5.1 Introduction

A clear relation between diet and health is now well established. In this context, functional foods, described as foods which have positive effects on health (Stanton et al., 2001), are gaining more widespread popularity and acceptance. Development of such foods involves fortifying foods with added ingredients that confer health effects on the consumers. Aloe gel is one such nutraceutical ingredient being explored for the development of functional foods.

A number of products with Aloe vera as an active ingredient in different forms are currently being marketed. Aloe juice has been used in production of food products like health drinks, soft drinks; ready to serve drinks, sports drinks and fruit and vegetable juices (Ahlawat and Khatkar, 2011). A health beverage was developed utilizing Aloe vera whole leaf juice, which was mixed with different proportions of Dangshen, Maidong juices and some Chinese herbs (Wei et al., 2004). Vinegar was prepared from Aloe vera juice utilizing Acetobacter sp. (Lee et al., 1999).

Dairy products incorporating Aloe vera are also gaining popularity. Aloe vera powder and Aloe vera juice were utilized for the preparation of yoghurt (Shin et al., 1995; Lee and Yoon, 1997). The yoghurt prepared with Aloe vera was reported to have a better quality retention compared to that prepared using dried skim milk. Another study reported preparation of chocolate utilizing Aloe vera juice along with sugar, skim milk powder and cocoa powder (Jayabalan and Karthikeyan, 2012). Manoharan et al., (2012) reported the preparation and sensory evaluation of herbal ice cream prepared incorporating Aloe gel pulp at different levels and recommended 20% level of addition to give optimum results.
Benward and Benward (2008) report preparation of healthy baby infant and toddler formula beverage from cow’s milk, sugar, goat’s milk, rice milk, along with *Aloe vera* juice and water. Use of *Aloe vera* in meat products (Erdmann, 2004) and chewing gum (Jenkins, 2003) has also been discussed from the viewpoint of consumer acceptance.

Other *Aloe vera* enriched products that have been suggested include squash, jams, jellies wherein *Aloe vera* concentrate could be used. Inner gel fillet is suggested as suitable for preparing candies, bars, and fruit smoothies, whereas, *Aloe vera* powder could be used in dahi, lassi and laddu (Ahlawat and Khatkar, 2011).

An important criterion for the development of Aloe gel enriched products is retention of its nutritional and therapeutic benefits in the end product. Fresh Aloe gel is, however, highly unstable and prone to enzymatic and microbial decomposition (Ramachandra and Rao, 2008). Hence, there is a need to appropriately process the gel, which will not affect the sensory and health functionality of the gel negatively.

Drying is one of the methods used to reduce degradation and preserve the gel (Yaron, 1993). Among spray and freeze drying methods recommended to retain the properties of fresh Aloe gel (Angsupanich *et al.*, 1993; Ramachandra and Rao, 2008), spray drying is considered as an efficient and economic option (www.processingtalk.com).

Pasteurization is another method employed to improve the keeping quality of the fresh Aloe gel. The temperature and time used for pasteurization are very important as improper conditions may adversely affect the nutritional and functional characteristics of the gel. High temperature short time (HTST) method has been recommended to obtain a desirable product (He *et al.*, 2005; Ramachandra and Rao, 2008).

The present study therefore evaluated the use of spray dried Aloe gel powder for formulating functional dairy (dahi) and fruit (papaya powder) products. Functional fruit beverage (papaya RTS beverage) was formulated using fresh Aloe gel. The effect of Aloe gel addition on the physico-chemical parameters; product functionality and sensory quality of the developed functional foods were assessed. Microbial quality and shelf life stability of the Aloe gel enriched products were also evaluated.
5.2 Review of literature

5.2.1 Fermented milk products - Dietary significance and value addition

Considerable attention towards consumption of healthy foods, in recognition of their nutritional and therapeutic benefits, has led to an increased demand for fermented milk products (Saavedra et al., 2004). In the international markets yoghurt and chilled desserts are gaining wide popularity (Kowalska et al., 2000).

In India, only 7% of the total milk produced is used for the production of fermented foods which mainly includes dahi (curd), shrikhand (sweetened concentrated curd) and lassi (stirred curd) (Aneja et al., 2002). Dahi/curd is considered to be the Western equivalent of yoghurt, though it varies from yoghurt in its preparation involving usually an indigenous, non-descriptive starter culture containing LAB and other fermentative organisms. It is a popular item in the Asian meal, and is esteemed for its pleasant and refreshing taste. It is highly nutritious and is also believed to assist digestion and cure intestinal disorders (Harun-ur-Rashid, 2007). Some of the other beneficial effects attributed to the consumption of dahi include its higher protein quality compared to milk (Shankar and Laxminarayana, 1974), presence of β-galactosidase enzyme (Dave et al., 1993) making it suitable for lactose-intolerant population (Chandrasekharan et al., 1975), antibacterial activity (Sarkar et al., 1996) and activation of the nonspecific immune system and protection against enteric infections (Singh and Kansal, 2003).

Value addition to fermented milk products has been carried out mainly to improve the functional quality and health functionality of the developed products. Some of the studies on fortification of fermented milk products and effects of such enrichment on storage are presented below.

Addition of various stabilizers such as pectin, guar gum, carboxy methyl cellulose, carrageenan, sodium alginate, corn starch and gelatin to yoghurt has been reported by Athar et al., (2000), wherein corn starch enriched yoghurts exhibited
optimum stability on storage. Đurđević-Denin et al., (2002) reported improved viscosity of set-style yoghurts fortified with demineralized whey powder on storage, compared to the control samples. El-Sayed et al., (2002) reported decreased susceptibility to syneresis, smallest decrease in microstructure and highest sensory score in 0.01% and 0.005% xanthan gum incorporated yoghurt and soy yoghurt, respectively, compared to samples without xanthan gum.

Effect of storage on sensory and rheological properties of yoghurts fortified with different commercial fibres such as apple, wheat, bamboo or inulin was studied by Staffolo et al., (2004). The authors reported no syneresis in the fortified yoghurts after 21d cold storage. Sensory acceptability of the fortified yoghurts was also higher than control except for apple fibre fortified yoghurt which showed browning.

Domagala et al., (2005) studied incorporation of oat maltodextrin on the rheological characteristics of yoghurt, in comparison to milk fat containing yoghurt and non-fat yoghurt during storage for 21d at 5\(^0\)C. No significant differences were recorded between the yoghurt containing fat or maltodextrin, but a higher degree of reduction in viscosity was reported of the oat maltodextrin enriched yoghurt on storage.

A study by Foda et al., (2007) studied the incorporation of turmeric in various concentrations (0-1%) to set yoghurt stored for 12d at 5 ± 2\(^0\)C. Addition of turmeric was reported to significantly decrease the whey syneresis and improve the firmness of set yoghurt, whereas, decreased sensory scores were recorded especially with higher concentrations of turmeric powder.

In a study by Ghadge et al., (2008), fortification of yoghurt was carried out using apple fruit pulp or honey in various concentrations. The authors concluded lower concentrations of the additives to give superior results as higher concentrations led to detrimental effects on the physico chemical properties and sensory acceptability of the product.

A study by Ahmed et al., (2010) reported yoghurts fortified with defatted wheat germ protein isolate at different concentrations (3-9g/100ml milk) to have higher
content of protein, carbohydrate, ash, apparent viscosity, firmness, pH, total solids, along with better sensory scores at lower concentrations of usage.

Incorporation of amaranthus on the sensory quality and texture of natural yoghurts was studied by Grega et al., (2001) who reported highest sensory scores after 7d of cold storage and decrease in sensory quality of the yoghurts after 14d of storage.

5.2.2 Fruit based products

5.2.2.1 Significance of processed fruit products

India is one of the largest producers of fruits and vegetables in the world and occupies second position after China, accounting for about 10.4 per cent of all fruits and nearly 40 per cent of tropical fruits produced globally (FAOSTAT, 2005).

On a comparative basis globally, only 2 per cent of the fruit production in India is processed compared to 70 per cent in Brazil, and 83 per cent in Malaysia (FAOSTAT, 2005). Further, it is estimated that about 25 to 30 per cent of fruits produced is wasted due to lack of suitable post-harvest technology and infrastructure (FAOSTAT, 2005). Papaya is a highly perishable fruit with a shelf life of very few days (2-3) at room temperature. The estimated postharvest losses of papaya fruits in India range from 40 to 100 per cent (Singhal, 1999).

In view of the huge surplus of fruits such as papaya which are good source of nutrients and phytonutrients, largely unprocessed and subjected to considerable post-harvest losses, it is imperative to develop preservation techniques/preserved products. Fruits could be processed into value added products which could help to increase export potential and foreign exchange earnings. This will help to minimize loss in both quality and quantity (Rao, 2004).

One of the methods to reduce the post-harvest losses is dehydration, an economic alternative processing technique for preservation of fruits and vegetables. Commercial interest in the production of fruit and vegetable powders
has also increased. These are in demand for use in various food products such as beverages, soups, pizza mixes, sauce powders, dairy products and bakery products.

The dehydrated powders owe their popularity to their ease of handling, transport and minimum storage requirements. Fruit juice powders have many benefits and economic gain over their liquid forms such as reduced volume or weight and longer shelf life. Powders also are suitable as they can be easily measured and added to many food and pharmaceutical products for various reasons which include imparting flavor and colour (Shrestha et al., 2007).

However, there are many challenges in producing fruit powders. These include stickiness, thermoplasticity and hygroscopicity particularly at high temperature and humidity levels causing problems in handling, packaging and storage (Bhandari et al., 1997; Cano-Chauca et al., 2005; Jaya et al., 2006). These characteristics are particularly seen in fruits with high sugar content (Bhandari et al., 1997). The fruit powders tend to be very hygroscopic in amorphous state leading to caking and reduction in flow characteristics. Different methods have been explored to produce free flowing fruit powders. One of the approaches is use of drying adjuncts such as maltodextrins and skimmed milk powder (Bhandari et al., 1997; Adhikari et al., 2004). With the changes in the socio economic status occurring in various countries and with technological advances, the scope for production for value added fruit powders is broadened. This scope is further strengthened by the building of scientific data on the health and therapeutic properties of fruits and vegetables. Supplementation of fruit powders could be thus used to enhance the nutritional and therapeutic benefits of other products.

Another convenient technique for the utilization of fruits and vegetables is development of ready-to-serve beverages, which could also help to meet the daily requirement of fruits and vegetables in the diet. Healthy beverages, particularly those that offer functional ingredients such as botanicals, minerals and antioxidants are increasing in demand. New product introductions in the health drink and fruit juice categories were found to reach over 700 new offerings in
year 2003, up 40% over 2002 (Anon 2003). Functional beverage sector has been reported to be the fastest growing segment (Roberts, 2009). Fruit-based functional beverages with refreshing flavors and tastes are being preferred over aerated drinks by the health-conscious consumers, in particular.

5.2.2.2 Value addition and utilization of fruit powders

Fruits powders have been enriched using pulse/cereals and milk product. A pulse-based papaya powder was developed and evaluated by Firoz et al., (2004) wherein roasted bengal gram flour was added at 10% level. The blended powder stored in glass bottles was reported to show better storage characteristics than that stored in LDPE bags.

