International Journal of Bio-resource and Stress Management

https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM June 2025, 16(6): 01-09

Article AR6129

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2025.6129

Development and Evaluation of *Aloe vera* Enriched Flavored Whey Beverage

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0009-0004-5858-4675

ABSTRACT

The present study was conducted from July, 2024 to Dec, 2024, at the College of Dairy Science and Food Technology, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Raipur, Chhattisgarh, India. Coupling whey and herbs would yield a refreshing nutrient rich drink with improved therapeutic properties. In the present investigation, paneer whey has been used as a base material to prepare flavoured whey beverage by incorporating *Aloe vera* juice and to evaluate their physical, chemical and sensory properties. Different concentrations 0, 5, 10, 15 and 20% of *Aloe vera* juice were optimized to prepare whey beverage. The effect of *Aloe vera* juice incorporation on sensory and physico-chemical characteristics of control and fortified whey samples were studied. The treatment samples were observed significant different and comparable to control samples on "9 point Hedonic sensory evaluation score card. The physico-chemical analysis of stored beverage samples i.e. viscosity, TCH, ash decreased and acidity increased. During the storage period the sensory scores beverage samples i.e. colour and appearance (C&A) score, flavour score, taste score, consistency score and Overall acceptability (OA) score decreased from 7.40 to 7.15, 7.42 to 6.10, 7.35 to 6.10, 7.37 to 6.30 and 7.27 to 6.25 on 9 point hedonic scale respectively.The performance of 10% and 15% *Aloe vera* juice incorporated whey based beverages was better than control in terms of sensory quality during the storage temperatures. However the shelf life of juice was established within 15 days.

KEYWORDS: Aloe vera juice, whey beverage, sensory, physico-chemical quality

***Citation* (VANCOUVER):** Kumar et al., Development and Evaluation of *Aloe vera* Enriched Flavored Whey Beverage. *International Journal of Bio-resource and Stress Management,* 2025; 16(6), 01-09. HTTPS://DOI.ORG/10.23910/1.2025.6129.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 14th February 2025 RECEIVED in revised form on 04th June 2025 ACCEPTED in final form on 15th June 2025 PUBLISHED on 24th June 2025

1. INTRODUCTION

The beverages provide hydration to the body and nourish our body with essential nutrients such as carbohydrates, protein, fat, vitamins and minerals (Kanchana et al., 2021). Due to the continuous growth of the dairy industry, large quantities of by-products are produced, mainly whey (Zandona et al., 2021). Whey is a rich source of nutritious components and has proven its effects in the treatment of various chronic diseases such as cancer, cardiovascular disease, HIV, etc .It can also be used in baby, geriatric and athletic foods because it is too nutritionally dense (Sharma et al., 2021). Around 80% of whey comes from Channa and Paneer, out of which only 2–3% is utilised and rest is drained. Whey contains contains about 50% of the milk constituents. The greenish translucent liquid whey retains about 45-55% of the milk nutrients comprising serum proteins, lactose, minerals and vitamins (Rashmi and Varghese, 2022). Furthermore, whey is widely recognized as a valuable source of highly nutritious and biologically active proteins, along with other organic compounds. Notably, whey protein accounts for approximately 20% of the total protein content in bovine milk. Due to these unique characteristics, whey protein products are increasingly sought after as food additives (Svanborg et al., 2015). Whey contains a diverse range of components, some with high nutritional value and biological activity, which has intensified interest in its utilization (Miloradovic et al., 2025). In past few years there are various whey based fruit,vegetable and herbal beverages which are developed successfully and also found to have the necessary acceptability (Joshi et al., 2020). Whey is a yellow-green liquid, coloured by riboflavin (vitamin B2) remaining after the removal of caseins and fat from milk, containing lactose, soluble salts, and globular proteins (Rejdlová et al., 2025).

