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Development and evaluation of different beverages from *Aloe vera* (L.) Burm.f. for their nutritional, functional and sensory qualities

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Present investigation was undertaken with the objective to develop palatable functional beverages from *Aloe vera* (L.) Burm.f. syn. *A. barbadensis* Mill. Nutritional, functional and sensory qualities of these products have been evaluated. Among various beverages, this juice contained negligible amount of sugars indicating its hypoglycaemic effect. The ascorbic acid content in different preparation of juice ranged between 23.75 to 234.85 mg/100 g. The products when tested for microbial enumeration, pure juice and sweetened juice showed negligible microbial load while gel, squash and RTS had 3.2, 1.0 and 2.3 CFU/mL, respectively. Developed products except RTS drink have shown antimicrobial activity against *E. coli*. Maximum zone of inhibition was shown by pure juice (25.7 mm), whereas minimum was observed in squash (12.10 mm). Similarly, highest antioxidant activity was found in pure *A. vera* juice (71.81 %), while lowest was recorded in RTS drink. Highest overall sensory acceptability (8.00) was recorded for sweetened juice by the panelists, which remained statistically non-significant with that of squash (7.80). Conclusively, the sweetened *A. vera* juice was found to be the best on the basis of its nutritional and sensory characteristics. Further, it has also shown potential for maintaining good health due to its appreciable nutritional and antioxidant properties.

Keywords: *Aloe vera* (L.) Burm.f., *Aloe barbadensis* Mill., Antioxidant activity, Functional beverages, Sensory qualities.

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Introduction

Aloe vera (L.) Burm.f. syn. *A. barbadensis* Mill. is one of the oldest known medicinal plants gifted by nature and is often called *miracle plant* or *natural healer*. It belongs to Liliaceae family which includes about 250 species; however only two species, viz. *A. barbadensis* Mill. and *A. arborescens* Mill. are considered as the most important ones[1,2]. The innermost part of the *A. vera* leaf is a clear, soft, moist and slippery tissue that consists of large thin walled parenchyma cells which contains vital ingredients, viz. polysaccharides, vitamins, minerals, amino acid, saponins, anthraquinones, etc[3,4]. Most of the health benefits associated with this plant have been attributed to the polysaccharides contained in the mucilageous gel of leaves[1]. The gel possess a number of biological and therapeutic activities, viz. wound healing, antifungal, antiseptic, hypoglycemic, anti-inflammatory immunomodulatory and gastro-protective properties[5-10].

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A. vera has been used in various food, confectionery and cosmetic products including flavored milk, icecream, chewing gum, face cream, hair cream, lotion, soap, shampoo, as flavoring agent, etc[6,9,11]. Presently, the interest and use of *A. vera* as a valuable ingredient for health food and pharmaceutical industry has increased dramatically due to its biological activities and functional properties[2,12,13]. Food which has physiological benefits beyond basic nutrition, also known as *functional food* is being preferred now-a-days to reduce the risk of chronic diseases[14]. Various authors have suggested the use of *A. vera* juice in food commodities such as beverages, jams, candies, wines and dairy products[2,8,15-18]. The antimicrobial activity of the juice against different Gram +ve and Gram –ve bacteria as well as molds has been established in various *in vitro* studies[19,20]. However, negligible scientific information is available on nutritional as well as antioxidant potential of such food products. Therefore, the present investigation was undertaken to develop *A. vera* based functional beverages and to evaluate their nutritional, antimicrobial activity, antioxidant potential as well as sensory qualities to ascertain their health benefits.

Materials and Methods

Raw material

Fully matured leaves were procured from Botanical garden, Department of Forest Products, Dr Y.S. Parmar UHF, Nauni, Solan. Sugar and other additives were purchased from the local market.

Extraction and preservation of *A. vera* juice

Freshly harvested leaves were washed thoroughly with water containing KMS @500 ppm and gel was extracted using cold extraction method[1]. For extraction of juice, gel was passed through grinder, homogenized and treated with pectinase enzyme (0.5 %) at 40-50 ºC for 30 min followed by filtration and pH adjustment (3.5) by adding citric acid. Further, it was pasteurized and stored for preparation of different value added products. The unit operations for extraction and preservation of *A. vera* juice for its further value addition is illustrated in Fig. 1.

Preparation of different *A. vera* beverages

Different beverages, viz. sweetened juice, squash and ready-to-serve drink were prepared as per standard method and specifications of FSSA-2006. Different combinations of *A. vera* juice and total soluble solids (TSS) were tried for optimization of a suitable combination for the preparation of palatable beverages as detailed in Table 1. Best combinations/treatments of different beverages were selected on the basis of sensory evaluation and evaluated for their nutritional, functional and organoleptic qualities.

