PROCESS OPTIMISATION AND QUALITY EVALUATION OF FRUIT PULP BASED YOGHURTS

By

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(2017-16-006)

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF HORTICULTURE

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DECLARATION

I, hereby declare that the thesis entitled "**Process optimization and quality evaluation of fruit pulp based yoghurts**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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Certified that the thesis entitled **"Process optimization and quality evaluation of fruit pulp based yoghurts"** is a bonafide record of research work done independently by **Ms. Lovely Mariya Johny** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

Acidification of milk by fermentation is one of the oldest methods of preserving milk solids. Fermented products vary considerably in their composition, flavour and texture according to the nature of fermenting organisms, the type of milk and the manufacturing process. The introduction of fermented milk products into the diet of man is thought to date back to the dawn of civilization, as reference is made to them in both the Bible and the sacred books of Hinduism. It has been supported by early civilization such as Samarians, Babylonians, Pharoes and Indians who were well advanced in animal husbandry (Robinson *et al.,* 1999).

The word yoghurt is derived from the Turkish word 'Jugurt' (Nathanon, 2002). Yoghurt is acidified, custard like semisolid dairy product produced by fermenting pasteurised milk with starter culture containing lactic acid bacteria (Munzur *et al*., 2004). It is a fermented product made from heat treated and standardised milk mixed by the activity of synbiotic blend of *Streptococcus thermophilus* and *Lactobacillus delbruckii* sub sp. *Bulgaricus* (Chandan *et al*., 2008).

Yoghurt is easily digested, has high nutritional value, and is a rich source of carbohydrates, protein, fat, vitamins, calcium and phosphorus (Sanchez *et al*., 2000). Yoghurts are well known for its nutritional value, therapeutic effects and functional properties. It is an excellent source of protein, calcium, potassium, vitamin B2, B6 and B12 (Wang *et al*., 2013).It is also very effective in curing diarrhoea, dysentery, constipation, lowering blood cholesterol and cancer (Roy *et al*., 2015).

Yoghurt is a safer product with unique flavor which has a high consumer preference. Hence consideration is given by nutritionists to incorporate inexpensive source of nutrients to make it an almost complete food (Hui, 1993). Fruits and vegetables are rich sources of vitamins, minerals, fibres and antioxidants, therefore can be used in making value added products (Con *et al*., 1996). Yoghurt is a good source of calcium, proteins and probiotic bacteria, while fruit is rich in vitamins, minerals, fruit sugars and dietary fibers. The two combined provide excellent and delicious food which is very healthy, and at the same time a favorite delicacy. Yoghurt prepared by adding fruits will improve the sensory and nutritional attributes.

Fruit yoghurts are popular among masses and particularly children who dislike the flavour of plain yoghurt. This modification enhances the yoghurt flavour and provides variety. Addition of fruits enhances the flavour and taste of yoghurts. Pectin and fructose of fruits improves the consistency and viscosity of yoghurts.

In the present study, underexploited and locally available fruits such as jackfruit (*Koozha* type), Banana (*Palayamkodan*), papaya, sapota and guava were used for yoghurt preparation. Fruits with their high profile nutrients, unique flavour, taste and health promoting qualities fix into the category of new functional foods, often labelled as super foods. Fruit yoghurts is widely popular due to its partially masked acetaldehyde flavour compared to plain yoghurt (Tamime and Robinson, 1999).

Functional foods are consumed not only to serve nutrition, beyond that they will provide positive health benefits. Consumer's interest towards functional food has increased (Hasler, 1998) and now a day's people are more interested in foods enriched with functional ingredients.

In the present study two functional ingredients such as garden cress seed and flax seed were incorporated with fruit pulp based yoghurts. Garden cress seed is a food supplement which contains several nutraceutical components with high iron content. The seeds have fair amount of protein, fat, dietary fibre and calcium (Sood and Sharada, 2002). Consumption of garden cress seed helps to prevent hypertension, renal diseases, cancer. It also act as memory enhancer and laxative for gastrointestinal diseases. Flaxseed is a rich source of healthy fat, antioxidants and fibre. The seeds contain protein, lignans and the essential fatty acid alphalinolenic acid, also known as ALA or omega-3. The nutrients in flaxseed help to lower the risk of diabetes, cancer and heart disease.

Development of different fruit pulp based yoghurts and with the addition of functional ingredients in to it enhances the nutritional properties and is beneficial to improve human health. Hence, the present study entitled "Process optimization and quality evaluation of fruit pulp based yoghurts" was undertaken with the following objectives

1. To standardise fruit pulp based yoghurt with jackfruit *(Koozha type),* papaya, sapota, guava and Banana *(Palayamkodan)*

2. To standardise functional ingredient incorporated fruit yoghurts

3. To evaluate the physicochemical, nutritional, organoleptic and shelf life qualities of the selected yoghurts

Review of Literature

2. Review of literature

The relevant literature of the study entitled "Standardisation and quality evaluation of fruit pulp based yoghurts" is briefly reviewed under the following subtitles.

2.1. Yoghurt - A fermented milk product

2.2. Diversification in yoghurt

2.3. Quality attributes of yoghurts

2.3.1. Physicochemical and nutritional attributes of yoghurts

2.3.2. Organoleptic qualities of yoghurts

2.3.3. Microbial aspects of yoghurts

2.4. Health benefits of yoghurt

2.1. Yoghurt - A fermented milk product

Yoghurt is a fermented milk product obtained from milk or milk products by the lactic acid fermentation through the action of *Streptococcus salivarius* subsp. *thermophilus,Lactobacillus delbrueckii* subsp. *Bulgaricus* (Champagne *et al.,* 2005). When a sufficient quantity of lactic acid is produced the milk coagulates and this coagulated milk is called yoghurt. Yoghurt can be defined as a food produced by culturing optional dairy ingredients such as milk, skimmed milk, cream etc. with lactic acid producing bacteria, *Lactobacillus delbruecki* subsp. *Bulgaricus* and *Streptococcus thermophiles.* Fermented milk with the presence of lactic acid bacteria gives a distinctive taste and aroma for the products (Chandan and Kilara, 2011).