Aloe vera is one of the oldest known medicinal plants gifted by nature and is often called "miracle"plant. *Aloe vera* gel is a clear thin gelatinous material that comes from inside the *Aloe vera* leave. *Aloe vera* juice consists of about 99 to 99.5% water (Raj and Singh, 2022). *Aloe vera* contains over 200 biologically active substances, such as anthraquinones (barbaloin, isobarbaloin, anthranols, aloetic acid), hydrosoluble and liposoluble vitamins, minerals, enzymes, polysaccharides, phenolic compounds, and organic acids (Kaur and Bains, 2023). In traditional medicine, a pale gel-like component of the grey-green leaves of *Aloe vera* is used to treat a wide range of ailments, including migraines, indigestion, and skin burns (Ghaffari et al., 2023). *Aloe vera* works as antiseptic, antibacterial, antiviral, anti-diabetic, anti-carcinogenic, anti-inflammatory and natural healer, improves human immune and digestive system (Asif et al., 2023). Sharma et al. (2021) prepared *Aloe vera* and coconut water based whey beverages from camel and goat milk. Similar research in the scientific field shows that *Aloe vera* has a clear inhibitory ability against the bacteria Mycobacterium smegmatis, Micrococcus luteus, Enterococcus faecalis, Bacillus sphaericus, and Klebsiella pneumonia (Arshad et al., 2022). In cosmetics, it is used for the preparation of creams, lotions, soaps, and shampoos, while in the food industry, it is used for the preparation of health drinks (Catalano et al., 2024). These trends are also creating new market growth opportunities for *Aloe vera* gel-based beverages. These trends are also creating new market growth opportunities for *Aloe vera* gel-based beverages (Maji et al., 2023). The present study was carried out to develop flavoured whey based beverage by incorporating *Aloe vera* juice and evaluate physico-chemical and sensory qualities of developed beverage.

2. MATERIALS AND METHODS

2.1. Dairy and non-dairy ingredients

The present study was conducted from July, 2024 to Dec, 2024, at the College of Dairy Science and Food Technology, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Raipur, Chhattisgarh, India.Fresh Buffalo milk was procured from Dairy farm at Serikhedi, National Highway -6, Raipur, (C.G). Fresh *Aloe vera* leaves were procured from Centre of Excellence on Medicinal & Aromatic plants and NTFP's of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G). Good quality cane sugar, orange flavour, orange colour and black salt were purchased from the local market of Raipur.

The samples were analyzed for various physicochemical parameters. The pH of beverage samples was determined by using "Digital pH analyzer" as per the procedure. Specific gravity was determined by finding out the weights of a certain volume of sample and of the same volume of distilled water at the same temperature taken in a specific Gravity bottle.The viscosity of the whey, *Aloe vera* and beverage sample was determined by Ostwald viscometer. The fat content of whey, *Aloe vera* juice and beverage sample was estimated by Gerber method. Titratable acidity was titrated against the standard 0.1 N NaOH solution using phenolphthalein as an indicator and the acidity was calculated by using following formula and expressed in terms of per cent lactic acid. Total solids measured by Gravimetric method, protein contents estimated as per the procedure using the Pelican Kel plus nitrogen estimation system. AOAC, (2010) procedure was adopted for estimating the ash content and was calculated using follows:

$$\%\text{ of ash} = \frac{\text{Weight of crucible dish after ashing} - \text{Weight of empty crucible dish}}{\text{Weight of the sample}} \times 100$$

2.2. *Preparation of aloe vera juice*

First, the fresh *Aloe vera* leaves were washed and then peeled. After that, its gel was completely homogenized by a mixer. The gel was pasteurized with a water bath at temperature of 70°C for 30 minutes. (Figure 1 and 2) (Manjili et al., 2024).

Paneer was prepared by standardizing buffalo milk to 6.0% fat and 9.0% SNF using the procedure (Kumar et al., 2014). The whey (Figure 3) obtained during paneer process was used for preparation of control whey beverage (T_0) and *Aloe vera* based whey beverage (Figure 4).

The treatment combinations used for preparation of Whey based *Aloe vera* beverage as depicted in Table 1. The *Aloe vera* juice (AVJ) was incorporated at different levels (0%, 5%, 10%, 15%, 20%), sugar incorporated at constant level @ 10% (based on preliminary trials, the amount of *Aloe vera* juice incorporation was restricted to a maximum of 20% for final study).

