Ann. Bangladesh Agric. (2021) 25 (1) : 43-54
www.doi.org/10.3329/aba.v25i1.58154

ISSN 1025-482X (Print)
2521-5477 (Online)

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

S. Alam[1], M. Ahiduzzaman[1]*, M. N. Islam[1], M. A. Haque[1] and M. A. M. Akanda[2]

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 rapeutics 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,

[1]Department of Agro-processing, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh. [2]Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh. *Corresponding authors: ahid.agp@bsmrau.edu.bd

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 creams, 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.

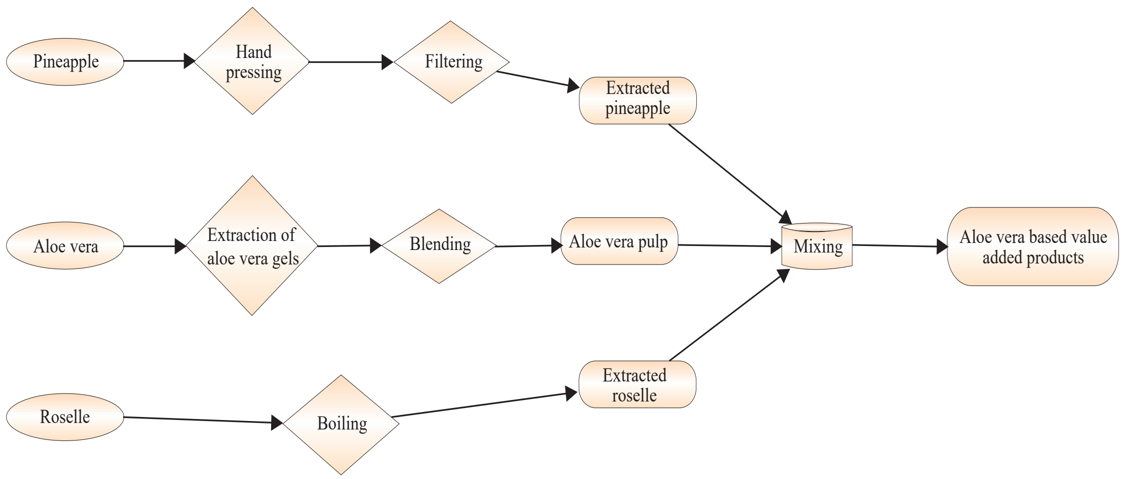

Fig. 1. Process flow diagram for the formulation of aloe vera based value added beverages.

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 ($H°$), browning index (BI) and

Table 1. Formulation of aloe vera based value added beverages

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 ºC 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^*	$H°$	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 brownness respectively since these products contain 4% of roselle extract, the redness values increased significantly. Higher $H°$ 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,

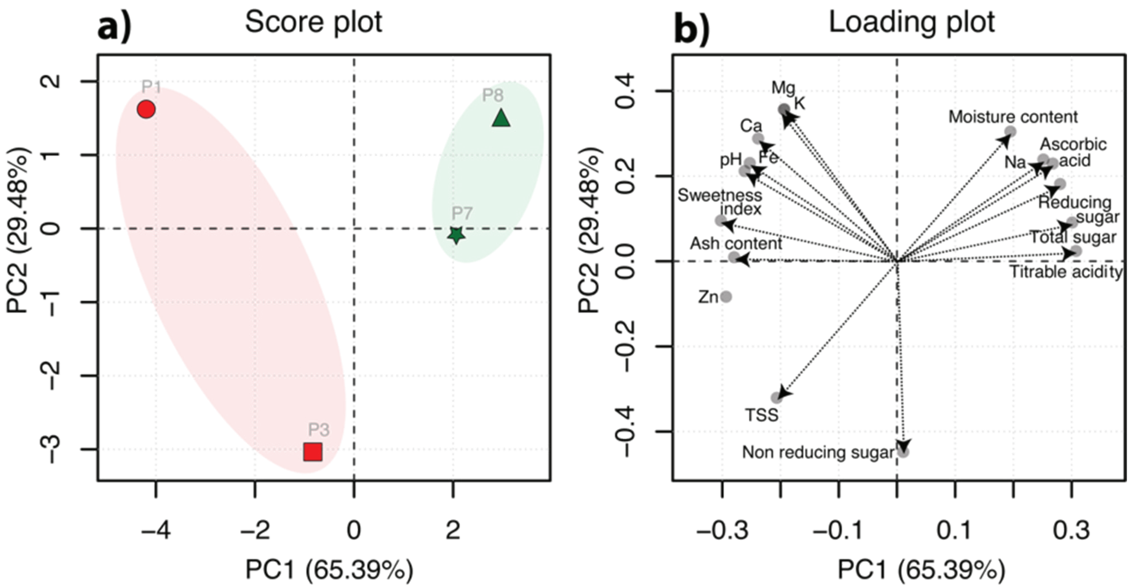

Fig. 2. Principal component analysis of the aloe vera based value added products.

