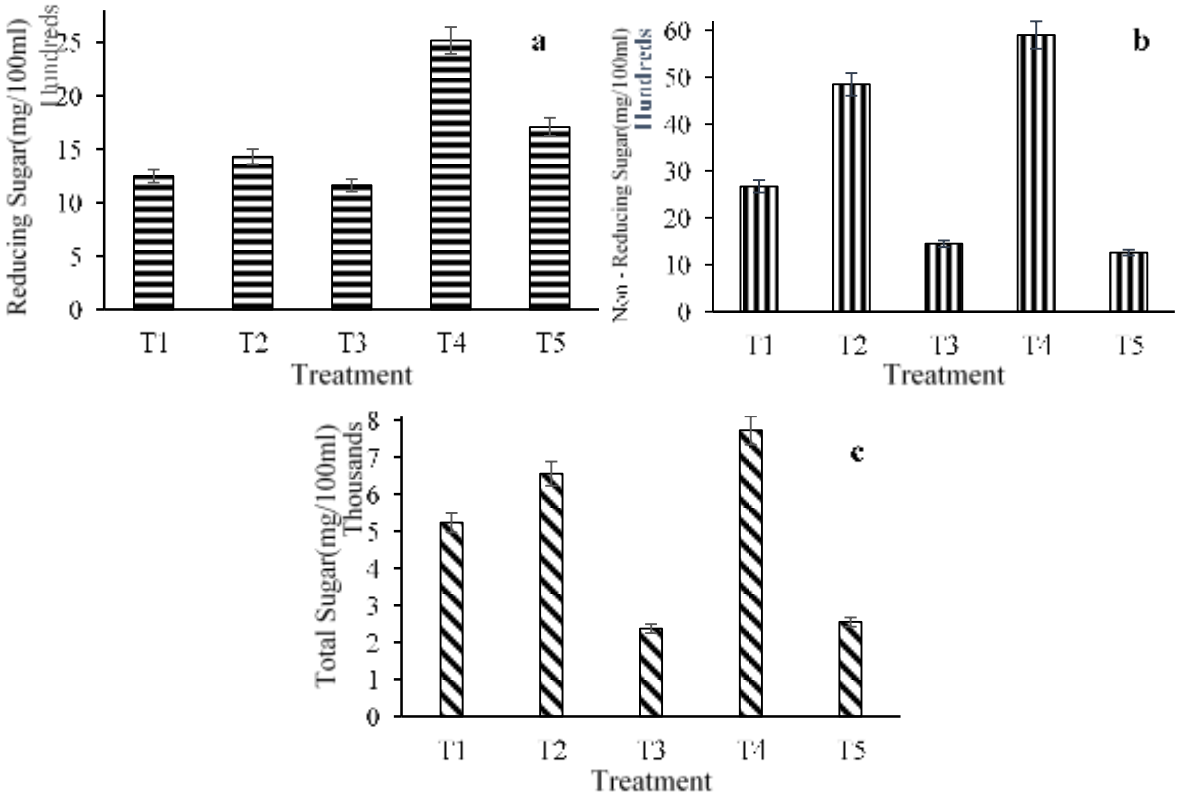

Figure 2: The reducing sugar (a), Non-reducing sugar (b), Total sugar content of freshly made underutilized star fruit jam blended with pineapple. The values are means of triplicates. Vertical bars indicate the standard errors of means. T1-T5. (T1: Star fruit + without pectin + sugar, T2: Star fruit + with pectin + sugar, T3: Star fruit + with gelatin + sugar substitute (Aspartame), T4: Star fruit + pine apple + with pectin + sugar, T5: Star fruit + pine apple + gelatin + sugar substitute).

Ash

The ash content of jam samples was significantly differed from each treatment. The least amount of mean value (0.27) (Figure 3) was showed in T2 (star fruit+ sugar+ pectin) sample. The highest mean value (0.57) was showed the T4 (star fruit+ pine apple+ pectin+ sugar) sample. T4 jam sample contained high amount of mineral content compared to other samples. Similar study was expressed in high values of ash content indicated high mineral constituent of food sample (18).

The moisture content (Figure 3) of each treatment was significantly differed ($p<0.05$) from each other. The lowest mean (67.63) value obtained from T1. The highest mean value (85.2) was obtained in T3 jam sample which contained high amount of moisture due to break down of sugar substitute (Aspartame). It can be due to presence of sugar substitutes other than sugar and it caused for reduce gelling ability of jam. According to the research studies showed that; when aspartame is stored for prolonged periods of time or exposed to high temperatures, it may break down.