Figure 1: Preparation of *Aloe vera* enriched flavored whey beverage

Figure 2: Aloe vera leaves, Aloe vera gel and Aloe vera juice

Fresh filtered Paneer whey

↓

Addition of sugar (10%)

↓

Heating (45^{0}C)

↓

Addition of *Aloe vera* juice @5, 10, 15 and 20%

↓

Addition of orange flavour and orange colour @0.1% and black salt (0.5%)

↓

Mixing

↓

Filter through muslin cloth

↓

Packaged in bottles

↓

Heat treatment (85^{0}C/2 min)

↓

Cooled& refrigerated at 7±1^{0}C

Figure 4: Control and Treatments of Aloe vera enriched flavored whey beverage

The treatment combinations used for preparation of Whey based *Aloe vera* beverage as detailed below:

T_0=89.3% whey+0% AVJ+10% sugar+0.5% Black salt+0.1% Colour+0.1% Flavour; T_1=84.3% whey+5% AVJ+10% sugar+0.5% Black salt+0.1% Colour+0.1% Flavour; T_2=79.3% whey+10% AVJ+10% sugar+0.5% Black salt+0.1% Colour+0.1% Flavour; T_3=74.3% whey+15% AVJ+10% sugar+0.5% Black salt+0.1% Colour+0.1% Flavour; T_4=69.3% whey+20% AVJ+10% sugar+0.5%Black salt+0.1% Colour+0.1% Flavour

3. RESULTS AND DISCUSSION

Table 1 : Effect of *Aloe vera* juice incorporation on physico-chemical quality during storage at refrigeration temperature (7±1°C)

Treat ments	Specific Gravity	Viscosity (cp)	Fat (%)	Protein (%)	Ash (%)	Total solids (%)	Total carbohydrates	Acidity (% LA)	pH
	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)
T_0	1.035^A	2.74^A	0.11	0.41	0.58^A	15.52^A	14.36^A	0.25^A	4.97^A
T_1	1.035^A	3.04^B	0.10	0.40	0.52^B	15.20^B	14.13^{AB}	0.27^B	4.87^B
T_2	1.033^B	3.26^C	0..09	0.37	0.52^B	14.94^C	13.85^{BC}	0.28^C	4.83^C
T_3	1.029^C	3.51^D	0.08	0.36	0.50^{CB}	14.74^D	13.62^{CD}	0.30^D	4.72^D
T_4	1.024^D	4.03^E	0.08	0.35	0.48^C	14.44^E	13.39^D	0.33^E	4.65^E

T: Treatment

3.1. Effect of Aloe vera juice incorporation on quality of whey beverage during storage

The sensory characteristic of whey beverage prepared with incorporation of *Aloe vera* is presented in Table 2. The sensory attributes for different treatment samples were evaluated following the 9-point hedonic scale rating. On this scale, 'like extremely' was given the highest score of '9' and 'dislike extremely' is given the lowest score of '1'. A judgment panel of 25 participants comprised of postgraduate students and faculty of 20–60 age group people those who are expertise in judging and grading of food & dairy products of the College of dairy and food technology raipur.

The effect of *Aloe vera* juice incorporation on quality of beverage during storage at refrigeration temperature (7±10C) was studied. The quality analysis was carried out at 0th, 3rd, 6th, 9th, 12th and 15th for refrigeration temperature. In refrigeration storage study acidity and pH were analyzed at regular interval while, specific gravity, viscosity, fat, protein, TS, TCH and ash content were estimated in the beginning and end of the storage.

3.2. Effect of Aloe vera juice incorporation on physico-chemical quality during storage at refrigeration temperature (7±1°C)

Table 2 : Effect of *Aloe vera* juice incorporation on sensory quality during storage period (7±1°C)

	Colour and appearance score*	Flavour*	Taste	Consis- tency	Overall accept ability*
	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)	Mean of (T)
T_0	7.40^A	6.71^A	6.73^A	6.76^A	6.78^A
T_1	7.32^B	6.79^B	6.79^{AB}	6.84^B	6.86^B
T_2	7.28^C	6.84^C	6.83^B	6.92^C	6.87^C
T_3	7.36^D	6.92^D	6.84^B	6.99^D	6.92^C
T_4	7.15^E	6.61^E	6.76^A	7.05^E	6.81^D

T: Treatment

3.2.1. Viscosity

The mean viscosity decreased significantly (p<0.05) from 3.41cp on 0th day to 3.21cp on 15th day during storage. The decrease in viscosity during storage might be ascribed to enzymatic degradation of polysaccharides leading to decrease in viscosity as time passes.