The process of yoghurt making is an ancient craft, which dates back to thousands of years, but it is assumed that prior to nineteenth century, the various stages involved in the production of yoghurt were little understood. The uniqueness of yoghurt is attributed to symbiotic fermentation (Vedamuthu, 1991). Use of fermented or cultured dairy products has been the essential part of our food consumption. Since ancient times, conversion of milk into cultured dairy products by souring with appropriate microbial inoculation was a common practice in every households. Yoghurt a traditional product of the Middle East countries is relatively a new introduction to Indian dietary system (Thompkinson and Sahal, 1995).

A fermented milk product has been defined by the International Dairy Federation as the milk product prepared from skimmed milk and with specific cultures. The micro flora is kept alive until sale to the consumers and may not contain any pathogenic germs. The fermented milk products used in different countries may be broadly classified into three categories such as moderately sour type with pleasant aroma e.g. cultured milk, sour and very high sour type eg. curd, yoghurt. Acid-cum alcohol in addition to lactic acid eg. kumiss and kefir (Gandhi, 2000).

The word yoghurt is derived from the Turkish word 'Jugurt' (Nathanon, 2002). Yoghurt is a product of the lactic acid fermentation of milk by addition of a starter culture containing *Streptococcus thermophilus*and *Lactobacillus delbrueckii*ssp. *Bulgaricus.* In some countries lesstraditional microorganisms, such as *Lactobacillus helveticus*and *Lactobacillus delbrueckii ssp. lactis* are sometimes mixed with the starter culture. There is a symbiotic relationship between the two species of bacteria *Lactobacillus bulgaricus* and *Streptococcus thermophilus* that's why there is more rapid acid development than in the single strain culture (Tamime, 2002).

According to Food Safety and Standards of India (FSSAI, 2010) yoghurt means a coagulated product obtained from toned milk, pasteurized or boiled milk by lactic acid fermentation through *Lactobacillus bulgaricus* and *Streptococcus thermophilus.* It may also contain cultures of *Bifidobacterium bifidus* and *Lactobacillus acidophilus,* if added. The product shall have smooth surface and custard like consistency with no whey separation.

Priyanka (2012) recommended that the use of 1.5 per cent inoculum and an incubation temperature of 43^0 C for 4 hour for preparation of yoghurt. The cultures used significantly influence the quality of yoghurt. Surajit (2015) reported that use of 2 per cent mixed culture of *Streptococcus* and *Lactobacillus* in the ratio of 3:1 to get good quality yoghurt with pleasing flavour. Francoise (2017) suggested the combination of 1:1 of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* for getting the desirable characteristics of yoghurt.

Venkateshaiah *et al.* (1994) found the use of yoghurt culture at 3 per cent level to be ideal in the preparation of yoghurt from modified milk containing groundnut protein isolate and buffalo milk. Chidanand (2003) observed that use of 2 per cent level of inoculum in egg white based yoghurt preparation was sufficient enough to obtain desired acidity of developed yoghurt.

Yoghurt is one of the most acceptable fermented dairy product all over the world nutritionally as well as organoleptically. According to Danone (2013) health benefits of yoghurt is well known for years ago.

Sugar present in milk known as lactose, through fermentation, is converted in to lactic acid which denatures protein and causes coagulation. It gives the unique texture and taste to yoghurt (Cheng, 2010). Fermentation of the milk sugar that is lactose, produces lactic acid which acts on milk protein to give yoghurt its texture and its characteristics tang. The yoghurt is preserved by its acidity (0.85-0.95 per cent acidity) which inhibits the growth of putrefactive or pathogenic bacteria (Amanze, 2011).

Milk of different mammals is used for the production of yoghurt in various region of the world. But majority of the industrialized production use cow's milk for the preparation of yoghurt (Hui, 1992).

Yoghurt made from cow's milk is widely consumed in the world. On the other hand, there is a desire for alternatives to cow's milk due to problems relating to gastrointestinal intolerance and market demand for the formulation of novel dairy products. Goat's milk is reported to have higher digestibility and lower allergenic properties compared to cow's milk (Ranadheera *et al.,* 2010). It also has a higher content of short chain fatty acids in milk fat, higher content of zinc, iron and magnesium and antibacterial characteristics (Slacanac *et al.,* 2012).

In Kazakhstan, goat, mare and camel milk are widely available. In last decades there is a growing demand on goat milk production. Compared to cow milk, goat milk has more health benefits. It improves the bioavailability of nutrients, strengthens immunity, reduces chronic diseases risks, strengthens bones and can be used for yoghurt production alone or as a mixture with cow, sheep and mare milk (Wang *et al.,* 2016).

The addition of goat's milk led to smaller changes in pH, a higher whiteness index, lower syneresis and a significant decrease in the firmness and consistence of the gel during storage. The physicochemical properties of yoghurts were correlated with gel microstructure. Sensory evaluation has shown that incorporating goat's milk had a significant impact on the whiteness, flavour, syneresis and lumpiness of yoghurts (Vargas *et al.,* 2008).

Yoghurt was traditionally being made from animal milk especially cow milk. However, over the years, milk from other sources has been used to make yoghurt. This development has been necessitated by a wide range of reasons such as allergies and affordability by consumers. Soy milk yoghurt has been adopted as substitute to cow's milk yoghurt especially by the low income earners due to its cheap raw materials as protein supplement at household level (Haenlein, 1996).

The type of milk used in various parts of world differs with food habits and popularity of the kinds of milk products consumed (Miller, 2000). In some cases, milk from different sources have been blended to improve sensory quality as reported by Kolapo and Olubamiwa (2012).