Aruna et al., (1998) developed a cereal-based papaya powder. Wheat flour was added at 10% level to the pulp and dried at 60°C. The powder was found to exhibit good sensory qualities, minimal microbial counts and lesser reduction in vitamin content up to 6 months storage.

Value-added mango powder using different varieties of mango with addition of wheat flour and milk concentrate (Khoo) was developed by Hymavathi and Khader (2004) in the ratio of 85:5:10 using vacuum dehydration.

There is an increasing popularity in use of fruit powders in various products. Coloring food stuffs using fruit powders may substantially profit from the fast growing functional food market because they offer health promoting and nutritional benefits (Pszczola, 2003).

The characteristic flavors, colors and nutrients as well as water binding properties of fruit powders make them ideal additives for soups, sauces, marinades, baby foods, dips, extruded cereal products, fruit purees for confections and fillings for frozen toasted snacks (Francis & Phelps, 2003; Pszczola, 2003).

A study was conducted by Mobhammer et al., (2006), where cactus pear powder was used for coloring dessert preparation, fruit/cereal bars, instant dishes and chocolates. Grabowski et al., (2006) have discussed the functional properties of sweet potatoes
powder which act as a natural color and flavor enhancer and also act as a thickening agent like pre-gelatinized starches in food systems. Jittanit et al., (2011), discussed about the advantages of incorporating tamarind powder in product development, where it would help to prevent microbial growth and reduce chemical and enzymatic reactions.

Majzoobi et al., (2011) have reported the use of tomato pomace powder in flat breads (Barbari bread). They report an improvement in the bread quality in terms of texture and delayed staling. Incorporation of bambangan fruit powder in biscuits and macroni increased the nutritional quality as the peels of bambangan fruits are a potential source of dietary fibre (Hassan et al., 2011).

Incorporation of dehydrated peach, plum, apricot fruit in fruit chutney mix, fruit pickle, RTS drink mix has been reported by Sharma et al., (2011). The developed products were reported to show good acceptability over a 6 months period.

5.2.2.3 Value addition to RTS fruit beverages

Ready to serve fruit beverages could be used effectively to deliver the minimum of five portions of fruits and vegetables per day (FSA, 2010) to the consumers in an attractive manner. Value added fruit beverages are healthier and becoming more popular. Value addition is generally achieved by blending two or more beverages and by incorporation of nutraceutical or functional ingredients. Some of the studies on value added RTS beverages are discussed below.

Kantharaj et al., (2011) studied the effect of blending tamarind juice with rose apple for the development of RTS beverage. The beverage blend with 15% pulp and 20° B TSS and 0.3% acidity was suitable for utilization and found to have maximum overall acceptability score after 90 days of storage. Another study (Raj et al., 2011) reported blending sand pear juice and apple juice in the proportion of 50:50 and 60:40 to have better quality, sensory score, and higher shelf stability than the unblended juice.

A study by Ukwuru and Adama (2003) reported preparation of soy flour (SF) and papaya pulp flour (PF) blend beverages with different concentrations of the
flours. The beverage blends showed good overall acceptability and microbiological stability up to twenty-ninth week of storage. Lima et al., (2009) reported good sensory acceptability of coconut water (75%) and acerola fruit juice (25%) beverage blend up to 6 months at room temperature.

Enrichment of orange juice with chitosan at different concentrations was studied by Martin-Diana et al., (2009). The authors reported the chitosan enriched juices to have lower enzymatic and non enzymatic browning, lower microbial spoilage and longer shelf life when used at concentrations below 1%. At higher levels, adverse effects in terms of reduced sensory acceptability and phytochemicals was reported.

A study by Yadav et al., (2010) reported development of a whey-based banana herbal beverage with the incorporation of Mentha arvensis extract at different concentrations (0-4%) and storage at 7±1°C for 20d. The authors reported improved quality and sensory acceptability of RTS with 0-2% Mentha extract. Yadav et al., (2013) explored supplementation of Aloe vera juice with mint and ginger for developing an RTS beverage with varying proportions of juice and sugar. The authors reported sample with 14% juice content and 14% TSS supplemented with mint and ginger in a ratio (80:10:10) to have better physico chemical properties, microbiological and organoleptic quality and could be preserved without any chemical additives for 60d under refrigerated conditions.

5.3 Materials and methods

5.3.1 Aloe gel enriched dahi

5.3.1.1 Formulation of Aloe gel enriched dahi

The milk used in the present study was purchased from the local supermarket (Goodlife brand, fat 3.6%, protein 3.2% and carbohydrate 4.6%). For the preparation of dahi, the homogenized milk was heated at 85-90°C for 5 minutes and cooled to 45°C. Skimmed milk powder was added at 2.5% level and then
inoculated with 10% standard dahi starter (Hatsun brand, fat 3.1%, protein 3.3% and carbohydrate 4.4%). Amount of starter was selected based on preliminary experiments. The inoculated milk was incubated at 45°C till the dahi was set. For the preparation of Aloe gel enriched dahi, skimmed milk powder was replaced with spray dried Aloe gel powder (200 X powder, procured from Excel Industries, Hyderabad, A.P., India) at 0.1%, 0.15%, 0.2% and 0.25% levels (Fig 5.1.1).

5.3.1.2 Product analysis

The fresh control and Aloe gel enriched dahi/curd samples were analyzed for physico chemical characteristics and sensory quality.

a) Physico chemical characteristics

Various physico chemical parameters affecting product quality of dahi were analyzed. These include setting time, total yield (TY), total solid content (TS), titrable acidity (TA), whey syneresis (WS) and water holding capacity (WHC). Instrumental analysis of viscosity and colour was also carried out.

- Setting time: The setting time in minutes was recorded from the time of inoculation till the formation of a firm coagulum (Ghadge et al., 2008).
- Total yield (TY): Yield of the dahi samples was determined in terms of grams of dahi obtained from 100 ml of milk.
- Total solid content: Total solid content was analyzed as per the standard method of AOAC (1995).
- Titrable acidity: Titrable acidity was estimated by standard titration method and expressed as lactic acid equivalent (AOAC, 1995).
- Whey syneresis (WS): Whey syneresis was determined by the modified method given by Amatyakul et al. (2006). A cup of set dahi was taken from the refrigerator (4°C), weighed and kept at an angle of approximately 45° to allow whey collection at the side of the cup. A needle connected to a syringe was used to siphon the whey from the surface of the sample and the cup of dahi was weighed.
Fig 5.1.1 Flow chart for the preparation of Aloe gel enriched dahi

1. **Toned milk (3% fat)**
2. Heated to 85-90°C and held for 1-2 minutes
3. Skim milk powder added at 2.5% level
4. Spray dried Aloe gel added at various concentrations
5. Mixture cooled to 40-45°C & inoculated with 10% standard curd starter (1.3x10⁴ /ml *S.thermophilus* & 2.8x10³ /ml *L.bulgaricus*)
6. Incubated at 45°C for 3 to 3½ hours
The siphon was carried out within 10s to prevent further leakage from the gel. The syneresis was expressed as quantity (ml) of whey obtained per hundred grams of the dahi samples.

- **Water holding capacity (WHC):** The WHC of the samples was determined as per the centrifugation method given by Amatyakul et al. (2006), with slight modifications. A cup of dahi was taken from the refrigerator and stirred using a glass rod. Five grams of the stirred dahi was taken and transferred to a 15 ml centrifuge tube. The stirred samples were centrifuged at 5000 rpm for 10 minutes and the separated whey was weighed. The water holding capacity was expressed as percentage weight of whey separated from the gel over the initial weight of the dahi.

- **Viscosity:** The viscosity of the dahi samples was determined using Brookfield viscometer (Model DV II+ Pro). Viscosity was measured (cps) at 20±1°C, with spindle number 3, at 30 rpm.

- **Whiteness index:** The colour of the dahi samples was measured in terms of L, a*, and b* values using the Konica Minolta colour reader CR-10 (Minolta Co. Ltd., Japan), which utilizes the CIELAB system. The whiteness index (Hsu et al., 2003) was calculated from these values as per the following formula.

\[
WI = 100 - \left[ 100 - L \right] + a^2 + b^2 \frac{100}{\sqrt{2}}
\]

b) **Sensory analysis**

Dahi samples were evaluated for acceptability by a group of ten dahi consumers. Colour, appearance, aroma, texture and taste of the developed dahi samples were evaluated using a 5-point hedonic rating scale on the basis of description of each attribute (5- like extremely to 1- dislike extremely). Overall acceptability was determined by calculating the mean total score based on weighted factors assigned to different attributes (Modzelewska- Kapitula, 2009). The following weighted factors were used: 0.15 for colour and appearance, 0.20 for flavor, 0.30 for texture and 0.35 for taste. The mean total score for each sample was calculated according to the equation:
(C × 0.15) + (F × 0.20) + (T × 0.30) + (TS × 0.35)

Where, C is the mean score for colour and appearance, F is the mean score for flavor; T is the mean score for body and texture, and TS, is the mean score for taste. The sensory panelists were given guidelines before the evaluation. The samples were evaluated at 10±1°C. The original unopened containers were given to the panelists, so as to reveal the true conditions of the product.

5.3.1.3 Storage studies

Based on the sensory acceptability and other important product characteristics, 0.15AGD was taken up for storage studies and compared with control dahi sample (CD). These two samples were analyzed for all the parameters mentioned in the previous section on 0d and after one week storage under refrigerated conditions (4±1°C). These samples were also analyzed for viable count of the LAB starter cultures (Streptococcus thermophilus and Lactobacillus bulgaricus) using standard media.

5.3.2 Aloe gel enriched functional papaya powder

5.3.2.1 Formulation of Aloe gel enriched functional papaya powder

Evenly ripened fruits were washed thoroughly in water. The cleaned fruits were peeled, sliced manually and blended to obtain the pulp. The TSS of the pulp obtained was adjusted to 10 Brix. The papaya pulp was mixed with the commonly used drying adjunct maltodextrin (MD) in the ratio 25:75 of the dry papaya solids. Skim milk powder was added to the pulp at 2.5% level. The pulp was then spread on trays and oven dried overnight at 55-60°C. To the dried samples obtained as flakes, TCP was added at 1.5% level before powdering in a lab scale homogenizer.

The powder obtained was divided into 4 sets. One part served as control and was designated as formulated papaya powder (FPP). To the other 3 sets, spray
dried Aloe gel (AG) powder was added at 1.5%, 3% and 4.5% level and the powders obtained were designated as 1.5AGFPP, 3AGFPP and 4.5AGFPP, respectively. These powders were blended in a mixer and sieved using 20mm mesh sieve to obtain fine flowable powders. The powders were packed in metalized polyester pouches, sealed and stored at room temperature (28±3°C) and refrigerated temperature (4±2°C) for 5 months (Fig 5.2.1).

5.3.2.2 Product analysis

Periodic analysis of the formulated powder samples was carried out at 0d, after 3 months and 5 months of storage at both the temperatures for various functional quality characteristics, chemical characteristics, instrumental color, sensory and microbial quality.

a) Functional quality characteristics

- **Total yield:** The total yield of the powders was calculated as per the method given by Pachanon (2005), using the formula given below

  \[
  \text{Yield} (\%) = \frac{x}{y} \times 100 \quad ; \quad x = \text{Wt. of dehydrated powder} \quad ; \quad y = \text{Initial wt. of pulp}
  \]

- **Moisture:** The moisture content in the raw materials and prepared powders were determined using method given by AOAC (1995).