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

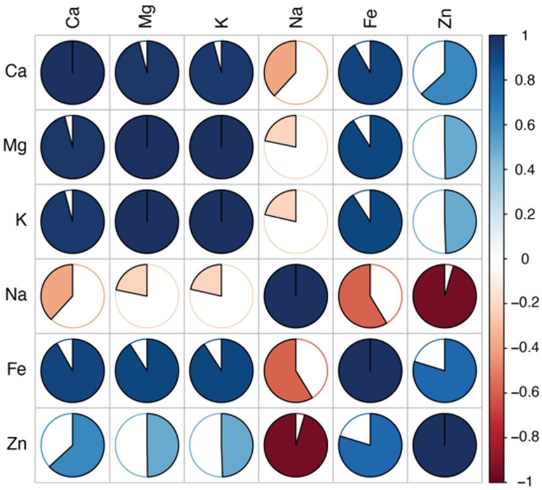

Fig. 3. Matrix of minerals correlation expressed as Pearson correlation coefficient.

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 4×10^3, 3×10^3 , 0 and 4×10^3 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 6×10^3, 25×10^3, 7×10^3 and 8×10^3 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

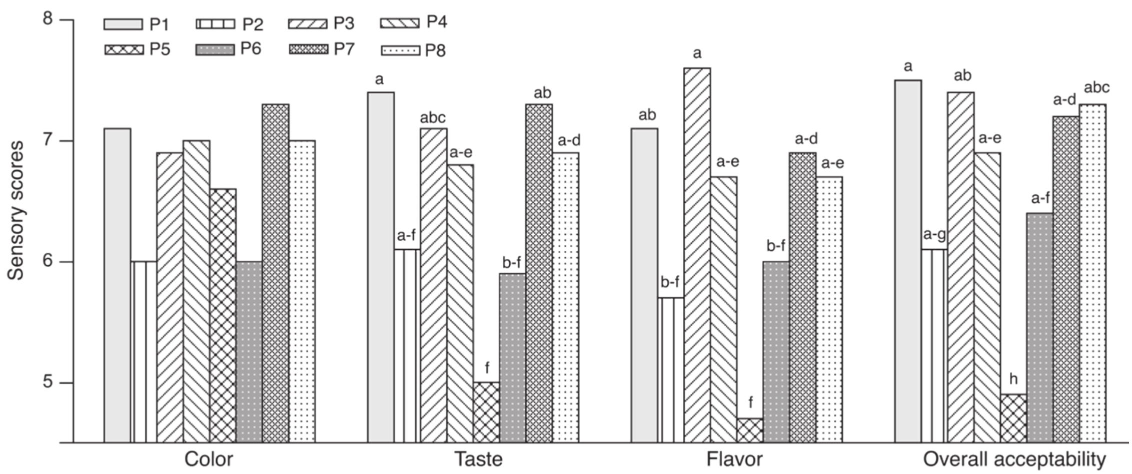

Fig. 4. Sensory evaluation scores of the aloe vera based value added beverages. Different letters indicate significant differences ($p < 0.05$) in the same group. Data show the mean value.

Table 5. Total colony count of final products during shelflife

Product	Dilution	at 0th Day (cfu/mL)	at 15th days of shelflife (cfu/mL)	at 30th days of shelflife (cfu/mL)
P1	10^{-3}	Nil	4×10^3	6×10^3
P3	10^{-3}	Nil	3×10^3	25×10^3
P7	10^{-3}	Nil	Nil	7×10^3
P8	10^{-3}	Nil	4×10^3	8×10^3