Use of goat milk has also become an opportunity to diversify the dairy market since it allows the development of added value to the fermented products with particular characteristics compared to cow milk. Different sources of milk differ in composition which after fermentation provides different types of flavoured yoghurt with different consistencies (Makanjoula, 2012).

Although cow is milk is an exceptionally good source of protein because of its excellent assortment of essential amino acid, it is expensive due to the rising cost of cow milk. Thus the development of soy-based milk is a cheap substitute for traditional cow milk yoghurt. There are currently many different ways of producing yoghurt and different modifications are continuously being developed and applied as reported by Farinde *et al*., (2010).

Soymilk is produced form the seed of the leguminous plant, *Glycine* max. Research has shown that soymilk has beneficial effects on health, sinceit is sugar free and cholesterol free with high quality protein. In addition, soymilk yoghurt improves bone health, reduces menopausal symptoms and risk of heart disease and certain cancers. These immense benefits have stimulated a lot of researchers on incorporating soybean into indigenous diets (Omogbai *et al.,* 2005).

Yoghurt produced from cow's milk is consumed in both developing and industrialized countries. However, the demand for alternatives to cow's milk is growing due to problems with allergenicity, desire for vegetarian alternatives and therefore interest in soy-based yoghurt has developed (Rachid *et al.,* 2002).

Mehran *et al.* (1996) described the recent trends on yoghurt research in Egypt which include the utilization of ultra-filtered buffalo buttermilk for yoghurt preparation. Attempt were also been made to replace normal yoghurt culture with *Entercocci* starter culture.

Yoghurt prepared from buffalo milk is white in colour and possesses firm body and slightly granular texture, whereas yoghurt prepared from cow is milk is less firm and smooth in texture. These differences are attributed to inherent variations in the protein make up of both the milks (Patel*et al.,* 2006).

Although fermented milk products such as yoghurt were originally developed simply as a means of preserving the nutrients in milk,it was soon discovered that, by fermenting with different microorganisms, an opportunity existed to develop a wide range of products with different flavours, textures, consistencies and, health attributes. The markets now offers a vast array of yoghurts to suit all palates and meal occasions. This versatility, together with their acceptance as a healthy and nutritious food, has ledto their widespread popularity across all population subgroups (Hjartaker *et al.*,2002).

2.2. Diversification in yoghurt

In recent years, the market for functional food has been increasing with the increasing consumer interest in adopting a healthy diet and the search for diversified food products. Food industry is interested in exploring new food products with good acceptance, improved nutritional values and health-promoting benefits. Yoghurt has been consumed as a safe and nutritious dairy food with increasing worldwide consumption (Batista *et al.,* 2015).

The accepted homeland of yoghurt is Middle Eastregion. To the communities living in those parts of the world, this type of fermented milk product is identified and known as natural/plain unsweetened yoghurt. The percapita annual consumption is high and in Bulgaria, in particular, is 31.5kg/ head/year(Tammine and Robinson, 2007).

In an attempt to improve yoghurt consumption in different markets of the world, the product has been mixed with a wide range of food ingredients in order to provide the consumer with flavours other than fruit types. Some examples may include the use of dried fruit and vegetable powders as additives which contain natural sources of pectin and vitamin C, and such yoghurts may have therapeutic effects for patients with digestive tract disorders (Arkhipova and Krasnikova, 1995).

Alternatively, carrot pulp and natural extracts obtained from raw vegetables have been used to flavour the yoghurt (Vesely *et al*., 1995).

Set yoghurt is a type of yoghurt prepared by fermenting the milk and cooled in the individual final package and is characterised by a firm jelly like texture. The heat treated milk is inoculated, filled into retail containers, and incubated at a suitable temperature normally 40-43^0 C for approximately 2.5 to 4 hour and then stored at temperature less than 5^0 C for overnight (Desai *et al.,* 1994).

Stirred yoghurt: The stirred yoghurt is prepared by fermenting the heat treated and cooled milk in the bulk and the final coagulum is broken by stirring before chilling and packaging into individual package. The texture of stirred yoghurt will be less firm than a set yoghurt and somewhat like very thick cream. A little reformation of coagulum will occur after packaging and storage at refrigerated condition. Stirred yoghurt is a non-Newtonian fluid, obtained by promoting the growth of *Lactobacillus delbruecki* subp. *Bulgaricus* and *Streptococcus thermophilus* at a mild temperature in between 40^0 and 43^0 C until a desired acidity level is reached (Tammine, 2002).

Drinking yoghurt: For preparation of drinking yoghurt, the coagulum is broken after fermentation and prior to cooling. In drinking yoghurt, the agitation used to break the coagulum is severe. As the name indicates the consistency of yoghurt will be thin and in a drinkable form. Very little reformation of coagulum may occur after packaging and during storage (FDA, 2013).

Frozen yoghurt: Frozen yoghurt is prepared by inoculating and incubating the milk in the manner similar to that of stirred yoghurt. However cooling is achieved by pumping the yoghurt through a whipper or freezer in a fashion similar to that of ice cream. The texture of the finished product is mainly influenced by the whipper or freezer and the size and distribution of the ice crystals produced (FDA, 2013).

Concentrated yoghurt: this type of yoghurt is prepared by inoculating and fermenting the milk in the same manner as that for stirred yoghurt. Following the breaking of coagulum, the yoghurt is concentrated by boiling off some of the water, which is often done under vacuum to reduce the temperature required. Heating of low pH yoghurt can often lead to protein being totally denatured and producing rough and gritty textures. This is often called strained yoghurt due to the fact that the liquid that is released from the coagulum upon heating used to be strained off in a manner similar to making soft cheese (FDA, 2013).

An increasing demand can be seen for fruit yoghurts. Introduction of various fruit flavoured yoghurts has significantly contributed to the consumption of yoghurt among all the ages (Chandan and Shahani, 1993). Incorporation of fruits give healthy images to the final product. Bardale (2011) reported that the addition of fruit preparations, fruit flavours, fruit purees and flavour extracts enhances versatility of taste, colour and texture for the consumer flavoured yoghurt.