- **Degree of caking:** Degree of caking was estimated by the method given by Pisecky (1985), with slight modifications. Powder was weighed and transferred onto a sieve. The sieve was then shacked for 5min in a shaking apparatus. The powder remaining in the sieve was weighed.

  The degree of caking, \( DC \) (%) was calculated by using the following formula:

  \[
  \text{DC} = \frac{a}{b} \times 100
  \]

  Where, \( a \) (g) is weight of the powder left on the sieve after sieving
  
  \( b \) (g) is weight of the powder used for sieving
Fig. 5.2.1 Formulation of Aloe gel enriched functional papaya powder

Selection of evenly ripened papaya fruits

Washing, Peeling and Cutting

Pulping and tray loading

Drying in convective air dryer (65 °C for 7-8 hours)

Dried flakes powdered to 20 mesh size

Formulated functional papaya powders

Packed in MP pouches and stored at 28 ±2°C & 4 ±1°C

Addition of MD and SMP

Addition of TCP and Aloe gel powder (0, 1.5%, 3% & 4.5%)
• **Bulk density, compressibility and flowability:** The bulk densities of the formulated powders were calculated using formula given by Ranganna (1986). Compressibility was derived from loose and tapped bulk density as per the formula given by Babu *et al.*, (2005) and flowability as per the scale given by Carr *et al.*, (1965).

Weighed samples of 10g were added in 50ml measuring cylinder. The initial volumes were noted. The samples were tapped using bulk density apparatus (SECOR, India) till constant final volumes were obtained.

\[
\text{Loose bulk density (LBD) g/ml} = \frac{\text{Wt. of sample}}{\text{Initial volume}}
\]

\[
\text{Compact bulk density (TBD) g/ml} = \frac{\text{Wt. of sample}}{\text{Final volume}}
\]

\[
\text{Compressibility} = 100 \times \frac{\text{TBD} - \text{LBD}}{\text{LBD}}
\]

**Scale of flowability**

<table>
<thead>
<tr>
<th>Compressibility(%)</th>
<th>Flow character</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10</td>
<td>Excellent</td>
</tr>
<tr>
<td>11-15</td>
<td>Good</td>
</tr>
<tr>
<td>16-20</td>
<td>Fair</td>
</tr>
<tr>
<td>21-25</td>
<td>Passable</td>
</tr>
<tr>
<td>26-31</td>
<td>Poor</td>
</tr>
<tr>
<td>32-37</td>
<td>Very poor</td>
</tr>
<tr>
<td>&gt;38</td>
<td>Very very poor</td>
</tr>
</tbody>
</table>

• **Rehydration test:** The rehydration ratios of prepared powders were estimated by using the method given by Ranganna (1986).

Weighed samples (5g) were placed in 500ml beakers. Distilled water (100ml) was added to each and covered. The mixtures were brought to boil within 3 minutes and heated further for 10 minutes at constant temperature. Mixtures were
transferred into Buchner funnel which was covered with Whatman No.1 filter paper. Gentle suction was applied and samples were drained with careful stirring for half to one minute. Samples were removed from the funnel and weighed.

\[
\text{rehydration ratio} = \frac{\text{Wt. after rehydration}}{\text{Wt. before rehydration}}
\]

- **Solubility**: Solubility of the powders was determined by the method given by Liu *et al.*, (2010).

The powder (1g) was mixed with 10ml of distilled water at 25°C. Mixture was agitated in a mechanical shaker for 30 minutes followed by centrifugation at 1000 rpm for 10 minutes. The supernatants obtained were placed in a pre weighed dish and dried in the oven at 105°C. They were then cooled in a desiccator and weighed. Solubility was determined as per the formula given below:

\[
\text{Solubility} \% = \frac{m_1}{m_0} \times 100
\]

*m_0* → total weight of the powder (g)

*m_1* → wt. of the powder soluble in the solution (g)

**b) Chemical characteristics**

- **Titrable acidity**: The titrable acidity was determined following the method given by Ranganna (1986).

Weighed samples of 10g were boiled in distilled water for an hour. Samples were cooled and were made up to 25 ml in a volumetric flask. The contents were filtered through Whatman No.1 filter paper. Aliquots of 10ml were taken and 75ml of boiling water and few drops of 1% phenolphthalein solution were added. The mixtures were titrated against 0.1N NaOH solution. Appearance of persistent pink color was taken as the end point.
\[ \text{Total acidity\%} = \frac{\text{Vol.of} \ 0.1N \ \text{NaOH} \ \text{rundown} \times \frac{\text{Vol.of Extract}}{\text{Aliquot taken for estimation}}}{\text{Normality of alkali} \times \frac{\text{Eq.Wt.of acid}}{1000} \times \frac{100}{\text{Wt.of the sample}}} \]

- **Total soluble solids**: The total soluble solids in °Brix were determined according to the method given by Ranganna (1986) using Abbe’s hand refractometer at 28°C. The temperature corrections in the readings were done using the standard table given.

- **Brix/acid ratio**: The Brix/ratio was determined using the method given by Ranganna (1986), by dividing the degree Brix of a sample by the percentage of titrable acidity of the sample.

\[ \text{Brix/acid ratio} = \frac{\text{°Brix}}{\text{Acidity}} \]

A higher ratio is an indication of sweeter product and vice-versa.

- **Non-enzymatic browning**: The non-enzymatic browning in samples was determined according to the method given by Ranganna (1986).

Five ml of 60% alcohol was added to 0.5g of macerated samples and kept overnight. The contents were filtered and the intensity of color was read at 440nm using 60% alcohol as blank.

\[ \text{Non-enzymatic browning} = (\text{O.D of sample} – \text{O.D of blank}) \]

- **Total and reducing sugars**: Total and reducing sugars were estimated by Ranganna (1986)

Sample (10g) was mixed with 10 ml of concentrated HCl and kept overnight for inversion of sugars. The inverted sugar samples were made up to (100 ml) after adding few drops of phenolphthalein indicator and neutralized with 1N NaOH till pink color appeared. The inverted sugar sample titration was done against Fehling’s A and B solutions (10ml each) with 10 ml of distilled water.
The methylene blue indicator was used as an internal indicator and the end point was noted after getting brick red color. The volume was noted and calculated as per the following formula;

\[
\text{Total sugars (\%) = \frac{\text{Fehling's factor} \times \text{dilution} \times 100}{\text{Titre value} \times \text{wt. of the sample}}}
\]

The same procedure was followed for reducing sugars without inverting the sugars.

c) Instrumental color

The developed functional papaya powders were completely filled in a 3 inch diameter petri plate. The color of the samples was then measured with Konica MINOLTA CR-10 color reader, using the Hunter L*, a*, b* units, where L* indicates luminosity or brightness, a* corresponds to greenness (-)/redness (+) and b* corresponds to blueness (-)/yellowness (+). The L*, a* and b* data were transformed to color index [CI= 1000 x a*/L* x b*] to ascertain the overall changes in the color of the powder during storage.

d) Sensory analysis

The sensory quality of the powders was evaluated initially and after each storage period by 20 female panel members. The following sensory parameters were rated as follows using a 5 point hedonic rating scale (Sidel and Stone, 1993).

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Mouthfeel</th>
<th>Color; Flavour ; Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>5- No lumpiness</td>
<td>5- Very fine</td>
<td>5- Like extremely</td>
</tr>
<tr>
<td>4- Slightly Lumpy</td>
<td>4- Fine</td>
<td>4- Like very much</td>
</tr>
<tr>
<td>3- Moderately lumpy</td>
<td>Moderately coarse</td>
<td>3- Neither like nor dislike</td>
</tr>
<tr>
<td>2- Lumpy</td>
<td>2- Slightly coarse</td>
<td>2- Dislike slightly</td>
</tr>
<tr>
<td>1- Very lumpy</td>
<td>1- Very coarse</td>
<td>1- Dislike extremely</td>
</tr>
</tbody>
</table>
e) Microbial analysis

The microbial examination of fresh and stored powders was performed for determining total yeast and mold count using potato dextrose agar medium (Aneja, 2001).

5.3.3 Aloe gel enriched functional RTS fruit beverage

5.3.3.1 Formulation of functional RTS fruit beverage

Papaya was selected for preparing RTS beverage. This basic beverage was blended with Aloe gel juice at different concentrations to formulate an organoleptically acceptable functional fruit beverage.

To prepare the basic beverage, papaya fruits were thoroughly washed under running tap water, peeled and cut into small pieces. The pieces were finely blended to obtain papaya pulp, which was filtered through a muslin cloth. Sugar syrup (20%) was prepared and blended with 15% of the obtained papaya pulp. Spice extract was prepared by boiling aniseed, ginger and pepper in water for few minutes. This was added to the papaya pulp-sugar syrup blend at 5% level, to enhance flavor and acceptability. Citric acid was also added at 0.1% level to achieve the desired acidity level recommended for beverages. The resultant basic product was termed as papaya RTS beverage (PB) and was selected as control beverage.

For preparing functional RTS beverage, fresh and healthy Aloe vera leaves were selected. The inner gel was removed carefully by the hand filleting method from the leaf. The gel was washed 3-4 times in distilled water, crushed, blended and filtered through muslin cloth. Aloe gel juice, thus, obtained was mixed with papaya pulp in the ratio of 10:90, 20:80, and 30:70 and designated as 10 AGPB, 20 AGPB and 30 AGPB, respectively. Sugar syrup, spices extract and citric acid were added as done for PB. The beverages were heated for a few minutes in low flame. They were then hot-filled into pre-sterilized glass bottles, screw capped
and pasteurized for about 4-5 minutes at 85-90 °C followed by immediate cooling Fig 5.3.1.

5.3.3.2 Product Analysis

The developed beverages were evaluated for sensory acceptability in terms of color, flavor, taste, consistency and overall acceptability. Among the 10AGPB, 20 AGPB and 30 AGPB samples the Aloe gel enriched sample found best in terms of the above mentioned parameters was selected for further storage analysis, along with the control beverage PB. The selected beverages were stored at room temperature (28±2°C) in dark up to five months. Analysis for various parameters was carried out on 0d and after 45d, 90d, 120d and 150d of storage. The beverage was evaluated for physico chemical characteristics, instrumental color, sensory and microbial quality.

- **Physicochemical characteristics**

  The samples were analyzed for various physicochemical parameters. The pH of the samples was read with a calibrated pH meter (Elico India L1-120 model). Titrable acidity (as percentage citric acid), total soluble solids (in °Brix) non-enzymatic browning (NEB), total and reducing sugars were determined using standard methods (Ranganna 1986), as described in section 5.3.2.2b.

- **Instrumental color**

  The instrumental color of the beverage samples were recorded as Hunter L* a* b* units and color index as explained in section 5.3.2.2c.