The lowest mean value (14.16) for dry matter content in jam samples were expressed in T3 sample due to presence of sugar substitutes. Due to presence of moisture by breaking down of sugar substitutes provide lower dry matter content in T3 jam sample by reducing the availability of soluble solids. The highest mean value (31.43) of dry matter content were observed in T1 sample. Because the star fruit contained higher amount of dry matter content. And also, it had the already added sugar, which was provided the higher amount of dry matter due to solubilization of solids. The similar concept was carried out on research; the dry matter content of ripe fruits is full with fats and sugars (19).

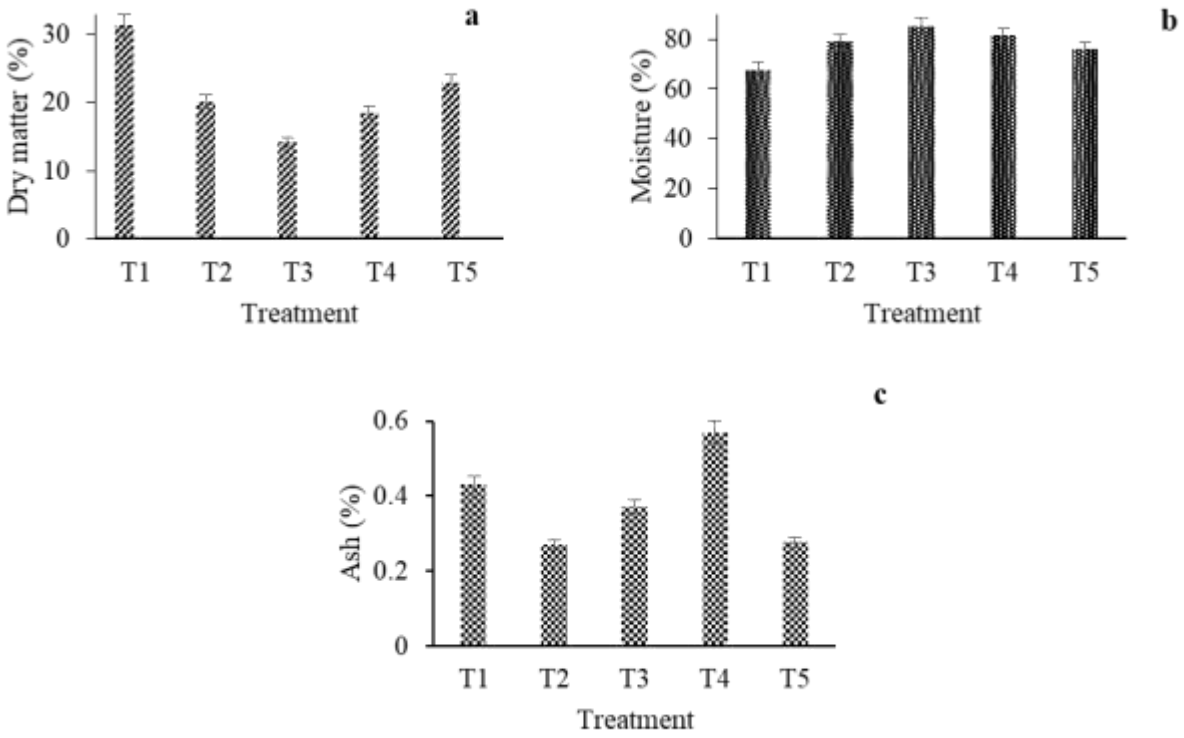

Figure 3: The dry matter (a), moisture (b), and ash content (c) of freshly made underutilized star fruit jam blended with pineapple.

Note: The values are means of triplicates. Vertical bars indicate the standard errors of means. T1-T5. (T1: Star fruit + without pectin + sugar, T2: Star fruit + with pectin + sugar, T3: Star fruit + with gelatin + sugar substitute (Aspartame), T4: Star fruit + pine apple + with pectin + sugar, T5: Star fruit + pine apple + gelatin + sugar substitute).

Organoleptic qualities

Colour plays an important part in helping to determine the first reaction to a food. Colour in particular gives an indication of what flavour a food might be. The appearance and colour of these products are thus the primary indicators of perceived quality. The acid presence in food influence for flavour, brightness of colour, stability, consistency and keeping quality of the product18. There were no significance differences between all five treatments for colour. The lowest mean value (4.8) in T3 sample and highest mean value (5.83) in T4 sample were obtained for colour (Table 2). Colour formation caused due to blending of two pulp of star fruit and pine apple with different ingredients.