Herbal yoghurts prepared with *Anethum graveolence, Mentha piperita and Ocimum basilicum* showed α amylase and α-glycosidase activities than that of the plain yoghurt which suggested that these herbal yoghurts may be beneficial to treat hypertension and diabetes mellitus (Amirdivani, 2007).

Shakeel-Asger *et al.* (1994) attempted for manufacture of a filled type product by replacing milk fat with polyunsaturated fatty acid rich in vegetable oil. This was successfully done in the form of bio-yoghurt with incorporation of sugar and mango juice to enrich the quality of product.

Yoghurt was produced from various kinds of cereals such as liquefied starch and cooked maize meal mixture (Zulu *et al.,* 1997). Wongkhalaung and Boonyaranakornkit (2000) developed yoghurt from rice blended with pectin and strawberry. Oats based yoghurt was developed by Martensson *et al.* (2001) had higher acceptability compared to milk yoghurt. Swati (2012) prepared yoghurt with different combinations of roasted and unroasted parboiled rice flour and had higher organoleptic acceptability than control yoghurt.

Hoyda *et al.* (1990) described a method of making fibre enriched yoghurt. It is claimed that yoghurt and fruit yoghurt may be fibre fortified without any resultant adverse taste or mouth feel due to fibre using the source of fibre which include soy, oat and gum arabic.

Fruit/Flavoured yoghurt: The flavours are usually added to yoghurt, just prior to filling into individual containers. Common additives are fruit or berries, usually as a puree or as whole fruit in syrup. These additives often have 50 per cent sugar in them (FDA, 2013).

Coisson *et al.* (2005) used Euterpeoleracea juice as functional pigment for yoghurt, which is dark purple in color having high anthocyanin and phenolic content.Now a days, there has been increasing trends to fortify the dairy product with fruits, natural fruit juice, pulp, dry fruits. Aesthetic value of new product can be increased by using fruit juice as a functional pigment in fermented milks with array of colors and flavor properties (Ghadge *et al.*, 2008).

A recent development in fruit processing is the use of the osmodehydrofrozen process which consists of osmotic treatment in sugar solution, limited air dehydration to reduce water activity, freezing and storage. Fruits processed using this technique require no preservatives, maintain their natural flavor and color and have an acceptable texture. Furthermore, when such fruits or dried pieces are added to yoghurt, they have the tendency to absorb some of the free or unbound water from the yoghurt gel and hence help to reduce whey separation of the product during storage (Tamime and Robinson, 2007).

Torreggiani *et al.* (1996) reported that the sensory properties of yoghurt with added osmodehydrofrozen apricot or peach cubes of high solids content significantly improved the consistency of the product.

Yoghurt producers are interested in diversification of their products by adding different fruits, cereals, flavours, etc. Fruits improve nutritional and sensorial properties of yoghurt. Strawberries are suitable for yoghurt preparation because of their flavour and high content of phenolic constituents, potassium and vitamin C (Sinha, 2006).

The walnuts were added in order to obtain a certain textural sensation as well as to improve the quality of yoghurt's fat. Walnuts are a rich source of monounsaturated fat and polyunsaturated fat (Payne, 2006).

Dorai and Karthik (2012) prepared value added yoghurt by incorporating pomegranate peel extract at a range of 0.5 to 1.5 per cent and evaluated the acceptability of the product, 1 per cent incorporation of peel got greater preference with a pH of 4.93 and acidity of 0.86 per cent.

Patil *et al.* (2009) reported that Guava pulp at 5 per cent could be very well accommodated in yoghurt to produce good blend of mild guava flavor with acidic taste of finished product. Guava fruit is therefore a very good additive to yoghurt, which not only improves the acceptability of the product but also enhances it vitamin C content.

Yoghurt has been proved to be suitable product to make a complete food by incorporating inexpensive nutrient source (Boghra and Mathur, 2000). Fruit dahi is widely popular due to its partially masked acetaldehyde flavour compared to plain dahi (Kumar and Mishra, 2004).

Fruits like strawberry, apple, watermelon, papaya, mango, banana and grape and vegetables are rich sources of vitamins, mineral, fibres and anti-oxidants, hence can be used in making value-added yoghurt (Vahedi *et al.,*2008).

Papaya and pineapple fruits have been selected as best flavor enhancer fruits and is used in dahi compared to kiwi and kaki fruits. FAO and WHO recommend 5-15 per cent of fruit concentration in making value-added yoghurt. Pectin and fructose of fruits improve consistency and viscosity of yoghurt by getting mixed with, and mouth feel is improved (Farahat and El-Batawy, 2013).

Hafeez (1992) observed an increase in syneresis in cashew apple stirred yoghurt during 15 days of refrigerated storage. Fruit yoghurt shows the higher wheying off at all the stages of yoghurt compared to plain yoghurt. This leads to softer body characteristics of yoghurt prepared with added fruits as compared to plain yoghurt. Fruit solids weaken the gel strength by sitting in between the casein micelles. Apart from this, reducing the gel also reduces the viscosity (El-Etriby *et al.,* 1997). Tarakci and Kukukoner (2004) reported that syneresis increased in the entire sample during storage, which was significant after 6th day of storage.

Yoghurt consumption has increased around the world because of its nutritional value, therapeutic effects and functional properties (McKinley, 2005). The use of different fruit and additives in fruit yoghurt production has improved its nutritional and sensory properties (Cakmakci *et al.,* 2012). Peaches, cherries, apricots, papaya, cactus pear and blue berries are frequently used in yoghurt preparation (Arslan and Ozel, 2012).