Physico-chemical analysis

Fresh leaves, juice and *A. vera* based beverages were analyzed for different physico-chemical characteristics as per the standard methods. Random samples of 15 leaves were selected for physical parameters. While TSS, pH, titratable acidity, total sugars, reducing sugars, ascorbic acids and total phenols were measured according to standard procedures[21,22]. The microbial load was recorded using standard plate count method[23].

Sensory analysis

Sensory evaluation of the products was conducted by a panel of 15 semi-trained judges using 9-point hedonic scale system for different parameters like appearance, body, flavor, taste and overall acceptability[24].

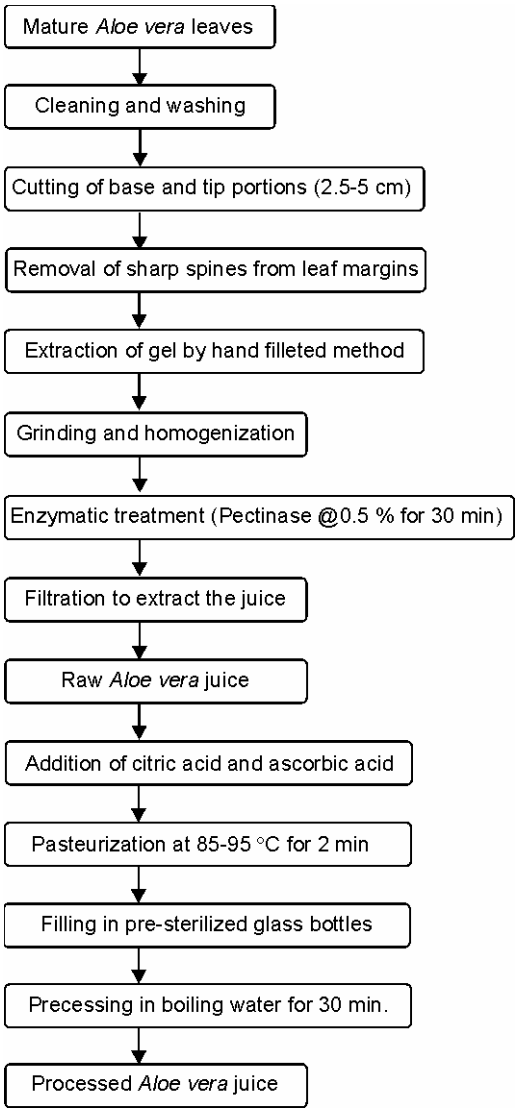

Fig. 1—Flow diagram for extraction and processing of *Aloe vera* juice

Table 1—Optimization of best combination of juice and TSS for preparation of different *Aloe vera* based beverages

Products	Juice (%)	TSS (°B)
Sweetened juice	85 and 90	10, 12 and 15
Squash	25 and 30	40, 45 and 50
RTS drink	10 and 15	10, 12 and 15

Antimicrobial activity

The antimicrobial activity against *E. coli* (procured from IGMC, Shimla, India) was measured by well diffusion method[25]. The inoculum was spread uniformly with the help of swab on the plate and a standard cork borer of 7 mm diam. was used to cut uniform wells on the surface of solid medium.

In each well 100 µL of sample was loaded and the plates were then incubated at 37 ºC for 24 h. The antimicrobial activity was expressed in terms of mean diameter of the zones of inhibition measured.

Antioxidant activity

Antioxidant activity (Free radical scavenging activity) was measured as per the method of Brand - Williams *et al*[26] where 2, 2 diphenyl-1-picrylhydrazyl (DPPH) was used as a source of free radical. A quantity of 3.9 mL of $6x10^{-5}$ mol/L DPPH in methanol was put into cuvette with 0.1 mL of sample extract and decrease in absorbance was measured at 515 nm for 30 min or until the absorbance becomes steady. Methanol was used as blank. The percent antioxidant activity was calculated using the following equation:

$$\text{Antioxidant activity (\%)} = \frac{Ab_{(B)}\, Ab_{(S)}}{Ab_{(B)}} \times 100$$

Where $Ab_{(B)}$ = Absorbance of blank;
$Ab_{(S)}$ = Absorbance of sample

Statistical analysis

All the analytical parameters were recorded in triplicates and the mean values of each parameter were described. The data of quantitative estimation of physico-chemical and nutritional characteristics were assessed by factorial CRD whereas the data pertaining to sensory evaluation were analyzed by RBD as described by Cochran and Cox[27].