3.2.2. Specific gravity

The mean specific gravity decreased from 1.035 (T_1) to 1.024 (T_4) significantly at every AVJ incorporation. The specific gravity is decreased at every level of AVJ incorporation owing to the fact that originally the AVJ had lower TS (1.0) and specific gravity (1.003). During storage period the mean specific gravity value was not affected, as indicated by the non-significant difference.

3.2.3. TCH

During storage period the TCH content decreased significantly (p<0.05) from 13.94 on 0th day to 13.81% on 15th day, it might be attributed to accerlated hydrolysis of insoluble polysaccharides and other carbohydrate polymers including like pectin, cellulose, starch etc. The mailard reaction and other chemical reactions of sugars with acids during storage also lead to a decrease in total sugar content. Ahmed et al., 2023 reported that TCH levels decreased significantly (p<0.05) during 25 days of storage of Novel Whey-Mango Based Mixed Beverage. In beverage processing, carbohydrates might be converted to alcohol, organic acids, and/or carbon dioxide by microorganisms such as bacteria, yeast, etc. Reducing sugars such as glucose and fructose are released during the hydrolysis of saccharides such as sucrose, which might also be a contributing factor for the decrement of carbohydrate contents in the prepared beverages during the storage period

Sakhale et al. (2012) prepared whey based RTS beverage from mango and observed that a reducing trend was observed in total sugar from 11.09 to 11.05% during 30 days of storage at refrigeration temperature.

3.2.4. Fat and protein

The mean fat and protein content varied from 0.08 (T_4) to 0.11per cent (T_0) and from 0.35 (T_4) to 0.41% (T_0) respectively. The incorporation of AVJ did not influence the mean fat and protein content of whey beverage and also during storage period as indicated by non significant difference existed to this parameter.

3.2.5. Ash

Aloe vera juice incorporation did influence the mean ash content of the whey beverage. Control had the highest ash content of 0.58%, while the lowest ash content was observed in T_4 (0.48%). Among *Aloe vera* incorporated whey beverage samples T_1 and T_2 had the highest ash content of 0.52%. The significant effect was noticed when the AVJ incorporation increased at and above 15% level. Decrease in ash contents in experimental samples as compared to control might be due to that the higher replacement of whey with *Aloe vera* juice might have reduced the ash content in their experimental samples.

3.2.6. Total solids content

The AVJ had significant effect on mean Total solid content of beverage sample, as the level of AVJ incorporation increased there was a progress decrease in TS which was significant (p<0.05) at every level. The control had 15.52 per cent TS on the 0th day and increased to 15.54% at the end of 15th day. While, in case of the experimental sample the TS content ranged from 14.41% (T_4) to 15.20 per cent (T_1), while at the end of 15th day storage it was observed to be 14.49% (T_4) to 15.21% (T_1) during storage. The lower TS values in experimented samples might be attributed to lower TS content in the AVJ. Though there was a slight increase in the mean TS content during storage (i.e. 14.94% 0th day to14.96% on 15th day) and this increase was found to be statistically non-significant. The interaction effect between treatment and storage period was found to be non-significant. However, Carbonated Flavored whey drink was prepared (CFWD) by Aysha Sameen et al. (2013) and reported that total solids content of the drink mean total solids content was 10.53% when fresh (0 day) which decreased to 9.15% at 30th day at refrigeration condition.

3.2.7. Acidity

Acidity increased significantly from 0.26% LA on 0th day to 0.33% LA on 15th day, The increase in acidity over a storage period was recorded in all the treatments. The increase in the acidity during storage might be due to growth of microbes and subsequent degradation of sugars leading to formation of acids. The increase might also have been attributed to polyphenols present in *Aloe vera* juice and their degradation. Similar results reported by Alves et al., 2020. Similar results found in whey-based peach beverage The main reason behind this increase in acidity was the development of different organic acids whilestoring the beverage. These acids include carboxylic acid, lactic acid, pectinic acid, citric acid and aceticacid, which are responsible for the increase in titratable acidity.