Aroma plays a vital role as a sensory parameter in determining the acceptability of a new product. There was significant difference between the aromas in each treatment. The lowest mean value of aroma (1.55) (Table 2) was obtained in T1 (star fruit+ sugar) and highest mean value was obtained in T4 (star fruit+ pine apple+ pectin+ sugar. It means the juice concentration used for the development of jam had the effect on the aroma of star fruit- pine apple blend jam.

Taste is the primary factor, which determines the acceptability of any product for market demand. The lowest mean value (3.43) for prepared jam for T3 (star fruit+ sugar substitutes). The reason for this, due to presence of sugar substitutes, which is provided the only artificially sweetened flavuor with somewhat bitter taste (low sugar content). T4 sample (pine apple+ star fruit+ pectin+ sugar) is provided the highest mean value (6.7) due to presence of star fruit blended with pine apple. T4 sample was significantly different from T3 and T5 samples. And also, it is non- significantly differed in treatments from T1 and T2 samples.

Table 2: Sensory scores jam prepared with star fruit jam.

Note: The values are means of triplicates ± standard error. Values with the different superscripts in lower case letters in the same column are significantly different at $p<0.05$, among the different treatments, T1-T5. (T1: Star fruit + without pectin + sugar, T2 : Star fruit + with pectin + sugar, T3 : Star fruit + with gelatin + sugar substitute (Aspartame), T4 : Star fruit + pine apple + with pectin + sugar, T5 : Star fruit + pine apple + gelatin + sugar substitute).

The texture is related to the property between physical condition (consistency and structure), which is detected visually, auditory and touch. Consistency is the connection among food components. T1 and T2 jam samples were not significantly difference from each treatment. T4 sample significantly differed from T1, T2, T3, and T5. The highest mean value (6.35) of texture obtained from the T4 sample. The reason for that pectin also causes jams to solidify. The pH, acidity and soluble pectin content are factors that may influence the gelling and therefore the texture of the final product (20). The least mean value (4.15) for texture obtained from T3 due to presence of sugar substitutes. T1 and T2 jam samples significantly differed from each treatment. T4 sample significantly differed from T1, T2, T3, and T5. The highest mean value (6.6) for overall acceptability obtained from the T4 sample. T4 (Table 2) had the highest score (6.6) in colour, aroma, texture, taste and overall acceptability. T3 had the lowest mean value (4.11).

Treatment	Colour	Aroma	Taste	Texture	Overall acceptability
T1	5.300±0.05a	1.550±0.005e	5.333±0.088b	5.816±0.072b	5.583±0.040b
T2	5.800±0.05a	5.716±0.06b	5.600±0.115b	5.816±0.109b	5.700±0.050b
T3	4.800±0.75a	4.283±0.044d	3.433±0.145c	4.150±0.028d	4.116±0.044d
T4	5.833±0.31a	6.400±0.057a	6.700±0.057a	6.353±0.101a	6.600±0.057a
T5	5.100±0.057a	5.400±0.057c	5.233±0.088b	5.300±0.028c	5.050±0.028c

Conclusions

Star fruit (Averrhoa Carambola) is one of Sri Lanka's underutilized fruit with very low-calorie, exotic, under-used fruits. It has an incredible list of essential nutrients, antioxidants, and vitamin C that helps the human body develop resistance to infectious agents and scavenge harmful free radicals from the body that are pro-inflammatory. This research was conducted to introduce new kind of jam to the market. Physico-chemical analysis of freshly made underutilized star fruit jam revealed that there was a decrease in pH, non-reducing sugar, ash%, moisture% and increment of the titrable acidity, total sugar, reducing sugar, TSS, ascorbic acid, dry matter% with the combination of more than one fruits and ingredients. Organoleptic evaluation of freshly prepared jams showed that the jam of blended star fruit with pine apple (T4), purely prepared star fruit jam with sugar (T1) and star fruit jam with pectin, sugar (T2) jams were most preferred at the day of preparation.

It can be concluded that the inclusion of pine apple pulp with star fruit pulp can improve the nutritional value of the jam and add variety to the diet. Treatment (T4) -star fruit pulp incorporated with pine apple pulp was considered to have the strongest physicochemical and organoleptic properties and had a positive effect on nutritional value. Therefore, the jam of star fruit blended with pine apple can be included in the daily diet of every age group which can definitely increase sensory attribute and nutrient intake for maintaining the good health and promoting immunity against infections. The development of star fruit blending jam with pineapple was therefore found to be acceptable in both sensory and nutritional quality characteristics. Utilization of underutilized fruits like star fruit with highly demand fruit like pineapple can be introduced to modern market towards the development of new value-added product-jam of star fruit blended with pineapple.

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