- **Sensory and microbial analysis**

  The sensory acceptability for color, taste, flavor, consistency and overall acceptability of the samples was evaluated by a group of 20 female panel members who were asked to rate the samples on a 5 point hedonic rating scale (Sidel & Stone, 1993).
Fig 5.3.1 Flow chart for the preparation of Aloe gel enriched RTS beverage

**Composition**
- Pulp - 15%
- Spices - 5%
- Citric acid - 0.1%

**Composition**
- Aloe gel - 30%
- Pulp - 15%
- Spices - 5%
- Citric acid - 0.1%

- Papaya fruits - Cut into pieces, pulped and strained
- Hot filled into pre sterilized bottles, crown capped and pasteurized for 20 minutes
- TSS adjusted to 15° Brix with sugar syrup
- Cooled and stored at room temperature for 6 months

**CONTROL**
- Papaya RTS beverage

**EXPERIMENTAL**
- Aloe – Papaya RTS beverage
The total bacterial count (TBC) and total yeast and mold counts (YMC) of the beverage samples were determined by standard plate count method and expressed as log CFU ml\(^{-1}\) (Aneja, 2001).

5.3.4 Statistical analysis

Data obtained for the various parameters were expressed as mean values ± standard deviations of at least three replications.

Student t-test was utilized to determine significant differences between control and Aloe gel enriched dahi samples for the various parameters in both fresh and stored samples. Statistical significance was set at P<0.05. Statistical analysis was carried out using MS Excel 2007 software.

Statistical analyses for functional powders and RTS beverage samples were performed using SPSS (Statistical software Student Version 16.0, Chicago, IL, USA). Data was analyzed using one way ANOVA. Statistical difference between the means were determined using Duncan’s multiple range test (DMRT) with the confidence limits set at p<0.05 (95%).

5.4 Results and discussion

Results of the studies on the effect of Aloe gel incorporation on the quality and shelf life stability of different products (Aloe gel enriched dahi, Aloe gel incorporated papaya powder and Aloe gel papaya beverage blend) are presented here.

5.4.1 Effect of Aloe gel enrichment on the quality of dahi

Results of the effects of Aloe gel enrichment in dahi, a fermented milk product, are presented first followed by the overall discussion.

5.4.1.1 Physico chemical characteristics

- Setting time and total yield

Setting time observed for the various dahi samples is shown in Table 5.1.1. The control dahi (CD) sample took the maximum time to set (232±7.5min).
Table 5.1.1 Setting time, total yield and viscosity of Aloe gel enriched dahi sample

<table>
<thead>
<tr>
<th>Dahi Samples</th>
<th>Setting time (min)</th>
<th>TY(g/100ml)</th>
<th>TS (%)</th>
<th>TA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>232±7.5</td>
<td>104.0 ± 1.1</td>
<td>15.8 ± 0.25</td>
<td>0.61±0.11</td>
</tr>
<tr>
<td>0.1 AGD</td>
<td>227±2.5 NS</td>
<td>106.9 ± 2.66 NS</td>
<td>16.2 ± 0.13</td>
<td>0.87±0.11*</td>
</tr>
<tr>
<td>0.15 AGD</td>
<td>215±5.0*</td>
<td>107.6 ± 2.60*</td>
<td>16.7 ± 0.19</td>
<td>0.87±0.12*</td>
</tr>
<tr>
<td>0.2 AGD</td>
<td>202±7.5*</td>
<td>107.9 ± 1.45*</td>
<td>17.2 ± 0.27</td>
<td>0.90±0.13*</td>
</tr>
<tr>
<td>0.25AGD</td>
<td>202±7.5*</td>
<td>108.2 ± 1.99*</td>
<td>18.1 ± 0.31</td>
<td>1.18±0.09*</td>
</tr>
</tbody>
</table>

Fig. 5.1.2 Effect of Aloe gel enrichment on whey syneresis (ml/100g) (a) and water holding capacity (%) (b) of Aloe gel enriched dahi samples

(a) Whey syneresis (ml/100g)  
(b) Water holding capacity

CD, 0.1AGD, 0.15AGD, 0.2AGD & 0.25AGD – Dahi enriched with 0%, 0.1%, 0.15%, 0.2% & 0.25% Aloe gel powder* Significantly different from control at P<0.05; NS – not significant
A reduction in setting time was observed with increasing concentrations of Aloe gel powder (AG). Dahi samples with 0.2% and 0.25% AG exhibited the least setting time of 202±7.5 minutes.

The yield of the samples (Table 5.1.1) was found to be higher in AG enriched dahi samples. The maximum yield was observed in 0.25AGD sample (108.2g/100ml), significantly higher than CD (104g/100ml). Significantly higher yield was also observed in 0.15 and 0.2AGD samples compared to control, though less than that of 0.25AGD.

- **Total solid content**

Sample enriched with the highest concentration of AG (0.25%) was found to record the highest TS content of 18.1%. Samples enriched with 0.15% and 0.2% AG recorded TS content of 16.7% and 17.2%, respectively. The lowest content of total solids was recorded in CD (15.8%) (Table 5.1.1).

- **Titrable acidity**

The analysis of the samples revealed a significantly higher (P<0.05) acidity (1.18%) in 0.25AGD sample, followed by 0.15AGD (0.87%) and the control sample exhibiting the lowest (0.61%) (Table 5.1.1).

- **Whey syneresis**

Whey syneresis of the dahi samples is depicted in Fig 5.1.2a. Whey syneresis decreased with the addition of AG. The sample enriched with 0.25% Aloe gel showed the lowest level of syneresis (0.97 ml), similar to that of 0.2AGD sample (0.98 ml), both of which were significantly lower than that of CD (1.9 ml). Whey syneresis of 0.1 AGD and 0.15AGD samples was also lower than that of control, though in case of 0.1 AGD sample, it was not significant.
• **Water holding capacity**

Lowest WHC (Table 5.1.2b) was recorded in control sample (88.5%). Maximum WHC of 91.8% was found in 0.25AGD, followed by 0.2 and 0.15 AGD samples (91.5% and 91.4%), respectively. These values were found to be significantly higher than that of control dahi.

• **Viscosity**

Viscosity (Fig. 5.1.3) of control dahi was found to be 1475 ±43cps recorded at 10 rpm. Aloe gel enrichment had an incremental effect on the viscosity of the dahi samples. Dahi samples with the highest concentration of AG (0.25%) resulted in highest viscosity value of 2789 ±59.5 cps. Significantly higher viscosity was observed for 0.15AGD, 0.2AGD and 0.25 AGD dahi samples compared to control.

• **Whiteness Index (WI)**

The L, a*, and b* values of dahi samples were recorded. Influence of AG addition on the color of dahi was determined in terms of whiteness index (Fig 5.1.4). A higher WI was observed in the samples enriched with Aloe gel compared to the control sample (63.4). Highest whiteness index of 65.9 was recorded in 0.2 and 0.25AGD samples followed by 0.15 and 0.1AGD samples (65.3 and 64.7), respectively.

5.4.1.2 Sensory acceptability

Organoletic properties (appearance, color, taste, flavor, and body and texture) of the dahi samples are presented in Table 5.1.2. Significantly higher acceptability score was observed for appearance in all the AG incorporated samples compared to control. However, the samples did not differ significantly with respect to color preference. With regard to taste, 0.1AGD sample obtained a significantly higher score (4.88) compared to CD (4.0).
Fig. 5.1.3 Effect of Aloe gel enrichment on viscosity of Aloe gel enriched dahi samples

Fig. 5.1.4 Effect of Aloe gel enrichment on whiteness index of Aloe gel enriched dahi samples
Table 5.1.2  Sensory acceptability of Aloe gel enriched dahisamples

<table>
<thead>
<tr>
<th>Dahi Samples</th>
<th>Appearance</th>
<th>Colour</th>
<th>Taste</th>
<th>Flavour</th>
<th>Body and Texture</th>
<th>Total sensory score</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>4.25±0.6</td>
<td>4.66±0.5</td>
<td>4.00±0.7</td>
<td>4.16±0.7</td>
<td>4.08±0.7</td>
<td>4.09±0.6</td>
</tr>
<tr>
<td>0.1AGD</td>
<td>4.55±0.1*</td>
<td>4.77±0.4\textsuperscript{NS}</td>
<td>4.88±0.3*</td>
<td>4.55±0.7\textsuperscript{NS}</td>
<td>4.41±0.5\textsuperscript{NS}</td>
<td>4.68±0.5*</td>
</tr>
<tr>
<td>0.15AGD</td>
<td>4.83±0.4*</td>
<td>4.66±0.5\textsuperscript{NS}</td>
<td>4.41±0.6\textsuperscript{NS}</td>
<td>4.41±0.5\textsuperscript{NS}</td>
<td>4.50±0.8\textsuperscript{NS}</td>
<td>4.44±0.6*</td>
</tr>
<tr>
<td>0.2AGD</td>
<td>5.00±0.5*</td>
<td>4.66±0.5\textsuperscript{NS}</td>
<td>4.11±0.3\textsuperscript{NS}</td>
<td>4.33±0.5\textsuperscript{NS}</td>
<td>4.77±0.4*</td>
<td>4.34±0.4\textsuperscript{NS}</td>
</tr>
<tr>
<td>0.25AGD</td>
<td>5.00±0.0*</td>
<td>4.88±0.3\textsuperscript{NS}</td>
<td>4.00±0.5\textsuperscript{NS}</td>
<td>4.33±0.7\textsuperscript{NS}</td>
<td>4.88±0.3*</td>
<td>4.37±0.5\textsuperscript{NS}</td>
</tr>
</tbody>
</table>

CD, 0.1AGD, 0.15AGD, 0.2AGD & 0.25AGD – Dahi enriched with 0%, 0.1%, 0.15%, 0.2% & 0.25% Aloe gel powder, respectively;
* Significantly different from control at P<0.05, NS – Not significant
The taste scores decreased with increase in the level of AG (4.41 to 4.0), but remained higher or similar to CD. AG enriched samples obtained higher acceptability scores for flavor (4.33 to 4.55) compared to control (4.16), though the difference was not significant. A greater acceptability for all the AG dahi samples was observed over the control with regard to body and texture. The values were significantly different from control in all except for 0.1AGD sample.

The total sensory score, computed from the various parameters, showed significantly (P<0.05) higher scores (4.68 and 4.44) in 0.1 and 0.15 AGD samples compared to CD with the least score of 4.09. Dahi samples with 0.2 and 0.25% AG obtained a total lower score of 4.34 and 4.37, respectively, but higher than CD.

5.4.1.3 Storage stability of Aloe gel enriched dahi

Analysis of fresh dahi samples revealed 0.15AGD sample to exhibit optimum level for maximum of the quality parameters studied. Also this level is considered adequate to bring about beneficial physiological effects. Use of Aloe gel as a supplement is recommended in the form of one or two ounces of single strength juice or 150 to 300 mg of 200: 1 gel powder, twice a day (Jones, 2007). Hence, 0.15AGD was selected and compared with CD for storage stability.

- **Physico chemical characteristics**

Table 5.1.3 shows the effect of storage on total solid content (TS). A decrease in TS from 15.8 to 14.5% in control, and from 16.7 to 16.1% in 0.15AGD was observed after 7 days of storage. The TS content remained significantly higher than control even on storage.