3.2.8. pH

pH decreased from 4.92 on 0th day to 4.72 on 15th day, The mean pH during storage on 0th day (fresh sample) was recorded as 4.92 and gradually decreased and reached to 4.72 at the end of the 15th day. The decrease was significant at every storage intervals. This fact is in accordance with the results obtained for acidities of different beverage samples as it leads to correspondingly decrease in pH. This might be due to the production of organic acids and amino acids due to the action of ascorbic acids on sugar of the beverages. Lactose & proteins are also converted into lactic acid and amino acids respectively leading to increase in acidity and decrease in pH of beverages. Ahmed et al. (2023) reported that pH values of formulated whey-mango-based mixed beverages were recorded as sample-1 (4.27±0.07–3.99±0.08), sample-2 (4.4 ± 0.02–4.21 ± 0.04), and sample-3 (4.58±0.09–4.28±0.03), respectively. There was a significant (p<0.05) decrease in the pH value of the formulations during storage due to a rise in titratable acidity, which is

Table 3: Cost analysis of *Aloe vera* enriched flavored whey beverage

Ingredients	Quantity required (g) for 1000 g of beverage					Rate in ₹ kg^{-1}	Cost in ₹				
	T_0	T_1	T_2	T_3	T_4		T_0	T_1	T_2	T_3	T_4
Paneer whey	893.0	843.0	793.0	749.0	693.0	2.0	1.79	1.69	1.59	1.49	1.39
Aloe vera Juice+% @ 0, 5, 10, 15,20	0	50.0	100.0	150.0	200.0	25.0	0.0	1.25	2.50	3.75	5.0
Sugar @ 10%	100.0	100.0	100.0	100.0	100.0	40.0	4.0	4.0	4.0	4.0	4.0
Black salt @ 0.5%	5.0	5.0	5.0	5.0	5.0	30.0	0.15	0.15	0.15	0.15	0.15
Color @ 0.1%	1.0	1.0	1.0	1.0	1.0	400.0	0.40	0.40	0.40	0.40	0.40
Flavour @ 0.1%	1.0	1.0	1.0	1.0	1.0	400.0	0.40	0.40	0.40	0.40	0.40
Total weight (g)	1000.0	1000.0	1000.0	1000.0	1000.0	Cost ₹ l^{-1}	6.74	7.89	9.04	10.19	11.34

inversely proportional to the pH. The whey-based peach drink contained 3.75–3.6 pH, 4 and 6% sucrose. While the apple-containing whey drink had 3.95–3.8 pH with 4% and 6% levels of sucrose, respectively during storage as reported by Zaman et al., 2023.

In contrast, traits namely transpiration rate (0.68%) and days to maturity (0.87%) exhibited low CV values, suggesting that they were more genetically stable. However, despite their lower variability, these traits remain critical for assessing the stress resilience of barley genotypes, especially under heat stress conditions. The low-to-moderate variability observed in most traits signaled that selection based on these traits would be fairly effective under heat stress in isolating superior barley genotypes with high productivity and stress tolerance (Bhagat et al., 2024).

3.2. Principal component analysis (PCA)

To delve deeper into the genetic structure of the barley genotypes and reduce the dimensionality of the data, we performed principal component analysis (PCA) and identified the main sources of variation. The PCA results summarized in Table 3 revealed that the first eight principal components (PCs) accounted for 71.5% of the total variation, underscoring the significance of these components in explaining the variability in the barley genotypes.

The loading of individual traits on the principal components as presented in Table 4 provides additional insight into the relationships between the traits and their contribution to the overall genetic variability. PCA rotates the principal axes in a way that groups similar traits together, facilitating the identification of trait clusters that can be used for selection in breeding programs.

The first principal component (PC1) which explained 19.5% of the total variation, was strongly associated with grain yield plant^{-1}, biological yield, SPAD, 1000-grain weight, NDVI 1, number of tillers plant^{1}, total soluble sugars and photosynthetic rate. These traits were critical components of productivity, and the strong loading of PC1 on these traits indicated that this component represented overall productivity potential. This is consistent with the findings of Kumar et al. (2021), identified high loading of grain yield and 1000-grain weight *etc*. on key principal components of yield in barley. The high contribution of PC1 to the total variability further emphasized the importance of yield-related traits in barley improvement programs.

This association suggested that the studied morphological, physiological and biochemical traits were genetically linked and contributed synergistically to the overall yield potential of the barley genotype. This supported the hypothesis that selection for increased 1000-grain weight, which is known to have a strong positive correlation with grain yield (Yadav et al., 2022), can lead to improved productivity in barley.