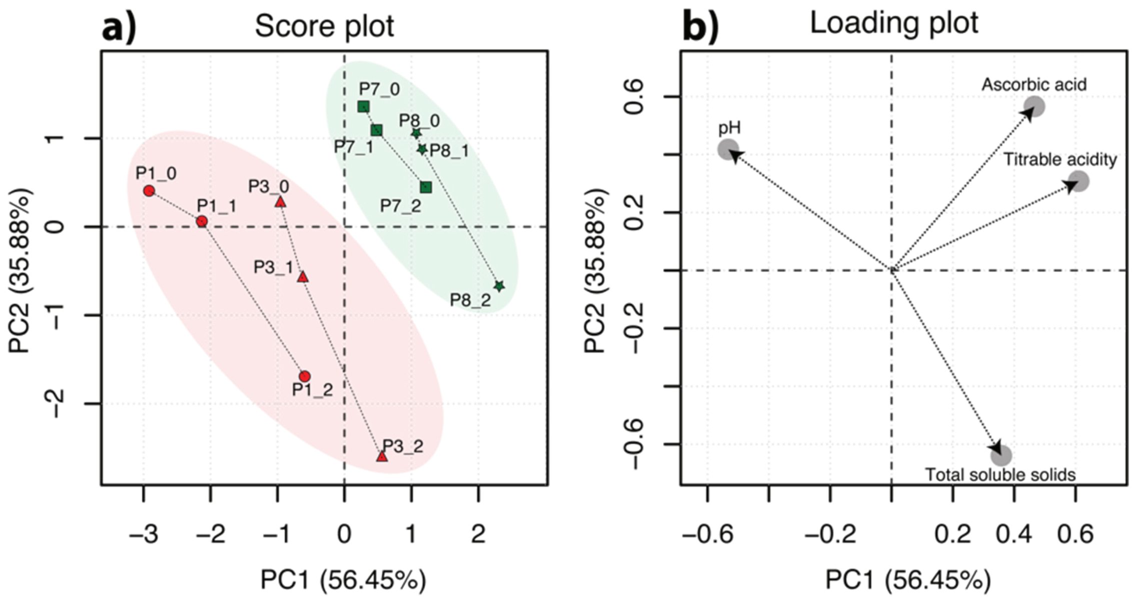

Fig. 5. Principal component analysis of the aloe vera based value added products in shelf-life. (0, 1 and 2 refer 0 days, 15 days and 30 days, respectively. Ellipses denote locations of drinks and juice samples.

molds among different variants of beverages might be due to potential antifungal activities possessed by aloe vera gel (Arunkumar and Muthuselvam, 2009; Hamid *et al.*, 2014; Antonisamy *et al.*, 2012).

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.

Acknowledgment

Authors acknowledge the support from RMW-BSMRAU Project "Preparation of concentrates from selected fruits and their utilization in different food formulation" (PN#5921-3) for financial support.

Conflict of interest: Authors declare no conflict of interest.

References

Ahlawat, K. S. and B. S. Khatkar. 2011. Processing, food applications and safety of aloe vera products: a review. *J. Food Sci. Technol.* 48(5): 525-533. http://doi.org/10.1007/s13197-011-0229-z.

Antonisamy, J. M. A., R. J. J. Malar, S. B. Nancy, S. R. Laju, G. Anupriya and T. J. J. E. Renola. 2012. Anti-bacterial and antifungal activity of Aloe vera gel extract. *Internat. J. Biomed. Adv. Res.* 3(3): 184-187.

Arunkumar, S. and M. Muthuselvam. 2009. Analysis of phytochemical constituents and antimicrobial activities of aloe vera L. against clinical pathogens. *World J. Agric. Sci.* 5(5): 572-576.

Baruah, A., M. Bordoloi and H. P. D. Baruah. 2016. Aloe vera: A multipurpose industrial crop. *Indust. Crops Prod.* 94: 951-963.

Cao, X., M. N. Islam, Z. Duan, X. Pan, W. Xu, X. Wei and S. Zhong. 2020a. Chlorogenic acid osmosis of snakehead fish: A novel approach to maintain quality and suppress deterioration during storage. *Internat. J. Food Propert.* 23(1): 387-399.

Cao, X., M. N. Islam, S. Zhong, X. Pan, M. Song, F. Shang, H. Nie, W. Xu and Z. Duan. 2020b. Drying kinetics, antioxidants, and physicochemical properties of litchi fruits by ultrasound-assisted hot air-drying. *J. Food Biochem.* 44(1): e13073. http://doi.org/10.1111/jfbc.13073.

Cao, X., M. Islam, W. Xu, J. Chen, B. Chitrakar, X. Jia, X. Liu and S. Zhong. 2020c. Energy consumption, colour, texture, antioxidants, odours, and taste qualities of litchi fruit dried by intermittent ohmic heating. *Foods.* 9(4): 425. http://doi.org/10.3390/foods9040425.

Choi, M., G. Kim and H. Lee. 2002. Effects of ascorbic acid retention on juice color and pigment stability in blood orange (*Citrus sinensis*) juice during refrigerated storage. *Food Res. Internat.* 35(8): 753-759.

Choi, S. and M. H. Chung. 2003. A review on the relationship between Aloe vera components and their biologic effects. Pp. 53-62. Seminars in integrative medicine, Elsevier.

Das, N. and R. Chattopadhay. 2004. Commercial cultivation of Aloe. *Natur. Product Radi.* 3(3): 85-87

Eshun, K. and Q. He. 2004. Aloe vera: a valuable ingredient for the food, pharmaceutical and cosmetic industries—a review. *Critic. Rev. Food Sci. Nutr.* 44(2): 91-96. https://doi.org/10.1080/10408690490424694.

Eggert, J. and K. Zook. 1986. Physical Requirement Guidelines for Sensory Evaluation Laboratories: A Manual (No. 913). ASTM International.

