FORMULATION AND SENSO-CHEMICAL EVALUATION OF ALOE VERA 
(Aloe barbadensis Miller) BASED VALUE ADDED BEVERAGES

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Abstract

The aloe vera pulp contains more than 98% water and less than 1% total soluble solids (TSS). Blending of pineapple juice and roselle extract with aloe vera may not only increases the TSS level but also add other nutritional properties in the final mixed products. The current study was carried out to investigate the different formulations and the quality of various types of mixed beverages prepared from aloe vera, roselle herb and pineapple juice. Developed products were evaluated for their chemical properties as well as sensory attributes. In addition, selected products were tested for shelf-life potentials. Formulated drinks and juices were found as highly nutritious (maximum of 6.86 mg/100 ml ascorbic acid, 0.045% Ca, 0.26% Mg, 0.154% K, 0.034%Na, and 12.09 ppm Fe). Sensory evaluation revealed that products with 20% and 40% aloe vera pulp with pineapple and roselle extract were highly liked by the consumers. With the storage time, pH and ascorbic acid content decreased (maximum around 40% for pH and around 10% for ascorbic acid respectively) in all the formulated beverages, while TSS increased regardless of the formulations. In addition, aloe vera with pineapple and sugar blend exhibited an acceptable level of microbial load during the shelf-life study. Results from this study suggest that it could be possible to commercially produce aloe vera based value added products, which in turn could play an important role in addressing socio-economic as well as health conditions.

Keywords: Juice, drink, aloe vera, pineapple, roselle.

Introduction

The botanical name of aloe vera is Aloe barbadensis Miller, it belongs to the family Liliaceae. The name Aloe barbadensis has been specified for the true Aloe, while the other aloes are normally known as Curacao aloe (Manvitha and Bidya, 2014). Aloe vera has been used for its medicinal properties since ancient times (Kumar and Debjit, 2010, Sahu et al., 2013). The application of aloe vera in the rapheutics has been recorded in several cultures (Sahu et al., 2013). Even the use of aloe vera has been mentioned in the Bible, where it was taken as the plant of immortality (Choi and Chung, 2003). Historically as a topical medicinal treatment, aloe vera leaves have been used to heal wounds and various skin diseases (Qadir, 2009). Aloe vera gel has got much more attention since it is being used in the cosmetic industry for making creams,
shampoos, lotions, and in the food industry for making different beverages and healthy drinks for curing certain diseases (Hamman, 2008); as a consequence, its’ interest as well as use has increased dramatically in the field of health care and cosmetics (Mishra et al., 2011). However, it is now becoming an industrial crop as it is largely used in the food industry for the preparation of immune-boosting value-added products such as tea, ice cream, dried juice, dessert and milk etc. (Shin et al., 1995, Baruah et al., 2016, Zapata et al., 2013). The extract of aloe vera is the most commonly used, and majority of it can be used to make aloe drinks (Eshun, 2004). Different attempts have been made to improve the taste of aloe drink, reduce costs and maintain nutritional properties. The number of aloe vera based drink and juice producers is increasing, and the value of the aloe vera processing industry has been estimated to be around $110 billion dollars (Ahlawat and Khatkar, 2011). Cultivation of aloe vera in south Asia, especially in Bangladesh, is increasing, and producers are selling the aloe leaves directly on the local market. In addition, street food vendors are processing raw juice from aloe gel and selling it to consumers in different urban and peri-urban areas. Nowadays, the cultivation of aloe vera is becoming a profitable business (Das and Chattopadhay, 2004). According to Srivastava et al. (2005), juice should contain 80-85% pulp, and the TSS of the juice should be around Brix. The development of improved aloe-based beverages will not only serve as an immune-boosting product but also will improve the socio-economic status of the country. Limited work has been conducted on the processing of aloe juice in Bangladesh. Although several researchers reported huge benefits of aloe vera, as discussed above, however very little information is available about the beverage products from aloe vera alone or mixed with other herbs and fruit juices. Therefore, this study was designed to investigate the formulation and the quality and microbial safety of beverages from aloe vera mixed with roselle herb and pineapple juice.