Results and Discussion

Optimization of suitable juice and TSS combination for preparation of different *A. vera* based beverages

For optimization of a suitable combination of juice percentage and TSS, sensory evaluation tool was employed. The data pertaining to sensory evaluation revealed non-significant differences in appearance score among all the treatments of different categories of the beverages, whereas significant differences were observed in taste and overall acceptability scores (Table 2). It was observed that the taste score decreased as the concentration of *A. vera* juice increased in all the products. It might be due to characteristic bitter taste of *A. vera*. Similar finding has also been reported by Sharma and Tandon[28] while working on bitter gourd functional squash. Further, out of various combinations tried, a level of 85 % juice and 12 ºB TSS (SJ_2), 25 % juice and 45 ºB TSS (S_2) and 15 % juice and 15 ºB TSS (R_6) were adjudged to be the best for the preparation of *A. vera* based sweetened juice, squash and RTS drink, respectively due to their significantly higher taste as well as overall sensory acceptability scores.

Physico-chemical, nutritional and sensory characteristics of different *A. vera* based beverages

The beverages of best treatment i.e. SJ_2 (Sweetened juice), S_2 (Squash) and R_6 (RTS) were evaluated for various physico-chemical and sensory qualities and were also compared with each other as well as pure *A. vera* juice. The maximum TSS (45.0 ºB) was found in squash while minimum was recorded in pure *A. vera* juice (2.52 ºB). The pure juice contained negligible amount of reducing sugars (0.95 %) indicating its carbohydrate free nature hence suitable for diabetic patients. The juice has also proved to be a good source of ascorbic acid (234.85 mg/100 g), whereas in different *A. vera* beverages, it ranged from 43.75 to 109.65 mg/100 g (Table 3). Similar findings have also been reported by other authors[12,18]. Total phenolic contents among different *A. vera* products were recorded between 8.20 to 62.65 mg/100 mL.

Table 2—Sensory characteristics of different *Aloe vera* based beverages

Treatment	Fruit part (%)	TSS (ºB)	Sensory characteristics		
			Appearance	Taste	Overall acceptability
Sweetened juice					
SJ_1	85	10	7.00	8.00	7.50
SJ_2	85	12	7.00	8.25	8.00
SJ_3	85	15	7.10	7.00	6.75
SJ_4	90	10	7.30	7.50	7.25
SJ_5	90	12	7.30	6.50	7.00
SJ_6	90	15	7.20	6.50	6.25
$CD_{0.05}$			NS	0.20	0.16
Squash					
S_1	25	40	6.50	6.00	6.25
S_2	25	45	7.00	8.00	8.00
S_3	25	50	7.00	7.00	7.00
S_4	30	40	7.50	8.00	7.50
S_5	30	45	7.50	7.00	7.00
S_6	30	50	7.25	6.95	6.80
$CD_{0.05}$			NS	0.12	0.10
RTS					
R_1	10	10	6.50	7.00	6.85
R_2	10	12	6.50	7.20	6.95
R_3	10	15	7.00	7.50	7.05
R_4	15	10	6.80	7.00	7.00
R_5	15	12	7.50	8.00	7.75
R_6	15	15	7.60	8.00	8.00
$CD_{0.05}$			NS	0.22	0.20

Table 3—Comparison of physico-chemical and nutritional characteristics of *Aloe vera* based beverages

Characteristics	Pure juice	Sweetened juice (Fruit part= 85 %; TSS= 12 °B)	Squash (Fruit part= 25 %; TSS= 45 °B)	RTS Drink (Fruit part= 15 %; TSS= 15 °B)
		Mean* ± SD		
Total soluble solids (°B)	2.52± 0.03	12.0± 0.04	45.0± 0.05	15.0 ± 0.04
Titratable acidity (% CA)	0.56± 0.02	0.50± 0.02	1.60± 0.03	0.50± 0.02
pH	2.70± 0.02	3.02± 0.02	2.53± 0.02	2.75± 0.02
Reducing sugars (%)	0.95± 0.08	2.08± 0.12	27.0± 0.15	4.06± 0.10
Total sugars (%)	1.56± 0.15	8.78± 0.20	36.85± 0.25	13.15± 0.20
Ascorbic acid (mg/100 g)	234.85± 0.30	109.65± 0.50	88.25± 0.65	43.75± 0.48
Total phenols (mg/100 mL)	62.65± 0.05	58.13±0.06	12.75±0.08	8.20±0.05