2.3. Quality attributes of yoghurts

2.3.1. Physicochemical and nutritional attributes of yoghurts

2.3.2. Organoleptic qualities of yoghurts

2.3.3. Microbial aspects of yoghurts

2.3.1. Physicochemical and nutritional attributes of yoghurts

The ideal pH of the finished product of yoghurt should be between 4 - 4.1. However this pH also depends on added fruits or flavouring agent to the yoghurt. But after fermentation when the yoghurt is ready to eat, the pH should be four.

The pH of yoghurt is decreased if the amount of skimmed milk powder is increased (Shaker *et al.*, 2000). Yoghurt were produced at 10, 20 and 30 per cent of milk substitution with coconut cake. The physicochemical analysis obtained had an increased pH (4.32-4.45). There were also remarkable increase in the values for moisture (80.10 to 85.23 per cent), fat (1.50-3.13 per cent), and total ash (0.53-1.01 per cent). A reverse trend was observed for acidity, total solids, protein and carbohydrate values (Ndife *et al.,* 2014).

The initial acidity of plain yoghurt was 0.74 per cent, which increased with time up to 1.35 per cent on 16 day of storage. The acidity of different fruit yoghurts at zero day ranged between 0.78 -0.92 per cent, which increased with increase in the storage period. At 16th day of storage, the acidity of fruit yoghurt ranged from 1.22 to 1.45 per cent (Shalini, 2006).

Lee (2010) studied the supplementation of soymilk with skim milk to develop yoghurt like product and observed its effect on physicochemical qualities. They observed that protein content was increased from 3.5 to 3.6 per cent, ash 0.36 to 0.64 and total solids 8.58 to 8.70 per cent.

Carbohydrate is the major constituent of yoghurt that is converted in to lactic acid during yoghurt fermentation. So the fermentation and conversion of lactose to lactic acid accounts for the low content of carbohydrate of yoghurt (Younus *et al.,* 2002).

Segarra *et al.* (2000) analysed copper, iron, zinc, manganese, calcium, magnesium, sodium and potassium in fruit added yoghurts and observed high concentrations of iron and manganese in the wild berry fruit and pineapple flavoured yoghurts.

Desai *et al.* (1994) described the utilization of different fruits in manufacture of yoghurt, such as mango, sapota, papaya, pineapple and kokum juice. They were added to yoghurt at 0, 10, 15 and 20 per cent levels. Fruit yoghurt contain significantly small amount of fat, protein and mineral than plain yoghurt. The TSS content of fruit yoghurts was significantly higher than that of plain yoghurt.

Rahman *et al.* (2001) prepared yoghurt by adding 5, 10 and 15 per cent level of jackfruit with milk. The quality of yoghurts was measured by organoleptic, chemical and microbiological tests. The score of yoghurt improved due to the addition of jackfruit. Addition of jackfruit juice increased the total solid content and decreased the protein and ash content. Yoghurt containing 5 per cent jackfruit juice showed the better performance.

Sweet cream buttermilk based yoghurt drink was developed by Ashok (1990) and it contains 1.52% fat, 3.59 per cent protein, 0.8 per cent ash.

Rice based yoghurt prepared by using strawberry contained 3.05 per cent protein, 2.67 per cent glucose, 0.047 per cent calcium, 0.86 per cent acidity (Wongkhalaung and Boonyaratanakornkit, 2000). Guava pulp incorporated yoghurt was found to have 3.4 per cent fat, 21.5 per cent total solids, one per cent acidity, 5 per cent reducing sugar, 7.9 per cent non-reducing sugar and 13.5 per cent total sugar and pH of 4.4 (Patil *et al.,* 2009).

According to Balakannan *et al.* (2012) yoghurt prepared by incorporating mango pulp in different proportions increased fat, protein, fibre, vitamin C and vitamin A content of the final product.

Aroyeun (2004) reported yoghurt with addition of cashew apple juice will improve its nutritional content, when compared to plain yoghurt and commercial non-fat plain yoghurt. Cashew apple yoghurt had higher content of vitamin C (53.7 per cent), 3.22 per cent protein and 3.2 per cent fat than plain yoghurt and commercial plain yoghurt.

Morvarid *et al.* (2013) prepared yoghurt with different fruit pulp including apple, banana and strawberry. The fruit pulp were added at the rate of 7 and 10 per cent level. They found that significant difference between plain yoghurt and fruit yoghurt in the pH, moisture, ash, protein, carbohydrate and acidity as compared to first day of storage. Highest value for water holding capacity and syneresis were belonged to yoghurt containing 10 per cent banana at 10^{th} day of storage with values of 90.32 per cent and 12 per cent respectively. Yoghurt containing 10 per cent strawberry had higher acidity than other fruit yoghurts.

Sengupta *et al.* (2014) studied the fruit yoghurt prepared by adding watermelon juice with milk. They found that significant difference between control yoghurt and fruit yoghurt in pH, moisture, ash, fat, protein, carbohydrate and total solid content, fruit yoghurt had higher acidity, viscosity and lower penetration value than control yoghurt.

Jayasinghe *et al.* (2015) reported that dragon fruit can be effectively used for the development of set fruit yoghurt. The highest sensory properties were observed in the product which consisted of 10 per cent dragon fruit juice. It had 23.58 per cent total solids, 9.64 per cent solid non -fat and 3.2 per cent fat. Dragon fruit yoghurt could be stored for 15 days under refrigerated condition without changing its quality parameters.

Addition of fruit pulp significantly affected the physico-chemical and sensorial properties of fresh yoghurt samples. Low syneresis value with better textural quality were found in the fruit yoghurt samples compared with the control sample at refrigerated condition. Addition of 15 per cent banana pulp resulted in lowest synersis in yoghurt among all treatments (Roy *et al.,* 2015).

Warakaulle *et al.* (2014) reported that incorporation of water melon juice could increase vitamin C content in the watermelon yoghurt. It had a vitamin C content of 16.46 per cent more than that of the plain yoghurt. Fat, ash and total solid content was higher in fruit yoghurt than plain yoghurt.