Materials and Methods
The aloe vera leaves, pineapples and roselle calyces were collected from the local market near by the Bangabandhu Sheikh Mujibur Rahman Agricultural University in Gazipur, Bangladesh. The aloe vera leaves were first washed with cold water and then sorted and graded manually. Only high-quality aloe vera leaves were used for the experiment. The main constituent used for making aloe vera juice is the aloe gel. The leaves of aloe vera were cut at about 0.5 inches from the base to drain out all the yellow sap material. The sap was collected using the hand filleting method. Pineapple juice, on the other hand, was extracted mechanically by pressing the pineapple cubes. The juice was then filtered and preserved for further preparation. In addition, 10 g of dry roselle calyces were taken and boiled with 100 ml of water, and 50 ml of roselle extract was collected and preserved for further use.

Preparation of beverages
The process for the formulation of beverages has been shown in Fig. 1. In preparation of the drinks and juices, aloe vera gel was blended using a blender machine. In addition, pineapple juice and roselle extract were used in the preparation of aloe vera based value added products.
An overview of the drinks and juices preparation with various concentrations has been shown in Table 1. From Table 1, it is apparent that aloe vera based value added drinks products are coded to be ‘P1’ (Aloe vera + Sugar), ‘P2’ (Aloe vera + Sugar + Citric acid), ‘P3’ (Aloe vera + Sugar + Roselle), ‘P4’ (Aloe vera + Pineapple + Sugar) and ‘P5’ (Aloe vera + Pineapple + Sugar + Roselle) while the aloe vera based value added juices are ‘P6’ (Aloe vera + Sugar), ‘P7’ (Aloe vera + Pineapple + Sugar) and ‘P8’ (Aloe vera + Pineapple + Sugar + Roselle).

**Physicochemical analysis**

Color properties such as lightness ($L^*$), redness ($a^*$), yellowness ($b^*$), chroma ($C^*$), hue angle ($H^\circ$), browning index ($BI$) and

| Products | Aloe vera pulp | Pineapple pulp | Sugar | Roselle extract | Citric acid |
|----------|----------------|----------------|-------|-----------------|-------------|
| P1       | 20%            | -              | 10%   | -               | -           |
| P2       | 20%            | -              | 10%   | -               | 0.05%       |
| P3       | 20%            | -              | 10%   | 4%              | -           |
| P4       | 10%            | 10%            | 10%   | -               | -           |
| P5       | 10%            | 10%            | 10%   | 4%              | -           |
| P6       | 80%            | -              | 8%    | -               | -           |
| P7       | 40%            | 40%            | 8%    | -               | -           |
| P8       | 40%            | 40%            | 8%    | 4%              | -           |

Footnote: Aloe vera based value added drink products: ‘P1’ (Aloe vera + Sugar), ‘P2’ (Aloe vera + Sugar + Citric acid), ‘P3’ (Aloe vera + Sugar + Roselle), ‘P4’ (Aloe vera + Pineapple + Sugar) and ‘P5’ (Aloe vera + Pineapple + Sugar + Roselle). Aloe vera based value added juice products: ‘P6’ (Aloe vera + Sugar), ‘P7’ (Aloe vera + Pineapple + Sugar), and ‘P8’ (Aloe vera + Pineapple + Sugar + Roselle).
whiteness index (WI) of juice and drinks were
determined using the methods and equations as
described by Islam et al. (2014). TSS (Islam,
2018), pH (Wang et al., 2014), moisture content
(Islam et al., 2010), and ash content (Cao et
al., 2020a) of the beverages were determined
following AOAC methods. Ascorbic acid,
titrable acidity, reducing sugar, and total
sugar were determined following the method
described in Cao et al. (2020b). The sweetness
index was calculated according to a method
described by Rangana (1994). The content
of calcium, potassium, magnesium, sodium,
iron, and zinc was determined using Atomic
Absorption Spectrophotometer (Shimadzu
AA-7000) by the method described by Piper
(2017). Proximate analysis was carried out
according to the procedure of Association of
Official Analytical Chemist (Cao et al., 2020c).

Sensory analysis
The descriptive sensory evaluation was carried
out according to “generic sensory descriptive
analysis” (Murray et al., 2001). The total
procedure consisted of three steps, namely
1) panel selection, 2) sample preparation,
and 3) evaluation. The panel consisted of 10
panelists (5 women, age 25-50 years) who
had more than two years of experience in
sensory evaluation. Before running the panel
test, the panelists were gone through two
training sessions. The panelists were agreed
to use a hedonic rating for color, flavor, taste
and overall acceptability of the products,
from 9, which represents “like extremely” to
1, which represents “dislike extremely”. The
samples were evaluated in triplicate according
to a complete randomized block design. The
sensory evaluation was performed in the
sensory evaluation room in the department of
Agro-Processing, BSMRAU, by maintaining
international standards (Eggert and Zook,
1986).