Hamid, G. H., E. A. El-Kholany and E. A. Nahla. 2014. Evaluation of aloe vera gel as antioxidant and antimicrobial ingredients in orange-carrot blend nectars. *Middle*

East J. Agric. Res. 3(4): 1122-1134.

Hamman, J. H. 2008. Composition and applications of aloe vera leaf gel. *Molecules.* 13(8): 1599-1616. http://doi.org/10.3390/molecules13081599.

Islam, M., M. Alam, M. Amin and D. Roy. 2010. Effect of sun drying on the composition and shelf life of Goat Meat (*Capra aegagrus hircus*). *Bangladesh Res. Pub. J.* 4(2): 114-123.

Islam, M. N. 2018. Postharvest Quality Changes of Onions during Long-Term Storage. Non-Destructive Quality Assessment and Modeling of Bulb Quality. PhD Thesis, Science and Technology, Aarhus University.

Islam, M. N., M. Zhang, B. Adhikari, C. Xinfeng and B.-g. Xu. 2014. The effect of ultrasound-assisted immersion freezing on selected physicochemical properties of mushrooms. *Internat. J. Refriger.* 42: 121-133. http://doi.org/10.1016/j.ijrefrig.2014.02.012.

Kumar, K. S. and B. Debjit. 2010. Aloe vera: A potential herb and its medicinal importance. *J. Chem. Pharmaceut. Res.* 2(1): 21-29.

Manvitha, K. and B. Bidya. 2014. Aloe vera: A wonder plant its history, cultivation and medicinal uses. *J. Pharmaco. Phytochem.* 2(5): 85-88.

Mgaya, K. B., S. Remberg, B. Chove and T. Wicklund. 2014a. Physio-chemical, mineral composition and antioxidant properties of Roselle (*Hibiscus sabdariffa* L.) extract blended with tropical fruit juices. *African J. Food Agric. Nutr. Develop.* 14(3): 8963-8978.

Mgaya, K. B., S. F. Remberg, B. E. Chove and T. Wicklund. 2014b. Influence of storage temperature and time on the physicochemical and bioactive properties of roselle-fruit juice blends in plastic bottle. *Food Sci. Nutr.* 2(2): 181-191. http://doi.org/10.1002/fsn3.97.

Mishra, A., A. Mishra and P. Chattopadhyay. 2011. Herbal cosmeceuticals for photoprotection from ultraviolet B radiation: A review. *Tropic. J. Pharmaceut. Res.* 10(3): 351-360.

Murray, J., C. Delahunty and I. Baxter. 2001. Descriptive sensory analysis: past, present and future. *Food Res. Internat.* 34(6): 461-471.

Piper, C. S. 2017. Soil and plant analysis. Interscience Publishers, Inc, New York.

Qadir, M. I. 2009. Medicinal and cosmetological importance of aloe vera. *Int. J. Nat. Ther.* 2: 21-26.

Rangana, S. 1994. Manual Analysis of fruits and vegetables production. In: Tata McGraw Hill Co. Ltd., New Delhi, India.

Sahu, P. K., D. D. Giri, R. Singh, P. Pandey, S. Gupta, A. K. Shrivastava, A. Kumar and K. D. Pandey. 2013. Therapeutic and medicinal uses of aloe vera: A review. *Pharmacol. Pharm.* 4(08): 599.

Shin, Y., K. S. Lee, J. S. Lee and C. H. Lee. 1995. Preparation of yogurt with aloe vera and its quality characteristics. *J. Korean Soci. Food Nutr.* 24(2): 254-260.

Srivastava, R., R. Srivastava and S. Kumar. 2005. Fruit and vegetable preservation: principles and practices. CBS Publishers & Distributors Pvt Ltd, India.

Velimirović, D. S., S. S. Mitić, S. B. Tošić, B. M. Kaličanin, A. N. Pavlović and M. N. Mitić. 2013. Levels of major and minor elements in some commercial fruit juices available in Serbia. *Tropic. J. Pharmaceut. Res.* 12(5): 805-811.

Wang, A., M. N. Islam, X. Qin, H. Wang, Y. Peng and C. Ma. 2014. Purification, identification, and characterization of d-galactose-6-sulfurylase from marine algae (*Betaphycus gelatinus*). *Carbohydr. Res.* 388: 94-99. http://doi.org/10.1016/j.carres.2013.12.010.

Yadav, L. and A. Chakravarty. 2013. Effect of keeping time period on acidity of fruit juices and determination of fungal growth in fruit juices. *Asian J. Home Sci.* 8(1): 166-169.

Zapata, P., D. Navarro, F. Guillén, S. Castillo, D. Martínez-Romero, D. Valero and M. Serrano. 2013. Characterisation of gels from different *Aloe* spp. as antifungal treatment: Potential crops for industrial applications. *Industr. Crops Prod.* 42: 223-230.