Upon storage, an increase in TA was observed in both the samples. A higher acidity (1.37%) was observed in 0.15AGD samples compared to control which recorded 1.12%TA after 7 days of storage (Table 5.1.3)
Table 5.1.3 Effect of storage on moisture (%), total solid content (%), titrable acidity (%), water holding capacity (%) and whiteness index of Aloe gel enriched dahi samples

<table>
<thead>
<tr>
<th>Dahi Samples</th>
<th>TS (%)</th>
<th>TA (%)</th>
<th>WHC (%)</th>
<th>Whiteness index (WI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 d</td>
<td>15.8 ± 0.25</td>
<td>0.61±0.11</td>
<td>88.5 ± 0.93</td>
<td>62.4±0.80</td>
</tr>
<tr>
<td>7 d</td>
<td>14.5 ± 0.32</td>
<td>1.12±0.09</td>
<td>85.2 ± 0.43</td>
<td>53.9±0.02</td>
</tr>
<tr>
<td>0.15AGD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 d</td>
<td>16.7 ± 0.19</td>
<td>0.90±0.13*</td>
<td>91.4 ± 0.56</td>
<td>65.5±1.20*</td>
</tr>
<tr>
<td>7 d</td>
<td>16.1 ± 0.13</td>
<td>1.37±0.05*</td>
<td>89.1 ± 0.72</td>
<td>55.1±0.07*</td>
</tr>
</tbody>
</table>

Fig 5.1.5 Effect of Aloe gel enrichment on whey syneresis (ml/100g)(a) and viscosity (cps)(b) of dahi samples on storage
CD, 0.15AGD – Dahi enriched with 0% and 0.15%, Aloe gel powder, respectively; * Significantly different from control at P<0.05
A considerable increase in WS (Fig. 5.1.5a) and subsequent decrease in WHC (Table 5.1.3) was observed in both control and 0.15AGD. A significantly higher WS of 2.96 ml and lower WHC of 85.2% were recorded in control sample over the 0.15AGD, which showed 2.3 ml WS and 89%WHC.

A reduction in whiteness index was observed after 7 days of storage, with the decrease being greater in control sample compared to the AG enriched sample (Table 5.1.3). Thus, a significantly higher WI value of 55.1 was recorded in 0.15 AGD compared to control (53.9).

Viscosity of dahi samples reduced on storage (Fig 5.15b). However, 0.15 AGD sample maintained a significantly higher viscosity (1276±59.3cps) compared to control sample (1565±48.1cps).

- **Sensory acceptability**

Table 5.1.4 shows the effect of storage on the sensory acceptability of control and AG enriched dahi. Significantly higher scores were obtained for 7 day old 0.15AGD than control for all the sensory parameters i.e. appearance (4.44 vs. 3.83), colour (4.55 vs. 4.11), taste (4.22 vs. 3.53), flavor (4.11 vs. 3.83), and for body and texture (4.33 vs. 3.88). The total sensory score was also significantly higher value for 0.15AGD (4.23) compared to control dahi (3.71).

- **Total viable count**

Aloe gel enriched sample (0.15AGD) demonstrated higher viable count of *S. thermophilus* and *L. bulgaricus* on the initial day, compared to control. On storage, increase in viable bacterial count by about one log was seen in 0.15AGD for both the organism strains, whereas, for CD an increase was seen only in *L. bulgaricus*. 
Table 5.1.4 Effect of Aloe gel enrichment on sensory acceptability of dahi samples on storage

<table>
<thead>
<tr>
<th>Dahi Samples</th>
<th>Appearance</th>
<th>Colour</th>
<th>Taste</th>
<th>Flavour</th>
<th>Body and texture</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 d</td>
<td>4.25±0.6</td>
<td>4.66±0.5</td>
<td>4.00±0.7</td>
<td>4.16±0.7</td>
<td>4.08±0.7</td>
<td>4.09±0.6</td>
</tr>
<tr>
<td>7 d</td>
<td>3.83±0.43</td>
<td>4.11±0.44</td>
<td>3.53±0.52</td>
<td>3.83±0.3</td>
<td>3.88±0.4</td>
<td>3.71±0.3</td>
</tr>
<tr>
<td>0.15AGD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 d</td>
<td>4.83±0.38*</td>
<td>4.66±0.5NS</td>
<td>4.41±0.6NS</td>
<td>4.41±0.5NS</td>
<td>4.50±0.8NS</td>
<td>4.44±0.6*</td>
</tr>
<tr>
<td>7 d</td>
<td>4.44±0.50*</td>
<td>4.55 ±0.5*</td>
<td>4.22 ±0.3*</td>
<td>4.11 ±0.5*</td>
<td>4.33 ±0.4*</td>
<td>4.23±0.3*</td>
</tr>
</tbody>
</table>

Table 5.1.5 Effect of storage on total viable count (log cfu/g) of Aloe gel enriched dahisamples

<table>
<thead>
<tr>
<th>Dahi Samples</th>
<th>0 d</th>
<th>7 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. thermophilus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>1.3X10⁴</td>
<td>2.1X10⁴</td>
</tr>
<tr>
<td>0.15AGD</td>
<td>2.0X10⁴</td>
<td>1.8X10⁵</td>
</tr>
<tr>
<td>L. bulgaricus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>2.8X10³</td>
<td>2.2X10⁴</td>
</tr>
<tr>
<td>0.15AGD</td>
<td>3.2X10³</td>
<td>2.5X10⁴</td>
</tr>
</tbody>
</table>

CD, 0.15AGD – Dahi enriched with 0% and 0.15%, Aloe gel powder, respectively;
* Significantly different from control at P<0.05, NS – Not significant
Discussion

The results presented above for fresh and stored dahi samples are discussed in the following paragraphs.

It can be observed from the results that addition of spray dried Aloe gel powder helped in minimizing the setting time and improving the total yield. These former effects could be attributed to the higher acidity of AG enriched samples, which indicates optimum metabolic activity of the microbial cultures present in the samples. Correspondingly, a higher microbial count of *S.thermophilus* and *L.bulgaricus* was observed in AGD.

Significantly lower whey syneresis (WS), an important parameter for set yoghurt was observed in AG enriched dahi products, is related to their higher total solids. Total solid content has been identified as a major factor affecting whey syneresis (Guler-Akin, 2009) and has been found to negatively correlate with whey syneresis in yoghurts (Amatyakul *et al.*, 2006; Ahmed *et al.*, 2010). Harwalkar and Kalab (1986) and Jaros *et al.* (2002) also report a reduction in whey separation in set yoghurt when total solids were increased. Similar findings have also been reported by Keogh and Kennedy (1998) when different hydrocolloids and stabilizers were added to yoghurt.

AG enriched dahi samples were also characterized by a significantly higher WHC compared to control both in fresh as well as in 7 day stored samples. This could be attributed to lower whey syneresis and higher total solid content of the samples. Ge *et al.* (2000) also reported a correlation between low whey syneresis and high water holding capacity of defatted wheat germ protein fortified samples.

Significantly higher viscosity was observed in AGD samples compared to control dahi. The viscosity increased with an increase in concentration of AG. Similar observation has been reported by Shin *et al.* (1995), wherein plain yoghurt prepared with mixed strains of *S. thermophilus* and *L.bulgaricus* exhibited a lower viscosity of
2604 cps, whereas similar yoghurt prepared with AG enrichment showed a higher viscosity of 4100 cps, after 24h of incubation at 37\(^0\)C.

The higher viscosity recorded in the present study in AG dahi samples could be again attributed to the higher TS in these samples. Savello and Dargan (1995) also reported yoghurt samples with increased average total solids to exhibit increased gel strength and viscosity. Other studies have also reported that addition of ingredients which increase the dry matter content increase the rheological properties of fermented milk (Sodini et al., 2002; Isleten and Karagul-Yuceer, 2006).

A reduction in the viscosity was observed in the samples after 7 days refrigerated storage. Yadav et al. (2007) also reported a reduction in viscosity in probiotic dahi on storage for 8 days.

In the present study the lower viscosity observed in the control sample, both in fresh and stored condition, could also be attributed to lower acidity of control samples compared to AG dahi. Lower acidity has been postulated to give lesser protein coagulation and formation of soft dahi, which could have offered reduced resistance to flow i.e. viscosity (Ghadge et al., 2008).

A higher acidity value observed for AG enriched dahi samples compared to control is in agreement to those obtained by Shin et al. (1995) on Aloe gel enriched yoghurt. A study by Ghadge et al. (2008), also reported lower pH and higher acidity in yoghurt fortified with honey and apple pulp compared to control. Higher acidity in yoghurt samples than dahi, generally reported, could be due to the use of different starter culture organisms.

Upon storage, an increase in acidity was observed in all the samples, with the AG enriched samples showing higher acidity. This is in agreement with other studies (Yadav et al., 2007). Hassan and Amjad (2010) attributed the increasing acidity upon storage to breakdown of lactose to lactic acid. A study by El-Sayed et al. (2002) on the addition of polysaccharides like xanthan gum, carrageenan, locust bean gum and CMC to yoghurt, reported no marked effect of addition on the acidity of the samples, both in the fresh state as well as upon storage. This indicates that Aloe gel
polysaccharide unlike the traditional polysaccharides has a stimulative effect on the metabolic activity of dahi microorganisms.

The whiteness index, computed through instrumental color analysis was significantly different between the control and AG dahi samples. However, sensory analysis revealed no significant difference in the sensory acceptability between the dahi samples in terms of color. A significantly lower acceptability value was obtained by the control sample for appearance, compared to the AG enriched samples. This could be attributed to the continuous and smooth and surface of the set AG dahi compared to control dahi which was characterized by irregular rough surface.

Control dahi also recorded lowest score with regard to taste and flavor. This could be due to the lower acidity and insufficient metabolic activity of microorganisms in the sample, resulting in blandness in taste and flavor. Conversely, AG dahi samples with higher acidity had better scores. Among the AG enriched dahi samples, the scores were lower in 0.2% AG and 0.25% AG samples. This could be due to the slightly bitter aftertaste encountered in these samples containing higher concentration of AG.

The overall acceptability scores revealed a significantly higher preference for AG dahi samples. Among the AG samples, 0.2% and 0.25% AG samples, in spite of obtaining higher scores for appearance, color and consistency, recorded lower preference, due to lower acceptability scores obtained for flavor and taste. Jaworska et al. (2005) studied the relative importance of various sensory attributes in the consumer acceptability of yoghurt. Their study revealed flavor (off-flavor) and taste (bitterness) to be the critical sensory attribute for consumer

Lower reduction in the scores of sensory attributes in stored AGD sample indicated the beneficial role of AG enrichment on maintenance of overall sensory quality of dahi. Higher microbial quality of starter cultures such as *S.thermophilus* and *L.bulgaricus* also indicate a prebiotic role of Aloe gel, which could be further explored.
5.4.2 Effect of Aloe gel enrichment on the quality of papaya powder

The effect of adding aloe gel powder at different concentrations and storage at different temperatures on the functional product characteristics, chemical parameters, sensory and microbial quality of formulated functional papaya powder is presented in this section.

5.4.2.1 Functional quality characteristics

- **Total yield**

  Total yield of the freshly formulated functional papaya powders was determined. The results indicated a considerable improvement in the yield with addition of Aloe gel powder from 18.5% in control to 24%, 28.5%, and 30% in 1.5AGFPP, 3AGFPP, and 4.5AGFPP, respectively. This could be attributed to the lower moisture content and degree of caking observed in AG added papaya powder samples as discussed below. As a result a greater amount of fine powder could be sieved out, minimizing the loss. A greater yield is advantageous for large scale production and will lessen the production cost.