2.3.2. Organoleptic qualities of yoghurts

Mango and pineapple pulps used at 7% level secured the highest sensory scores of 8.23 and 8.14, while banana pulp at 9% level secured highest score of 8.25 with respect to overall acceptability (Amna *et al.,* 2008).

Hursit and Temiz (2000) studied the organoleptic, chemical and physical properties of set and stirred yoghurt produced using fruit pulps and flavours. Organoleptic analysis showed that stirred yoghurt had higher scores in terms of sweetness, fruit content and flavour but set yoghurt had higher viscosity and curd tension.

Salwa *et al.* (2004) prepared plain yoghurt and carrot yoghurt from cow's milk. Carrot yoghurt was prepared by blending milk with 5, 10, 15 and 20 per cent carrot juice. Sensory quality were investigated during refrigerated storage at 4^0 C for 3 weeks. Sensory score was maximum for yoghurt with 15 per cent carrot juice.

Desai *et al.* (1994) reported that yoghurt made from mango pulp received highest scores (7.64) followed by pineapple (7.47), plain (6.96), sapota (6.88) and papaya (5.87). Sensory evaluation by a taste panel showed a preference for the yoghurt stored for 2 months. Yoghurt flavoured with orange juice was preferred over plain yoghurt (Ozdemir *et al.,* 1999).

Lutchmedial *et al.* (2004) studied the effect of addition of different level of soursop nectar properties. Yoghurt with 5 per cent soursop nectar had the highest score for flavour compared to plain yoghurt.

Twentyfive per cent incorporation of water melon juice into yoghurt mix enhance consumer appeal of fruit yoghurt than that of 20 and 30 per cent incorporation rates (Warakaulle *et al.,* 2014).

Amal *et al.* (2016) reported that yoghurt containing 15 per cent papaya pulp had the highest overall acceptability as compared to cactus pear yoghurt and also plain yoghurt.

Roy *et al.* (2015) prepared yoghurt with three different fruit pulp such as banana, papaya and water melon. All fruit yoghurts were found nutritionally and organoleptically superior than control. Papaya yoghurt was most preferred over banana and watermelon yoghurts.

Jayasinghe *et al.* (2010) prepared yoghurt with pasteurised dragon fruit juice at varying proportions of 5, 7.5, 10 and 12.5 per cent respectively. The highest sensory scores were observed in the product which consisted of 10 per cent dragon fruit juice.

Mahmood *et al.* (2008) prepared banana, apple and plain yoghurts with buffalo milk and found that the highest sensory score was attained to the stirred yoghurt with 8 per cent apple and 8 per cent banana pulp.

Yousel *et al.* (2013) prepared yoghurt with different fruit pulps including apple, banana and strawberry and stored up to 10 days. The fruits were added at 7% and 10% level. Sensory qualities of fruit yoghurts were determined during 1^{st}, 6^{th} and 10^{th} day of storage. The yoghurt containing strawberry had the highest overall acceptability scores as compared to other fruit yoghurts samples and plain yoghurt.

Thumrongchote (2014) studied the sensory properties of fruit yoghurts such as pineapple, mango and papaya yoghurts during the storage at refrigerated temperature for three weeks. These fruits addition were acceptable and highest score was obtained for pineapple yoghurt followed by mango and papaya yoghurts.

2.3.3. Microbial aspects of yoghurts

Derg (2003) found that yoghurt made using pure culture showed no growth of yeast and mould up to 4th day of storage. Yoghurt shelf life is based on whether the products display any of the physical, chemical, microbial or sensory characteristics that are undesirable for consumption. Studies of changes in these quality characteristics during storage would be instrumental in predicting the shelf life of the product (Salvador and Fiszman, 2004).

Salwa *et al.* (2004) reported the increase in yeast, mould and *coliform* counts during 21 days storage of carrot yoghurt. Yoghurt is classified as fresh with a shelf life of up 16-21 days under refrigerated condition and thermized yoghurt with shelf life of 8-12 weeks (Alakali *et al.,* 2008).

Mataragas *et al.* (2011) developed a predictive model to quantify the spoilage of yoghurt with fruits. Samples were stored at various temperatures (5-20^0 C). Samples were subjected to microbial (total viable count, lactic acid bacteria, yeast and moulds) analysis. Lactic acid bacteria was the dominant micro-flora. Yeast population increased at all temperatures but a delay was observed during the first day of storage.

Shalini, (2006) reported that the yeast, mould and *coliform* were absent in one g sample of plain yoghurt up to 4th day, which increased to 3.06 log (cfu/ml) on 16th day of storage. The average yeast, mould and *coliform* counts of different fruit yoghurts ranged 1.44-1.57 cfu/ml and 1.43-1.75 cfu/ml respectively, which increased with increasing period of storage. At 16th day of storage, the counts were 3.24 to 3.40 and 3.14 to 3.21 cfu/ml for yeast, moulds and *coliforms* respectively.

Yeast and mould were present in first day of storage in fresh control and experimental yoghurt samples. The count in fresh control and flaxseed containing samples was 20 cfu/g. At the end of 17 days of storage the counts of all samples including control were more than 100 cfu/g and in case of experimental yoghurt the count was found to be 140 cfu/g. Hence at the end of 17 days of storage the sample were found not acceptable as per the microbiological standards (Sivakumar, 2014).

Presence of contaminating bacteria in fermented products was reported by Aziz *et al.* (2002). Ariaii *et al.* (2011) also reported increase in contaminating bacteria count during storage.

Swati (2012) found that mould and yeast were not detected in rice based yoghurt and in control throughout the storage period, but in case of fruit enriched yoghurt mould and yeast growth were observed on 14^{th} day of storage.