*Values expressed are mean of three replicates; SD- Standard deviation

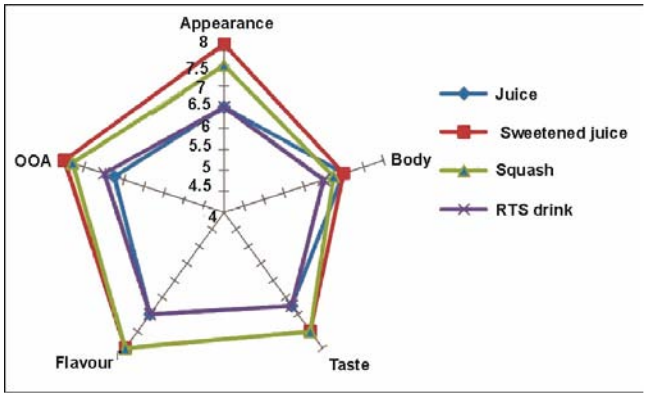

Fig. 2—Comparison of sensory characteristics of different *Aloe vera* based beverages

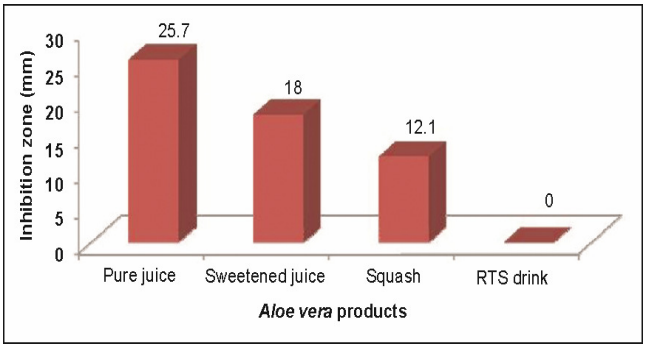

Fig. 3—Antimicrobial activity of different *Aloe vera* based beverages

The pH of *A. vera* based products corroborated with their titrable acidity. When tested for microbial enumeration, the pure and sweetened juice showed negligible amount of microbial load while squash and RTS had shown 1.0 and 2.1 log CFU/mL, respectively. Perusal of data pertaining to sensory evaluation (Fig. 2) revealed that the maximum mean value for appearance (8.0) was shown by squash, whereas minimum value (6.0) was recorded in juice. Overall acceptability of the developed products indicated highest acceptability (8.0) for sweetened juice followed by squash (7.80), while the lowest in case of juice (6.75). Comparatively low sensory scores recorded in pure *A. vera* juice might be due to its bitter taste which was not liked by the panelists. Due to bitter after taste of *A. vera* juice, other authors have suggested blending of *A. vera* juice with other fruits like aonla, ginger, papaya etc. for product development[12,16,18].

Antimicrobial activity and antioxidant characteristics of different *A. vera* based beverages

The comparison of antimicrobial activity shown by different *A. vera* based beverages against human pathogen (*E. coli*) is given in Fig. 3. Maximum zone of inhibition was shown by pure juice (25.7 mm), minimum was shown by squash (12.10 mm) while RTS drink failed to show any zone of inhibition. Prashar *et al*[20] recorded 5.00 mm zone of inhibition in ethanolic extract of *A. vera* leaf against *E. coli,* whereas DMSO gel extract of *A. vera* exhibited 13 mm zone of inhibition for *E. coli*[10]. In another study, Karunyadevi *et al*[7] recorded 20 mm zone of inhibition in *A. vera* juice against *E. coli.* Further, the maximum antioxidant activity was shown by pure *A. vera* juice (71.81) while minimum (7.90) was shown by RTS drink (Fig 4). Apparently, both the activities were directly related to the amount of juice used in the product development.

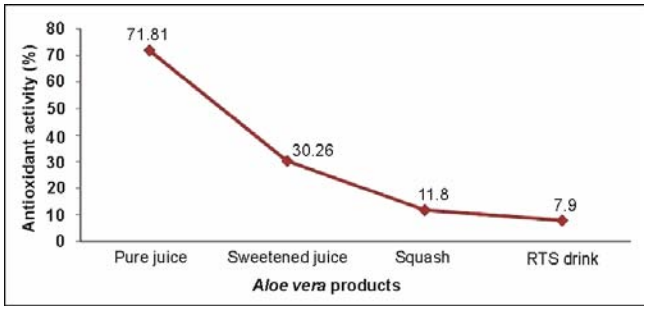

Fig. 4—Antioxidant activity of different *Aloe vera* based beverages

Conclusion

It is concluded that *A. vera* sweetened juice and squash received a sensory score corresponded to "*liked very much'* on 9-point hedonic scale by the panelists and hence were regarded as the best products. Further, based on nutritional, antimicrobial and antioxidant characteristics, *A. vera* based beverages have shown potential to serve as a health/functional product and hence their availability in the market will definitely benefit the health conscious people.

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