- **Moisture content**

  In the 0d samples, the control sample (FPP) recorded significantly higher moisture content of 6.95 g% compared to 5 g% in 3AGFPP and 4.5AGFPP (Fig 5.2.2). The moisture content of jackfruit powders has been reported to range from 5.71 – 8.22 g% (Pua et al., 2007).

  An increase in moisture content on storage was observed in all samples, especially those stored at ambient temperatures. Lower moisture content was seen in the AG enriched samples 3AGFPP (7.35%) and 4.5AGFPP (6.6%) compared to control (10.7%) at the end of 5 months storage under refrigerated conditions.

  Increase in moisture content in fruit powders upon storage has also been reported by other workers (Hymavathi et al. 2005; Pua et al. 2008). The increase has been attributed to the migration of water vapour from the storage environment...
through the packaging material into the fruit powders, which have a relatively very low water activity.

- **Degree of caking**

  Caking of free flowing powders during storage is a deleterious phenomenon by which a low moisture, free-flowing powder is first transformed into lumps, and then into an agglomerated solid and ultimately into a sticky material, resulting in loss of functionality and lowered quality (Peleg, 1973).

  Control samples showed 10% degree of caking (DC), significantly higher than 3AGFPP and 4.5AGFPP (4.8% and 4.3%, respectively) on the initial day (Fig 5.2.3). The trend continued till the end of 5m storage period, with the AG enriched samples recording significantly lower DC compared to control. Samples stored at ambient temperature recorded higher DC than the samples stored at refrigerated temperature. The degree of caking was found to be directly related to the moisture content of the papaya powders. Similar observations have also been made by Pua et al., (2008) in jackfruit powder who reported an increment in moisture uptake and concomitant increase in lumpiness upon storage.
Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions
• **Solubility**

Solubility, expressed as the percentage of solids soluble in water, is considered to be an important specification in fruit powders as it gives an indication of the product reconstitution.

In the fresh samples, the solubility ranged from 67% in FPP to 72% in 4.5AGFPP (Fig 5.2.4). A decrease in solubility was observed on storage. However, higher solubility was observed in AG enriched samples in both the storage temperatures. Under refrigerated condition after 5 months, 3AGFPP and 4.5AGFPP recorded 63.5% and 64.5% solubility, respectively, compared to FPP (59.7%).

Lower moisture content observed in the Aloe gel enriched powders could have contributed to the increase in dissolution ability. A similar observation was recorded by Goula et al., (2005) in tomato powder, wherein an inverse co-relation was observed between moisture content and solubility of tomato powder.

• **Rehydration ratio**

Rehydration has been defined as a measure of injury to the material (Okos et al., 1992), with higher rehydration values indicating lower damage and vice versa. Rehydration is a complex process aimed at restoration of raw material properties, when dried material is contacted with water (Lewicki, 1998).

Significantly higher rehydration ratios of 3.75 and 3.76 were recorded by the 3AGFPP and 4.5AGFPP compared to 3.34 in FPP on the initial day (Fig 5.2.5). Rehydration ratios of 3.2, 2.8 and 1.8 have been reported for dehydrated peach, plum and apricot, respectively (Sharma et al., 2011).

A reduction in RR was seen on storage especially in samples stored under ambient conditions. End of 5m storage under refrigerated conditions was marked by 11.5% and 7.6% higher RR in 4.5AGFPP and 3AGFPP samples, respectively, compared to control. Similar reduction in RR on storage has also been reported in other dehydrated fruits (Sharma et al., 2011).
Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions.
The authors attributed this phenomenon to chemical and structural changes that occur during storage leading to reduction in water binding sites.

- **Loose and tapped bulk density**

  Bulk density (BD) is an important physicochemical parameter that has a direct impact on the packaging requirement of powders. It provides indication of physical properties like cohesion and porosity and may affect flowability and storage stability (Moreyra and Peleg, 1980). It has been reported to have significant co-relation with the powder moisture content, with the powders having higher moisture having larger bulk volume and lower bulk density. Product with lower moisture content would be less sticky and produce a free flowing powder of higher BD.

  The fresh fruit powder samples recorded a loose bulk density (LBD) ranging from 0.71 in FPP to 0.81 in 4.5AGFPP (Fig 5.2.6a). The tapped bulk density (TBD) of FPP was 0.76, lower than AG enriched papaya powders (0.81-0.82) (Fig 5.2.6b). Jittanit et al., (2011) reported the bulk density of spray dried tamarind powder to range from 0.47-0.81.

  Both TBD and LBD were found to decrease on storage in all samples. A 21.5% higher LBD was recorded in 3AGFPP and 4.5AGFPP compared to control at the end of 5m refrigerated storage. In case of TBD, highest value of 0.79 was seen in 4.5AGFPP sample significantly higher than control (0.70) and 1.5AGFPP (0.71) and 3AGFPP (0.76) samples.

- **Compressibility and flowability**

  Compressibility, calculated from loose and tapped bulk densities is another important parameter. A higher degree of compressibility indicates a lower flowable material and vice versa.
Fig 5.2.6 Effect of Aloe gel enrichment on loose bulk density (a) and tapped bulk density (b) of formulated papaya powders on storage

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions
In the present study, higher compressibility value (Fig 5.2.7) resulted in lower degree of flowability (Table 5.2.1) in FPP both on the initial day and after 3 and 5 months. The FPP samples stored under ambient conditions for 3m and 5m fell into the category from fair to poor, whereas, with an increase in content of AG powder the samples demonstrated good to excellent flowability. After 5m of refrigerated storage, 3AGFPP and 4.5AGFPP samples continued to exhibit excellent flowability, whereas, in control samples only a fair degree of flowability was recorded.

5.4.2.2 Chemical characteristics

- *Titrable acidity*

  Titrable acidity (Fig 5.2.8) ranged from 2.05% in FPP sample to 2.46% in 4.5AGFPP sample. Higher titrable acidity in samples with higher concentration of Aloe gel powder could be attributed to the presence of various acids such as citric acid, tartaric acid and malic acid that have been reported to be present in the Aloe gel (Joshi and Iyengar, 1978). Titrable acidity of 2.62% has been reported for apple powders (Sharma and Kaushal, 2003).

  On storage, acidity increased in all powder samples. However, AG enriched papaya powders, 3AGFPP and 4.5AGFPP, recorded lower values of 2.62% and 2.57% after 5 months of refrigerated storage, respectively, compared to control (2.75%).

  Formation of acids due to interconversion of sugars and other chemical reactions during storage could have resulted in an increase in titrable acidity. Similar increase in TA on storage has also been reported in guava powder (Verma *et al.*, 2013) and in dehydrated aonla fruit (Dahiya and Dhawan, 2003).

- *Total soluble solids*

  Fig.5.2.9 presents the results of the total soluble solids content in AG enriched formulated papaya powders.
Fig 5.2.7 Effect of Aloe gel enrichment on compressibility of formulated papaya powders on storage

Table 5.2.1 Effect of Aloe gel enrichment on flowability of formulated papaya powders on storage

<table>
<thead>
<tr>
<th>Samples</th>
<th>0d</th>
<th>3MA</th>
<th>5MA</th>
<th>3MR</th>
<th>5MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP</td>
<td>Excellent</td>
<td>Passable</td>
<td>Poor</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>1.5AGFPP</td>
<td>Excellent</td>
<td>Fair</td>
<td>Passable</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>3AGFPP</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>4.5AGFPP</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions
Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFP), 3% (3AGFP) and 4.5% (4.5AGFP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions
The TSS recorded by FPP, 1.5AGFPP, 3AGFPP and 4.5AGFPP samples were found to be 42.6, 44.3, 46.3 and 47.5, respectively, on the initial day. A study by Kandhasamy et al., (2012) reported the TSS of non foam and foam - mat dried papaya powders to range from 11.6-12.7 °Brix. A higher TSS recorded in the present study for papaya powders could be attributed to the addition of maltodextrin which was used as a carrier agent. Similar observations of increased TSS with the use of maltodextrin during dehydration have also been reported for passion fruit powder (da Costa et al., 2013). The Aloe gel enriched powders recorded significantly higher TSS compared to control on the initial day itself, which could be contributed by various soluble substances present in the spray dried AG powder.

Reduction in TSS on storage was seen in the samples, with the degree of reduction being greater in samples stored under ambient conditions. The reduction in TSS upon storage has also been reported for other powders. Aruna et al., (1998), reported a significant decrease in TSS on storage from 58.67 °Brix to 57.67 °Brix in cereal-based papaya powder after 3 months storage. A study by Firoz et al., (2004) reported a reduction in TSS of pulse based papaya powders from 61.8 to 60.5 °Brix on storage for two months.

Aloe gel enriched samples (3AGFPP and 4.5AGFPP) recorded significantly higher TSS of 41.4 °Brix and 43.7 °Brix, respectively, after 5m ambient storage compared to FPP (39.4 °Brix). Under refrigerated conditions, the FPP samples recorded TSS of 40.9 °Brix significantly lower than 3AGFPP (44.6 °Brix) and 4.5AGFPP (46.4 °Brix).

- Non enzymatic browning

Non enzymatic browning (NEB) is an important parameter which indicates the quality of the product upon storage. Browning is a result of chemical process which is a function of the temperature and structure of material during processing and storage. Several factors such as temperature, moisture, carboxyl compounds,
organic acids, air, oxygen, sugars have been reported to be responsible for NEB in powders (Muralikrishna et al., 1969).

Fresh papaya powders recorded a NEB of 0.08-0.09 (Fig 5.2.10). Topuz et al., (2009) reported the NEB of paprika powders dried under different conditions to range from 0.05-0.13. Lemon powders were reported to record an NEB ranging from 0.12-0.14 on the initial day of storage (Sharma et al., 2009).

NEB of the samples increased on storage with maximum increase observed in samples stored under ambient conditions. FPP samples showed 43% higher NEB compared to 4.5AGFPP samples after 3 and 5 months of refrigerated storage, demonstrating that AG enrichment helped in reducing degree of browning. Similar increase in NEB on storage has also been reported in paprika (Topuz et al., 2009) and lemon (Sharma et al., 2009) powders. The formation of brown polymers on storage could be attributed to the reaction between aldehydes, ketones and reducing sugars with the amino acids and proteins present in the powders. Another reason could be the oxidative degradation of phenolics and ascorbic acid (Sharma et al., 2009).

Lower degree of browning obtained for Aloe gel incorporated papaya powders observed in the present study, could also be attributed to the anti-browning efficacy of Aloe gel (Chauhan et al., 2011).