Wang *et al.* (2015) prepared protein fortified set yoghurt and found that probiotic bacteria *Bifidobacterium* was stable during the 10 weeks of storage. The bacterial population of *S. thermophilus* and *L. delbruecki* ssp. *bulgaricus*decreased in the plain yoghurt during the 20^{th} day of storage (Akgun *et al.,* 2016).

2.4. Health benefits of yoghurt

A number of health benefits are claimed in favour of products containing probiotic organisms including antimicrobial activity and gastrointestinal infections, improvement in lactose metabolism, anti-mutagenic properties, anti-carcinogenic properties, reduction in serum cholesterol, anti-diarrhoeal properties, immune system stimulation, improvement in inflammatory bowel disease and suppression of *Helicobacter pylori* infection (Shah, 2004).

Probiotics are live microorganisms that when consumed in adequate amounts can confer health benefits onto the host (Guarner and Schaafsma, 1998). These microorganisms should belong to the same bacteria already present within the host and have the ability to tolerate acidic environments (Ross *et al.,* 2002).

Benefits associated with the consumption of probiotics are the inhibition of pathogenic microbes, lowering blood cholesterol, reduction in the incidences of constipation, diarrhoea and bowel cancer, improvement of lactose intolerance, calcium absorption, vitamin synthesis, and the stimulation of the immune system (Gueimonde *et al.,* 2009).Yoghurt is a very popular functional food product in a number of countries due to its healthy reputation, with the recent addition of pro and prebiotics (Annuziata and Vecchio, 2013).

Lactose that is not hydrolyzed into glucose and galactose remains in the gut and acts osmotically to draw water and electrolytes in the duodenum and jejunum. The resident flora in the colon can more or less completely ferment the lactose into volatile fatty acids, lactic acid. This can decrease or suppress diarrhoea by reducing the osmotic load but excess of gases from fermentation results in flatulence and abdominal pain (Rambaud *et al.,* 1994). Yoghurt is more nutritious than other fermented milks because of its higher milk solid contents. Kaup (2011) stated that yoghurt is recommended to the lactose intolerance individuals because of the reduced lactose content. Besides this, lactic acid also helps in the absorption of calcium and phosphorous in the intestine.

Yoghurt is valued for its therapeutic value, yoghurt is useful for controlling the growth of harmful bacteria and in curing intestinal diseases like constipation, diarrhoea, dysentery (Shahani and Chandan, 1997). Yoghurt is well tolerated by individuals who have lactose intolerance. As lactose maldigestion or intolerance is associated with a low calcium intake and bone mineral density, probably because of the unnecessary exclusion of milk and dairy from the diet (Stallings *et al.,* 1994).

Lactase activity may be contributing to the improved lactose tolerance associated with yoghurt. For example, the different viscosity of yoghurt compared to milk may result in slower gastric emptying and thus a longer transit through the gastrointestinal tract, which, in turn, may improve the absorption and reduce the lactose load in the colon (Vesa *et al.,* 1996).

Yoghurt is also being used in the management of acute diarrhoeal disorders (WHO, 1995). Yoghurt feeding in children with acute watery diarrhoea decreased stool frequency and shortened the duration of diarrhoeal episodes (Boudraa *et al.,* 2001). According to Tamin and Deeth (2007) the yoghurt culture are capable of controlling intestinal disorders such as diarrhoea and constipation.

L. bulgaricus can inhibit intestinal putrifraction and can be effective in treating gastrointestinal disorders.

Tomar and Prasad (2009) noticed that specific strains of *Lactobacili* have been demonstrated to be effective in limiting a number of transplanted and chemically induced cancers.

Yoghurt culture are capable of controlling blood cholesterol (Rao *et al.,* 1994). Probiotic bacteria could possibly contribute to coronary heart disease prevention by reducing serum cholesterol levels as well as to blood pressure control. Proposed mechanisms include interference with cholesterol absorption from the gut, direct cholesterol assimilation, and production of end fermentation products that affect the systemic levels of blood lipids and mediate an antihypertensive effect (Sanders, 1999).

Daily consumption of 100 g yoghurt significantly improved the cholesterol while raising the high density lipoprotein. Consumption of yoghurt enhances immunity in the respiratory tract. The regular consumption of live yoghurt culture produce higher level of immunity boosting interferon as this bacteria culture stimulate infection fighting white blood cells in the blood stream and anti - tumour effects (Maltock, 2007).

Yoghurt consumption is also reported to be effective in cytokine production, T-cell function and natural killer-cell activity, and thereby result an overall immunological enhancement (Mckinley, 2005).

Racedo *et al.* (2009) studied the effect of yoghurt on the immune response against a respiratory pathogen. Resistance to infection, innate and specific immune responses were studied. Results showed that yoghurt was more effective in protecting mice, improved activation and recruitment of phagocytes in the respiratory tract, capable of increasing the number of IgA cells in the bronchus and levels of pathogen specific IgA and IgG in blood.

Yoghurt contain intestinal friendly bacteria culture that foster a healthy colon and reduce the risk of colon cancer by promoting the growth of the health bacteria and thereby deactivate harmful substances that can cause problems in the colon. It is also rich in calcium which contribute colon health and reduce colon cancer level (Gray, 2007).

The antimicrobial properties of yoghurt are well established (Kamruzzaman*et al.,* 2002). Specific strains of lactobacilli capable of limiting a number of transplanted and chemically induced cancers (Tomar and Prasad, 2009). Antimicrobial properties of yoghurt were well effective against pathogens, especially against gram negative intestinal bacteria, epidemiological studies proved that consumption of dairy products fermented by *lactobacili* reduce the risk of colon cancer among humans and animals (Reshmi, 2014).

Ringdahl (2001) reported that regular consumption of yoghurt relieves vaginal yeast infection in women. Probiotic strains administered in dairy products have shown to improve the therapeutic outcome in women with bacterial vaginitis, most probably by supporting the normal vaginal *lactobacilli* micro biota (Falagas *et al.,* 2007).