The second principal component (PC2) explained 13.1% of the variation and was closely associated with number of grains spike^{-1}. Similarly, stomatal conductance on third; relative water content on fourth component; peduncle length, spike length, harvest index and transpiration rate on PC5 had high loading values. Principal component (PC6) loaded with the malondialdehyde (MDA) while days to maturity and canopy temperature depression were highly loaded on PC7 which accounts for the 5.6% of the total variability. The last major component (PC8) explained the 4.8% of the variation and loaded with the days to heading, plant height, NDVI 2 and proline content. This component reflected the genotype's ability to tolerate heat stresses.

The association of principal components with stress-adaptive traits such as SPAD, proline and Malondialdehyde aligned with research of Zeng et al. (2018), who found that proline content and SPAD value is a key indicator of abiotic stress tolerance in barley, as proline accumulation helped the plant to maintain cellular function under stressed conditions.

The proportion of variance explained by the first few PCs supported the use of PCA for understanding the complex genetic structure of barley, where major sources of variation were captured by a small number of components (eight components). This finding aligned with the study of Yadav et al. (2021), who found that the first five principal components explained more than 90% of the total variation in barley genotypes. Similarly, Sreesaeng et al. (2024) were also found that four key components contributed 72.5% variation in the data. Enyew et al. (2019) study revealed that 49.96% of the total variations was alone contributed by the principal component one (PC1) whereas Jha et al. (2015) also recognized the 60.8% contribution by first three PCs in total variability existed in the genotypes under high temperature stress, emphasizing the effectiveness of PCA in identifying key traits for selection.

3.3. Factor scores and genotype classification

The factor scores, derived from the Anderson-Rubin method, provided a means of classifying the genotypes based on their performance across the principal factors. The distribution of genotypes along the first two principal components (PC1 and PC2), as shown in Fig.1, revealed clear differentiation between high yielding genotypes and those with stress tolerant characteristics.

For instance, genotypes such as BH 1039, BH 1027, EIBGN 48 (21-22) and BH 946 which scored high in PC1, exhibited superior productivity with traits such as grain yield plant^{-1}, 1000-grain weight and total soluble sugars *etc*. These genotypes were promising candidates for breeding programs focused on improving barley yield under favorable conditions. Genotypes like NBGSN-1 (21-22) and EIBGN-34 (21-22) which loaded with high scores in

PC2, exhibited strong resilience to heat stress.

Genotypes such as BH 19-44, BH 1029, BH 1039 and EIBGN-31 (21-22) exhibited strong correlations with PC1, indicated that they were promising candidates for selection based on high yield. Meanwhile, genotypes such as BH 21-36 and EIBGN-6, associated with PC2, are well-suited for breeding programs targeting heat stress resilience.

3.4. Correlation between principal components and traits

The correlation analysis presented in Table 5 and Figure 2 highlighted the relationships between principal components and specific traits, providing further insights into the biological processes underlying barley productivity and stress adaptation. PC1 and PC2, which were strongly associated with productivity and stress tolerance traits, respectively, served as key indicators for breeding selection.

For example, the positive correlation of proline content and number of grains spike^{-1} with PC2 suggests that these traits play a synergistic role in osmotic adjustment and thermotolerance, crucial for maintaining cellular integrity under stress conditions. The negative correlation between MDA (malondialdehyde), a marker of oxidative stress, and yield-related traits such as grain yield plant^{-1} indicated that oxidative stress negatively impacted the productivity, emphasizing the need for breeding genotypes with reduced oxidative damage under stress conditions (Kumar et al., 2024c).

The associations between remaining major PCs (PC3 to PC8) with biochemical traits and physiological water retention traits such as relative water content, stomatal conductance and transpiration rate, further highlighted the role of water-use efficiency in heat stress adaptation. These traits were crucial for barley's survival in regions experiencing terminal heat stress, as efficient water use and timing of growth stages significantly impacted the overall yield of the barley.

The findings of this study emphasized the importance of integrating both productivity traits and physio-biochemical traits into barley breeding programs, especially in light of climate change and the increasing frequency of heat stress. The integration of PCA into barley breeding strategies can accelerate the development of varieties that were not only high-yielding but also resilient to the stresses that had been becoming more prevalent in global agricultural systems.