5.4.2.3 Color index

The L, a* and b* values were found to range from 53.9-57.9, 14-16.5 and 21-21.8, respectively, showing non-significant differences between the samples on the initial day (Table 5.2.2). Correspondingly, no significant differences were recorded in the initial range of color index (12.3-13.5) (Fig 5.2.11). On storage, a steady reduction in the L, a* and b* values were observed in all the samples, with samples stored under ambient conditions showing greater degree of reduction.
Fig 5.2.10 Effect of Aloe gel enrichment on non enzymatic browning (O.D) of formulated papaya powders on storage

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels stored for 3 months and 5 months at ambient (3MA and 5MA) and refrigerated (3MR and 5MR) conditions
Table 5.2.2 Effect of Aloe gel enrichment on L*, a* and b* values of formulated papaya powders on storage

<table>
<thead>
<tr>
<th>Storage period</th>
<th>FPP</th>
<th>1.5AGFPP</th>
<th>3AGFPP</th>
<th>4.5AGFPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0d</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>53.9 ± 0.72b</td>
<td>56.1 ± 0.34a</td>
<td>57.9 ± 0.56a</td>
<td>56.8 ± 0.72a</td>
</tr>
<tr>
<td>a*</td>
<td>14.2 ± 0.64b</td>
<td>15.5 ± 0.51a</td>
<td>15.3 ± 0.43a</td>
<td>16.5 ± 0.78a</td>
</tr>
<tr>
<td>b*</td>
<td>21.1 ± 0.51a</td>
<td>21.7 ± 0.37a</td>
<td>20.8 ± 0.61a</td>
<td>21.5 ± 0.62a</td>
</tr>
<tr>
<td>3MA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>50.9 ± 0.54c</td>
<td>53.6 ± 0.41b</td>
<td>53.9 ± 0.25b</td>
<td>54.9 ± 0.35a</td>
</tr>
<tr>
<td>a*</td>
<td>12.1 ± 0.62c</td>
<td>13.3 ± 0.67b</td>
<td>13.8 ± 0.45b</td>
<td>15.2 ± 0.51a</td>
</tr>
<tr>
<td>b*</td>
<td>20.4 ± 0.58b</td>
<td>20.9 ± 0.72b</td>
<td>21.4 ± 0.53a</td>
<td>21.9 ± 0.42a</td>
</tr>
<tr>
<td>5MA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>50.4 ± 0.31b</td>
<td>51.3 ± 0.46b</td>
<td>52.1 ± 0.38a</td>
<td>52.2 ± 0.44a</td>
</tr>
<tr>
<td>a*</td>
<td>10.6 ± 0.53c</td>
<td>13.1 ± 0.52b</td>
<td>13.6 ± 1.12b</td>
<td>14.8 ± 0.32a</td>
</tr>
<tr>
<td>b*</td>
<td>20.2 ± 0.61c</td>
<td>21.4 ± 0.37b</td>
<td>21.5 ± 0.56b</td>
<td>22.3 ± 0.59a</td>
</tr>
<tr>
<td>3MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>52.2 ± 0.29b</td>
<td>54.9 ± 0.54b</td>
<td>56.3 ± 0.81a</td>
<td>56.5 ± 0.72a</td>
</tr>
<tr>
<td>a*</td>
<td>13.8 ± 0.57d</td>
<td>14.4 ± 0.76c</td>
<td>15.3 ± 0.36b</td>
<td>16.1 ± 0.72a</td>
</tr>
<tr>
<td>b*</td>
<td>20.7 ± 0.72a</td>
<td>21.0 ± 0.35b</td>
<td>20.8 ± 0.44a</td>
<td>21.1 ± 0.72a</td>
</tr>
<tr>
<td>5MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L*</td>
<td>51.6 ± 0.72b</td>
<td>53.4 ± 0.26b</td>
<td>55.3 ± 0.53a</td>
<td>55.8 ± 0.41a</td>
</tr>
<tr>
<td>a*</td>
<td>13.1 ± 0.72c</td>
<td>14.4 ± 0.52b</td>
<td>14.9 ± 0.65b</td>
<td>15.8 ± 0.27a</td>
</tr>
<tr>
<td>b*</td>
<td>22.3 ± 0.72a</td>
<td>22.1 ± 0.58a</td>
<td>21.2 ± 0.56b</td>
<td>21.4 ± 0.36b</td>
</tr>
</tbody>
</table>

Different alphabets in a row indicate significant difference (P<0.05)

Control papaya powder samples showed significantly lower a* values compared to 3% and 4.5% AG enriched papaya powders both under ambient and refrigerated storage condition. Since a* values mainly indicates the red to orange color of papaya powder, a loss in the color could be evidenced which was confirmed through sensory acceptability testing. A reduction in L, a* and b* values on storage has also been reported for freeze dried and refractive window dried paprika powder (Topuz et al., 2009).

The color index followed a decreasing trend on storage, with a greater reduction observed in control and in samples stored under ambient conditions. Highest reduction in CI was observed in the FPP samples stored for 5m under ambient conditions (10.4). Samples enriched with AG at 4.5% level were found to be best in terms of minimal changes in CI on storage, with the CI being 13.5 and 13.2 after 3m and 5m of refrigerated storage, respectively.
5.4.2.4 Microbial quality

Microbial quality of the samples was evaluated in terms of yeast and mold count (Table 5.2.3).

On the initial day, the samples recorded yeast and mold counts (YMC) ranging from 3.82-4.12 log CFU/g, significantly lower for 3AGFPP and 4.5AGFPP. An increase in yeast and mold count on storage was observed for FPP and 1.5AGFPP samples, with higher count recorded in samples stored under ambient conditions. Whereas, in 3% and 4.5% AG enriched samples, a reduction in yeast and mold count was seen after 3m and 5m storage, both under ambient and refrigerated conditions. Lowest YMC of 3.04 log CFU/g was recorded in 4.5AGFPP after 5m storage at refrigerated temperature. This reduction in YMC on storage could be attributed to the potent antifungal efficacy of Aloe gel described in several studies (Saks and Barkai Golan, 1995; Jasso de Rodriguez, 2005).

Table 5.2.3 Effect of Aloe gel enrichment on yeast and mold count (log CFU/g) of formulated papaya powders on storage

<table>
<thead>
<tr>
<th>Samples</th>
<th>0d</th>
<th>3MA</th>
<th>5MA</th>
<th>3MR</th>
<th>5MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP</td>
<td>4.12 ± 0.36a</td>
<td>5.34± 0.43a</td>
<td>6.57± 0.37a</td>
<td>4.56± 0.22a</td>
<td>5.21± 0.32a</td>
</tr>
<tr>
<td>1.5AGFPP</td>
<td>4.06± 0.32a</td>
<td>4.92± 0.25b</td>
<td>5.69± 0.42b</td>
<td>4.24± 0.31a</td>
<td>4.87± 0.41b</td>
</tr>
<tr>
<td>3AGFPP</td>
<td>3.95± 0.21b</td>
<td>3.54± 0.54c</td>
<td>3.65± 0.36c</td>
<td>3.12± 0.41b</td>
<td>3.17± 0.45c</td>
</tr>
<tr>
<td>4.5AGFPP</td>
<td>3.82± 0.31b</td>
<td>3.17± 0.31d</td>
<td>3.45± 0.31d</td>
<td>2.89± 0.53c</td>
<td>3.04± 0.36c</td>
</tr>
</tbody>
</table>

Values expressed as Mean ± S.D;
Different alphabets in a column indicate significant difference (P<0.05).

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels; 3MA & 5MA – samples stored for 3 and 5 months, respectively, under ambient conditions; 3MR & 5MR - samples stored for 3 and 5 months, respectively, under refrigerated conditions.
5.4.2.5 Sensory acceptability

All the samples recorded scores ranging from 4-5 for the parameters evaluated on the initial day, indicating good to very good acceptability (Fig 5.2.12a and b).

A reduction in the scores was seen in all parameters on storage. The control samples for 3m and 5m under ambient conditions recorded significantly lower scores compared to 3AGFPP and 4.5AGFPP. Lower scores for appearance observed in the FPP samples were due to increased lumpiness which could be correlated to the higher moisture content and degree of caking observed in these samples. Lower moisture content in AG enriched powders could have contributed to the free flowing nature of the powder with minimal lumping.

Due to increased lump formation, mouthfeel of the FPP samples was affected with the powder becoming increasingly sticky and coarse. On the other hand, the 3 and 4.5% AG enriched powders recorded higher scores since the powders were not sticky and fine.

Mouthfeel also adversely affected the flavor of the FPP samples thereby recording lower scores, since coating over the tongue is a prerequisite for flavor perception in powders. AG enriched samples were found to uniformly coat the tongue thereby promoting better flavor perception and hence recorded higher scores. Lower scores for color obtained in the control samples especially under ambient storage could be correlated to the reduced color index, lower a* value and higher browning, compared to the Aloe gel enriched samples.

The flavor and overall acceptability of the FPP samples was found to become 2.5 by the end of 5m ambient storage, significantly lower than 3AGFPP and 4.5AGFPP which recorded overall acceptability scores of 3 and 3.5 after 5m of ambient storage and 4 after 5m refrigerated storage.
Fig 5.2.12a Effect of Aloe gel enrichment on sensory acceptability of formulated papaya powders on 0d (i) and after storage under ambient conditions for 3 months (ii) and 5 months (iii)

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels
Fig 5.2.12b Effect of Aloe gel enrichment on sensory acceptability of formulated papaya powders on 0d (i) and after storage under refrigerated conditions for 3 months (ii) and 5 months (iii)

Formulated papaya powders with Aloe gel added at 0% (FPP), 1.5% (1.5AGFPP), 3% (3AGFPP) and 4.5% (4.5AGFPP) levels
5.4.3 Effect of Aloe gel enrichment on the quality of papaya RTS beverage

5.4.3.1 Selection of level of Aloe gel enrichment for papaya RTS beverage

The various beverage blends of Aloe gel and papaya formulated were initially evaluated for sensory acceptability (Table 5.3.1). With regard to color, 30 AGPB recorded significantly higher score of 4.78 compared to control (4.57). This could be attributed to the appealing brighter color of 30 AGPB. Similarly, in terms of taste and flavor, 30 AGPB recorded significantly higher scores compared to control. The lower score for control sample could be due to its predominantly sweet taste which was not well appreciated by the panelists when given in the generally consumed portion size (100 ml). A more balanced taste was witnessed in the AG enriched samples, which was found to increase with increase in percentage of AG.

The sensory scores for consistency ranged between 4.75 to 4.85 which was not significantly different. The overall acceptability scores indicated 20 AGPB and 30 AGPB to be highly acceptable with scores of 4.64 and 4.71, respectively, significantly higher than 10 AGPB and control. A major problem with commercial Aloe gel juice and beverages is adverse/bitter taste, which could be successfully avoided in the present study with suitable processing operation, with addition of spices and blending with papaya. Literature studies on Aloe gel administration to human subjects recommend about 30 ml consumption per day. Since the average consumption of a beverage for an individual could be about 100ml and also because addition of AG at higher levels were more acceptable, 30 AGPB was chosen for further storage studies.
Table 5.3.1 Sensory acceptability of papaya – Aloe gel beverage (AGPB) blends

<table>
<thead>
<tr>
<th>Sample</th>
<th>Colour</th>
<th>Taste</th>
<th>Flavor</th>
<th>Consistency</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% AGPB/PB</td>
<td>4.57 ± 0.39b</td>
<td>4.41 ± 0.36b</td>
<td>4.35 ± 0.44c</td>
<td>4.85 ± 0.22a</td>
<td>4.35 ± 0.41c</td>
</tr>
<tr>
<td>10% AGPB</td>
<td>4.58 ± 0.44b</td>
<td>4.51 ± 0.34b</td>
<td>4.58 ± 0.34b</td>
<td>4.75 ± 0.38a</td>
<td>4.58 ± 0.44b</td>
</tr>
<tr>
<td>20% AGPB</td>
<td>4.71 ± 0.46a</td>
<td>4.71 ± 0.36a</td>
<td>4.71 ± 0.24a</td>
<td>4.74 ± 0.22a</td>
<td>4.64 ± 0.34a</td>
</tr>
<tr>
<td>30% AGPB</td>
<td>4.78 ± 0.36a</td>
<td>4.71 ± 0.36a</td>
<td>4.85 ± 0.22a</td>
<td>4.78 ± 0.24a</td>
<td>4.71 ± 0.36a</td>
</tr>
</tbody>
</table>

PB (Papaya beverage) and 10%, 20% & 30% AGPB (Aloe gel papaya beverage blends) is Aloe gel added at 10%, 20% and 30% levels, respectively.