Shelf-life study
The shelf-life of a product governs by
either physical, microbiological or chemical
processes. Products were stored at room
temperature for 30 days. pH, TSS, titrable
acidity and content of ascorbic acid were
determined during shelf-life assessment. To
assess the microbial load, each sample was
diluted up to 10^{-3} and 1 ml of the diluted
sample was added to the agar media (Yeast
extract, peptone, agar powder). The plates
were incubated at 37 °C for 24 hours for total
viable bacteria. All analyses were carried out
every 15 days.

Statistical analysis
Analysis of variance (ANOVA) tests was applied
to identify differences between the different
formulation of drinks and juices. Duncan’s
multiple range test (DMRT) at (P<0.05)
was applied for multiple comparisons of the
mean values. Principal component analysis
(PCA) was carried out to explore the relations
between various chemical properties of juices
and drinks. A Pearson correlation matrix
was generated to understand the correlations
between different mineral contents. All analysis
was carried out using R software (version 3.4.4,
R Development Core Team, 2018).

Results and Discussion
Physicochemical properties of aloe vera
pulp and value added products
The proximate analytical results of the aloe
vera pulp and aloe vera based value added
products are presented in Table 2. Aloe vera
pulp had the highest of 97.25% moisture
content. Ascorbic acid, titrable acidity, total
Table 2. Physicochemical properties of the aloe vera based value added products

| Products       | MC (%) | Ash content (g/100g) | pH value | TSS (ºBrix) | Ascorbic acid (mg/100 ml) | Titrable acidity (%) | Total sugar (%) | Reducing sugar (%) | Non-reducing sugar (%) | Sweetness index (%) |
|----------------|--------|----------------------|----------|-------------|---------------------------|----------------------|------------------|-------------------|----------------------|---------------------|
| P1             | 89.75  | 0.24                 | 5.43     | 10.2        | 4.78                      | 0.107                | 20.00           | 14.29             | 5.71                 | 95.33               |
| P2             | 87.25  | 0.28                 | 3.45     | 12.7        | 4.16                      | 0.192                | 23.80           | 20.50             | 3.30                 | 66.15               |
| P3             | 89.00  | 0.22                 | 4.06     | 11.0        | 4.58                      | 0.256                | 25.00           | 14.40             | 10.60                | 42.97               |
| P4             | 91.26  | 0.22                 | 3.85     | 8.2         | 5.41                      | 0.212                | 35.70           | 28.70             | 7.00                 | 38.68               |
| P5             | 90.00  | 0.21                 | 3.77     | 9.5         | 5.62                      | 0.192                | 38.17           | 24.40             | 13.77                | 49.48               |
| P6             | 86.25  | 0.28                 | 5.17     | 13.3        | 4.99                      | 0.149                | 20.67           | 20.60             | 9.07                 | 89.26               |
| P7             | 90.00  | 0.22                 | 4.30     | 9.7         | 6.24                      | 0.448                | 37.80           | 30.90             | 6.90                 | 21.65               |
| P8             | 92.25  | 0.20                 | 3.95     | 8.1         | 6.86                      | 0.467                | 39.30           | 32.80             | 6.50                 | 17.34               |
| Aloe vera pulp | 97.25  | 0.19                 | 5.00     | 2.1         | 5.41                      | 0.400                | 2.55            | 0.20              | 2.36                 | 5.25                |

sugar and reducing sugar was highest in P8 as 6.86 mg/100gm, 0.467%, 39.3% and 32.8%, respectively. P5 showed the lowest pH of 3.77 and P6 showed the highest TSS of 13.3. P1 had the highest sweetness index of 95.33% as it contains only 20% aloe vera pulp and 10% sugar.

It can be seen from Table 3 that all the minerals varied with the different formulations of the drinks and juices. Aloe vera pulp showed an average of 0.035% calcium and magnesium, 0.030% potassium, 0.027% sodium and 10.07 ppm iron. While, all the formulated products had an average of 0.032% calcium, 0.18% magnesium, 0.07% potassium, 0.02% sodium and 9.4 ppm iron.