3.3. Effect of Aloe vera juice incorporation on sensory quality during storage period (7±1°C)

3.3.1. Colour and appearance(C&A)

The mean colour and appearance(C&A) score during storage on 0th day (fresh sample) was recorded as 7.41 and gradually decreased and reached to 7.15 at the end of the 15th day. The decrease in the colour and appearance mean score during storage period might be attributed to fading away of colour and appearance as adjudged by the sensory panel. Nedanovska et al. (2022) prepared ovine whey based beverage and reported that beverage samples showed significant (p<0.05) decrease in sensory values during storage period on last 15th day due to colour as a sensory characteristic became less desirable. This could be linked to various physicochemical changes leading to a shift in particle size distribution, decreased sediment and enhanced brightness of the beverages, all of which lead to less appealing colour.

3.3.2. Flavour

The mean flavour score during storage gradually decreased from 7.42 (0th day) to 6.10 (15th day). Due to increase in acidity, increase multiplication of micro-organisms, and other bio-chemical changes, loss of volatile aromatic substances that would have reduced the flavour mean score during storage). Sasikumar and Deka (2015) developed Low calorie therapeutic *Aloe vera* RTS beverage and concluded that flavour score decreased from 8.50 to 7.50 at refrigerated temperature for 60 days.

3.3.3. Taste

The mean taste score during storage gradually decreased from 7.35 (0th day) to 6.10 (15th day). Reason for the decrease in taste score might be attributed to the development of slight bitterness and acidity in the sample during storage. The control secured taste score of 5.85 at the end of 15th day, which was adjudged as either liked or disliked, and since the score was below 6.0 (on 9-pint hedonic scale), it was considered spoiled. While the performance of *Aloe vera* incorporated sample was better than control and secured more than 6.0 score at the end of 15th day.

3.3.4. Consistency

The consistency score of beverage during storage gradually decreased from 7.37 (0th day) to 6.30 (15th day). The decrease was significant at every storage interval. The decrease in consistency mean score during storage period might be attributed to enzymatic degradation and reduction in viscosity as storage period progressed.

3.3.5. Overall acceptability (OA)

The mean OA score during storage gradually decreased from 7.27 (0th day) to 6.25 (15th day). The decrease in OA score might be attributed to the development of acidity in the samples during storage and also it is quite natural that bio chemical changes in any product would reduce the acceptability of product during storage. Ahmad T et al., 2023 developed and studied novel whey mango beverage and reported that the decrease in overall acceptability scores might have been caused by the beverages' loss of color due to browning, increase in acidity, and change in taste and flavor after storage. The performance of 10% and 15% AVJ incorporated whey based beverages was better than control in terms of sensory quality during the storage at both temperatures. Similar results reported by Sharma et al. (2022) that whey beverages with a composition of 79% whey and 15% *aloe vera* juice (T_1A_3) had obtained maximum overall acceptability (7.54±0.050) whereas for coconut water based whey beverage the composition of 79% whey and 15% coconut water (T_2C_3) had obtained maximum overall acceptability (7.29±0.032).

3.4. Cost analysis of aloe vera enriched flavored whey beverage

The Table 3 shows the various ingredients used and their cost in the manufacture of beverage.

Cost of Whey based *Aloe vera* herbal beverage was estimated simply by considering the price of each ingredient. The cost estimates include only the raw materials cost incurred in the preparation of 1000 gm of final beverage. *Aloe vera* was procured at ₹ 10.0 kg^{-1} and was converted in to juice as per the procedure. The yield of AVJ was about 40%. The cost of AVJ was calculated as ₹ 25.0 kg^{-1}. This AVJ was used for manufacture of beverage by incorporating at different levels. The cost kg^{-1} of whey based *Aloe vera* herbal beverage was calculated to be ₹ 6.74 (T_0), 7.89 (T_1), 9.04 (T_2), 10.19 (T_3) and 11.34 (T_4). The higher difference in the cost of experimental samples was attributed to the fact that the raw material *Aloe vera* juice itself had higher cost $liter^{-1}$ (₹ 25/-). Though the costs of AVJ incorporated beverages are higher than control, the health benefits derived in terms of therapeutic value from *Aloe vera* juice could be offset.

4. CONCLUSION

Aloe vera juice was successfully utilized for incorporation in whey based beverages. The most organoleptically good quality *Aloe vera* enriched flavored whey beverage was prepared with *Aloe vera* juice incorporated @15 per cent to produce without adversely affecting the sensory and physico-chemical properties of the product. The Production cost of most acceptable level (T_3) was 10.19/- per liter.

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