The control papaya beverage was designated as PB and 30% Aloe gel-papaya beverage blend as AGPB. The results of the periodic analysis of various parameters on storage are discussed in the following section.

5.4.3.2 Effect of storage on the quality of formulated functional Aloe gel papaya beverage blend

a) Chemical characteristics

The chemical characteristics of the beverage samples are given in table 5.3.1.

- Titrable acidity

The initial titrable acidity of the samples was found to be 0.27%. With an increase in storage time, the acidity was found to increase. This could be attributed to the decomposition of fermentable substrate, especially, carbohydrates in the fruits and added sugar, thereby increasing the acidity (Fasoyiro et al., 2005). PB was found to exhibit a higher increase in acidity to 0.62% after 150d of storage. Whereas, AGPB recorded significantly (P<0.05) lower acidity throughout the storage period with the value recorded as 0.54% at the end of storage. Increase in acidity on storage has been also reported in other beverages such as jamun (Das, 2009) and fruit flavored drinks (Fasoyiro et al., 2005).
Table 5.3.2 Quality characteristics of the developed functional beverages on storage

<table>
<thead>
<tr>
<th>Sample</th>
<th>Storage period (days)</th>
<th>Titrable acidity (%)</th>
<th>Total soluble solids (° Brix)</th>
<th>Total sugars (mg/100ml)</th>
<th>Reducing sugars (mg/100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB</td>
<td>0</td>
<td>0.27 ± 0.04f</td>
<td>15.6 ± 0.41d</td>
<td>16.7 ± 0.6d</td>
<td>6.7 ± 0.2e</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.37 ± 0.03e</td>
<td>16.4 ± 0.55c</td>
<td>21.6 ± 0.8c</td>
<td>8.6 ± 0.2c</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.49 ± 0.04d</td>
<td>15.9 ± 0.25c</td>
<td>25.7 ± 1.4b</td>
<td>10.3 ± 0.4a</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>0.58 ± 0.03b</td>
<td>18.4 ± 0.3a</td>
<td>27.8 ± 1.4a</td>
<td>10.6 ± 0.4a</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>0.62 ± 0.01a</td>
<td>18.7 ± 0.25a</td>
<td>29.1 ± 1.1a</td>
<td>11.1 ± 0.3a</td>
</tr>
<tr>
<td>AGPB</td>
<td>0</td>
<td>0.27 ± 0.04f</td>
<td>15.7 ± 0.25d</td>
<td>17.2 ± 0.3d</td>
<td>6.9 ± 0.1e</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.32 ± 0.02e</td>
<td>17.6 ± 0.41b</td>
<td>18.2 ± 0.7d</td>
<td>7.3 ± 0.2d</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>0.41 ± 0.02a</td>
<td>16.3 ± 0.25c</td>
<td>21.7 ± 0.7c</td>
<td>8.7 ± 0.2c</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>0.48 ± 0.01d</td>
<td>17.1 ± 0.11b</td>
<td>23.2 ± 1.3c</td>
<td>9.0 ± 0.2c</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>0.54 ± 0.02c</td>
<td>17.4 ± 0.21b</td>
<td>24.5 ± 1.5b</td>
<td>9.5 ± 0.3b</td>
</tr>
</tbody>
</table>

PB – Papaya beverage; AGPB – 30% Aloe gel papaya beverage blend; Values are mean ± SD of three replications. Different alphabets in a column indicate significant difference at P<0.05

- Total soluble solids

Total soluble solids on the initial day were similar in PB (15.6 °Brix) and AGPB (15.7 °Brix). An increase in TSS was observed on storage. Similar to titrable acidity, PB recorded a higher TSS throughout storage compared to AGPB. A significantly (P<0.05) lower TSS of 18.7°Brix was recorded in the AGPB compared to PB (25.2 °Brix). The increase in TSS observed on storage could be due to the conversion of polysaccharides to simple sugars. As discussed below, in the present study too, an increase in total sugars was observed on storage. Support data /study.
• Total and reducing sugars

The PB beverage recorded an increase in total sugar content from 16.7% on the initial day to 29% at the end of storage period. This increase was lesser in case of AGPB from 17.2% to 24.5% from 0d to 150d of storage. Similarly the initial reducing sugars content of the beverages was found to range from 6.7%-6.9% which increased to 11.1% and 9.5% in PB and AGPB, respectively. An increase in reducing sugars has also been reported in case of whey-based banana herbal beverage during storage. This is attributed to the conversion of non-reducing sugars to reducing sugars (Yadav et al., 2010).

• Non-enzymatic browning

Another important parameter critical during storage is non-enzymatic browning (NEB) which has been reported to be caused due to Maillard reaction and degradation of pigments. An increase in NEB on storage was seen in both the samples. An increase in NEB has also been reported in sand pear apple juice beverage blends on storage (Raj et al., 2011). However, the extent of browning was significantly higher in the PB samples compared to AGPB (Fig 5.2.10). The Aloe gel enriched beverage (AGPB) recorded a 35% lower NEB which could be attributed to the beneficial effect of Aloe gel addition. Aloe gel has been reported to have an anti browning functionality when applied as a coating on whole (Martinez-Romero et al., 2006) and minimally processed fruits (Chauhan et al., 2011).

b) Instrumental color

The color of the papaya RTS beverage samples was determined in terms of Hunter L*, a* and b* values (Table 5.3.3) and expressed as color index (Fig 5.2.11). In the papaya beverage, the predominant color is orange-red and hence +a* value which denotes redness is the most important parameter, followed by +b* which denotes yellowness.
Fig 5.3.2 Effect of Aloe gel enrichment on non enzymatic browning (NEB) of papaya RTS beverage

Fig 5.3.3 Effect of Aloe gel enrichment on color index (CI) of papaya RTS beverage

PB-Papaya beverage; AGPB-Aloe gel papaya beverage blend
Table 5.3.3 Effect of Aloe gel enrichment on color index (CI) of papaya RTS beverage

<table>
<thead>
<tr>
<th>Sample</th>
<th>Storage period (days)</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB</td>
<td>0</td>
<td>45.6 ± 1.16a</td>
<td>1.63 ± 0.12b</td>
<td>9.23 ± 0.28d</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>43.2 ± 1.21b</td>
<td>1.36 ± 0.21d</td>
<td>8.83 ± 0.40e</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>44.5 ± 0.73a</td>
<td>0.91 ± 0.08e</td>
<td>8.10 ± 0.41f</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>42.1 ± 0.81b</td>
<td>0.69 ± 0.21e</td>
<td>7.91 ± 0.08f</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>41.2 ± 0.52b</td>
<td>0.61 ± 0.14e</td>
<td>7.83 ± 0.26f</td>
</tr>
<tr>
<td>AGPB</td>
<td>0</td>
<td>46.4 ± 0.66a</td>
<td>2.36 ± 0.33a</td>
<td>11.9 ± 0.37a</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>41.5 ± 1.02b</td>
<td>2.06 ± 0.12b</td>
<td>12.3 ± 0.69a</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>45.1 ± 0.36a</td>
<td>1.71 ± 0.26c</td>
<td>11.4 ± 0.75b</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>44.5 ± 0.33a</td>
<td>1.53 ± 0.24c</td>
<td>10.3 ± 0.06c</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>44.1 ± 0.12a</td>
<td>1.31 ± 0.21d</td>
<td>9.31 ± 0.17d</td>
</tr>
</tbody>
</table>

PB (Papaya beverage); AGPB (Aloe gel papaya beverageblend); Values are mean ± SD of three replications. Different alphabets in a column indicate significant difference at P<0.05

A higher a* value of 2.36 was recorded in the AGPB compared to PB (1.63) on the initial day. Correspondingly, a higher color index of 4.38 was recorded by AGPB, compared to PB (3.89).

A degradation of red color was witnessed on storage for both the samples. The AGPB samples could maintain higher a* scores of 1.31, significantly higher than PB (0.61) by the end of storage period. A decreasing trend was also witnessed in b* values from 9.23 to 7.83 in PB and from 11.9 to 9.31 AGPB, from the initial to final day of storage, respectively. The AGPB samples successfully maintained significantly higher b* value during storage, thereby resulting in a brighter and
more acceptable product. Higher CI of 2.86 was also seen in the AGPB samples, significantly higher than PB (1.85).

Better color in the AGPB could be attributed to the lower degree of browning seen in these samples.

c) Microbial quality

Both the beverage samples were found to be free from microbial proliferation till the end of storage period in terms of standard plate count and yeast and mold count, thereby indicating its fitness for consumption even after 5 months of storage. This could be attributed to the effective pasteurization treatment, addition of citric acid which acts as a preservative and also due to the addition of spices which are known to possess good antimicrobial activity (Suhaj, 2006; Tajkarimi et al., 2010).

d) Sensory acceptability

The effect of storage on the sensory acceptability of PB and AGPB is depicted in figure 5.3.4 as web plots. No significant differences were observed between the samples initially, except in terms of taste and flavor wherein AGPB scored higher due to its balanced taste. A gradual reduction in sensory attributes was witnessed particularly after 90d of storage. This could be due to the changes observed in TSS and acidity, parameters related to taste and flavour.
Fig. 5.3.4 Sensory acceptability of the developed beverages PB (papaya beverage) and AGPB (Aloe gel papaya beverage blend) after 0d (A), 90d (B) and 150d (C) of storage
Changes in consistency and color were lesser. On comparison, AGPB retained a higher sensory quality till 150d of storage with an overall acceptability score of 4 (good), whereas, the score of 2.9 in PB indicated poor acceptability. Sensory shelf life of PB was found to be 90d and for AGPB, it was 150d. Results, thus, indicated the beneficial effect of Aloe gel incorporation in maintaining a good sensory quality for a longer period in the formulated RTS beverage.

5.5 Conclusions

Enrichment of naturally fermented dahi with spray dried powder of Aloe gel resulted in better product quality in terms of physicochemical, microbial, textural and sensory characteristics. The AG dahi also stored better at 4°C for 7 days. The present investigation demonstrates the feasibility of incorporating Aloe gel powder to dairy products in particular. This would not only help in improving the product quality characteristics, but would also bestow functional benefits to the product. Further optimization of the product in terms of addition of other stabilizers and alternative sweeteners can be further explored.

In papaya powder, the efficacy of Aloe gel in maintaining desirable physicochemical and functional characteristics along with better microbial and sensory quality during storage was demonstrated. Incorporation of these powders into suitable products could be explored.

This study results also revealed various beneficial effects of Aloe gel incorporation on the quality characteristics and shelf stability of spiced papaya beverage compared to the control beverage. Further enhancement of value could be carried out by fortification/ or by addition of nutraceuticals. Nutraceuticals from botanical origin have a great scope to offer varied health benefits such as improved anti-oxidant profile and protection against various chronic metabolic diseases such as diabetes.