**Quality attributes**

The color properties of the formulated products are shown in Table 4. Higher lightness values were found in product P1,

Table 3. Mineral contents of the aloe vera based value added products

| Products       | Ca (%) | Mg (%) | K (%) | Na (%) | Fe (ppm) |
|----------------|--------|--------|-------|--------|----------|
| P1             | 0.04   | 0.108  | 0.09  | 0.016  | 9.69     |
| P2             | 0.025  | 0.118  | 0.098 | 0.019  | 10.37    |
| P3             | 0.014  | 0.031  | 0.026 | 0.011  | 5.72     |
| P4             | 0.025  | 0.017  | 0.015 | 0.018  | 7.97     |
| P5             | 0.031  | 0.16   | 0.134 | 0.023  | 12.09    |
| P6             | 0.037  | 0.185  | 0.154 | 0.028  | 9.84     |
| P7             | 0.046  | 0.23   | 0.036 | 0.034  | 4.43     |
| P8             | 0.045  | 0.26   | 0.052 | 0.034  | 6.23     |
| Aloe vera pulp | 0.035  | 0.035  | 0.030 | 0.027  | 10.07    |
Table 4. Color properties of aloe vera based value added beverages

| Products | $L^*$  | $a^*$  | $b^*$ | $H^o$  | $C^*$  | $BI$  | $WI$  |
|----------|--------|--------|--------|--------|--------|-------|-------|
| P1       | 78.12±1.45 | -6.13±1.02 | 5.04±1.33 | 0.55±0.06 | 7.99±1.29 | -5.05±1.03 | 76.70±1.75 |
| P2       | 76.70±0.28 | -1.49±0.44 | 1.93±0.19 | 0.67±0.04 | 2.44±0.40 | -1.13±0.39 | 76.57±0.24 |
| P3       | 34.64±2.27 | 47.01±1.44 | 28.45±1.34 | 0.47±0.006 | 54.95±1.88 | 87.28±2.51 | 14.58±0.71 |
| P4       | 69.09±2.42 | -7.57±0.68 | 33.83±1.14 | 0.77±0.008 | 34.68±0.96 | -3.24±1.04 | 53.50±0.95 |
| P5       | 41.73±1.19 | 47.80±2.54 | 27.75±2.38 | 0.46±0.009 | 55.28±3.39 | 75.18±1.93 | 19.63±1.54 |
| P6       | 80.67±0.65 | -0.73±0.46 | 4.22±0.68 | 0.77±0.008 | 4.31±0.62 | -0.13±0.48 | 80.19±0.50 |
| P7       | 84.87±0.49 | -8.92±0.83 | 43.08±2.25 | 0.77±0.002 | 43.99±2.25 | -2.7±0.73 | 53.46±1.96 |
| P8       | 29.90±2.84 | 43.34±3.39 | 17.07±3.81 | 0.34±0.039 | 46.62±4.57 | 88.48±0.29 | 15.70±0.22 |

P2, P6 and P7. Those products either contain only aloe vera pulp or a mixture of aloe vera and pineapple juice, provide a higher lightness value. Product P3, P5 and P8 shows $a^*$ values of 47.01, 47.80 and 43.34, respectively. With the increasing $a^*$ values, browning index also increased. These parameters showed a similar pattern. In a previous experiment Mgaya et al. (2014a) found that redness value decreased proportionally with the concentration of roselle extract. Higher $a^*$ and BI value indicates more redness and browning respectively since these products contain 4% of roselle extract, the redness values increased significantly. Higher $H^o$ values were obtained in products contain pineapple juices such as P4, P6 and P7. Whiteness index followed a similar pattern like lightness values, products containing aloe vera and pineapple showed a higher whiteness index. On the other hand, in the presence of citric acid, chroma value decreased in P2. A low chroma value indicates a more grayish color. These findings are in accordance with previous research carried out by Choi et al. (2002).

Fig. 2 shows the scores and loading plot of the principal component analysis. The PCA was carried out with three PCs. The first PC explained 65% variation of the data, while the second PC explained 29% of the variation. From the score plot, two separate clusters can be found (Fig. 2a). These two clusters show a clear separation between drinks and juices. Drinks are mainly attributed to a higher sweetness index, which complies with our preparation (Table 1). On the other hand, juices are mainly attributed to ascorbic acid, total sugar, titrable acidity etc. Interestingly, minerals such as Mg, K, Ca, Fe were found highly correlated. Na, however, was found to be negatively correlated with the other minerals. Non-reducing sugar and TSS were found to be highly correlated, which is in accordance with the previous study.

To verify the correlations found in Fig. 2b, a correlation matrix was built. Fig. 3 summarizes the Pearson correlation coefficients for pairwise comparison. The strongest correlations were found between Ca-Mg and Ca-K (Pearson 0.96). The correlation between Ca-Fe was strong as well (Pearson 0.92); correlations between Fe-Mg and Fe-K were also very strong (Pearson 0.91). These correlations were also reflected in the top left corner of the loading plot (Fig. 2b). In addition,
poor correlation values were obtained in the case of Na and Zn, which is also in accordance with the previous results (Fig. 2b). Mineral analysis in the commercially available fruit juices showed similar correlations between the elements (Velimirović et al., 2013).

The data from the sensory analysis are presented in Fig. 4. According to the panelist’s scores, colors for all products were not significantly different. However, product P7 was highly liked, followed by P1, P3, P4 and P8 by the panelist. Liking in taste value differed significantly. The taste of P5 was mostly disliked by the panelists. The taste of P1, P3, P7 and P8 was mostly liked by the panelists. Interestingly the flavor of P3 was mostly preferred by the sensory panelists. It clearly indicates that blend of aloe vera and roselle extract juice attained highest preference in flavor attribute by the panelists. In a similar trend, product P5 was less preferable by the evaluators. Among drinks, product P1, P3 and among juices product P7 and P8 were highly accepted by the evaluators. Based on the overall acceptability of the products from the sensory evaluation, product P1, P3, P7 and P8 were selected for chemical analysis and self-life study. Aloe vera base juice blended with pineapple juice and roselle extract attained highly acceptance from consumer preferences.

**Shelf-life study**

Fig. 5 shows the PCA score and loading plot for the samples subjected to shelf-life study. The PCA was carried out with three principal components. The first principal component explained 56% of the variance, while the second one explained 35% of the total variation. Two clearly separate clusters can be seen in the score plot, which indicates drinks and juices (Fig. 5a). Juice products such as P7 and P8 are mainly attributed to higher ascorbic acid content and titrable acidity (Fig. 5b). At the starting of the shelf-life study, products have higher pH, ascorbic acid and titrable
Acidity. With the storage time, all products, regardless of drinks and juices, increased TSS while decreased their pH and acidity (Fig. 5 a and b). Similar trends of TSS have been observed in the shelf-life study of roselle juice by (Mgaya et al., 2014b). The phenomenon of decreasing acidity with the storage time is in accordance with previous findings (Yadav and Chakravarty, 2013).

Microbiological study

Table 5 shows the amount of microbiological load during the shelf-life study. No colony formed in product P1, P3, P7 and P8 on day 0. After 15 days of the shelf-life total colony were found to be $4 \times 10^3$, $3 \times 10^3$, $0$ and $4 \times 10^3$ CFU/ml for product P1, P3, P7 and P8, respectively. On the other hand, after 30 days of the shelf-life total microbial colony of $6 \times 10^3$, $25 \times 10^3$, $7 \times 10^3$ and $8 \times 10^3$ CFU/ml were found for P1, P3, P7 and P8, respectively. In terms of microbial load, P7 showed an excellent result for 15 days.

Products were completely unsafe after 30 days. In general, effective heat processing, higher sugar content, and the addition of preservatives such as sodium benzoate increases the shelf life and ensure a safe level of the microbial colony in any juice and drink. However, no molds growth was found in the microbiological study. The absence of
Conclusion

The study evaluated aloe vera base eight different formulations of beverages in terms of physicochemical quality and self-life. Pineapple pulp and roselle herb extracts were blended with aloe pulp at a various ratio to produce a new type of beverage product. Aloe vera base juice blended with pineapple juice and roselle extract obtained high acceptance from the taste panel. The storage study indicated that the TSS increased with the increase of storage period, while acidity, as well as pH, decreased. The juice and drink prepared from aloe pulp and pineapple were found superior to other combinations in respect of organoleptic properties throughout the storage period. On the basis of the results...
revealed in the present study, it could be concluded that the formulation of mixed blend beverages from pineapple, aloe vera and roselle can satisfy consumer preferences along with imparting health benefits.

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