Materials and Methods

3. MATERIALS AND METHODS

The methods followed and the materials used in the study **"Process optimisation and quality evaluation of fruit pulp based yoghurts"** are given under the following heads.

3.1. Collection of raw materials.

3.2. Standardisation of fruit pulp based yoghurts

3.2.1. Optimisation of fruit pulps

3.3. Organoleptic evaluation of fruit pulp based yoghurts and selection of the most acceptable products.

3.4. Quality evaluation of selected fruit pulp based yoghurts

3.4.1. Physicochemical composition

The physico chemical constituents like moisture, acidity, pH, water holding capacity, syneresis, viscosity and curd tension were analysed.

3.4.2. Nutritional properties

Total soluble solids (TSS), reducing and total sugars, energy, carbohydrate, lactose, protein, fat, vitamin A, vitamin C, calcium, iron, potassium and total ash were analysed.

3.4.3. Shelf life studies

The selected six treatments were packed in food grade plastic containers and stored for fifteen days under refrigerated conditions. The quality aspects were studied at five days intervals for period of fifteen days throughout the storage period. Minerals content was analysed initially and at the end of storage period.

3.5. Standardisation of selected yoghurts by incorporating functional ingredients

3.5.1. Flow chart for the preparation of functional ingredients incorporated yoghurts

3.5.2. Organoleptic evaluation of functional ingredients incorporated yoghurts

3.6. Quality evaluation of selected functional ingredients incorporated yoghurts

3.6.1. Physicochemical composition

The physico chemical constituents like moisture, acidity, pH, water holding capacity, syneresis, viscosity and curd tension were analysed.

3.6.2. Nutritional properties

Total soluble solids (TSS), reducing and total sugars, energy, carbohydrate, lactose, protein, fat, vitamin A, vitamin C, calcium, iron, potassium and total ash were analysed.

3.6.3. Shelf life studies

The selected six treatments were packed in food grade plastic containers and stored for fifteen days under refrigerated conditions. The quality aspects were studied for fifteen days at five days intervals throughout the storage period. Minerals were analysed initially and at the end of storage period.

3.7. Cost of production of selected products

3.8. Statistical analysis of the data

3.1. Collection of raw materials

Yoghurt is a coagulated milk product that results from the fermentation of lactose in milk by *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Homogenised cow milk required for the preparation of yoghurts was procured from the local market. Standardised milk with fat and SNF content of level of 3.5 and 8.5 per cent respectively were found to be best for the preparation of yoghurt.

The cultures *Lactobacillus bulgaricus* and *Streptococcus thermophilus*required for the study were purchased from College of Dairy Science and Technology, Kerala Veterinary and Animal Sciences University (KVASU), Mannuthy, Thrissur District.Functional ingredients such as flax seeds, garden cress seeds and all other ingredients were purchased from the local market.

3.2. Standardisation of fruit pulp based yoghurts

3.2.1. Optimisation of fruit pulps

For making fruit pulps, good quality ripened fruits such as jackfruit *(Koozha),* Banana (*Palayankodan),* papaya, sapota and guava were purchased from local households and local market. The fruits were washed, peeled and sliced. The slices were made in to a fine pulp. The pulp obtained was filled in conical flasks and then pasteurised at 70^0 C for 30 seconds. For papaya pulp, the pasteurisation temperature was 90^0 C for 30 minutes.

Fig. 1. Flow chart for the preparation of fruit pulp based yoghurts

Milk, preheated to 55^0C

↓

Addition of skimmed milk powder (1%) + sugar (8%)

↓

Pasteurisation

↓

Cooling 55^0C

↓

Addition of fruit pulp

↓

Inoculating with 2% yoghurt culture (42 ^{0}C)

↓

Mix gently

⇩

Incubation (42^0C for 4 hours)

⇩

Refrigeration

Table No: 1 Details of treatments used for the standardisation of fruit pulp based yoghurts

Treatments	Combination
T_0 (Control)	M (100%) (Plain yoghurt)
T_1	M (90%) + JFP (10%)
T_2	M (85%) + JFP (15%)
T_3	M (80 %) + JFP (20%)
T_4	M (75%) + JFP (25%)
T_5	M (70%) + JFP (30%)

(M-Milk, JFP- Jackfruit pulp)

The above experiments were repeated by replacing JFP with Banana pulp *(Palayankodan)*(BP), papaya pulp (PP), guava pulp (GP) and sapota pulp (SP).

3.3. Organoleptic evaluation of fruit pulp based yoghurts and selection of the most acceptable products.

Organoleptic evaluation of fruit pulp based yoghurts including control was conducted by using score cards by a panel of fifteen judges.

3.3.1. Selection of judges

A series of acceptability trials were carried out using simple triangle test at the laboratory level to select a panel of fifteen judges between the age group of 18 to 35years as suggested by Jellinek (1985).

3.3.2. Preparation of score card

Score card containing eight quality attributes namely appearance, colour, flavour, texture, taste and overall acceptability was prepared for organoleptic evaluation of developed products. Each quality attribute was assessed by a nine point hedonic scale.

3.3.3. Selection of the most acceptable product

Based on the organoleptic scores, the best treatments most suitable for yoghurt with jackfruit pulp *(Koozha type),* Banana pulp *(Palayankodan)*, papaya pulp, guava pulp and sapota pulp were selected for further studies.

3.4. Quality evaluation of selected fruit pulp based yoghurts

3.4.1. Physicochemical composition

3.4.1.1. Moisture

Moisture content of fruit pulp based yoghurts was estimated by the method of A.O.A.C. (1980). To determine the moisture content, five gram of the sample was taken in a petridish and dried at 60 -70°C in a hot air oven, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying.

3.4.1.2 Acidity

Acidity of yoghurt samples was estimated by A. O. A. C. (1990). Yoghurt sample 10g was mixed thoroughly with 30ml of lukewarm distilled water. It was titrated against 0.1N NaOH using phenolphthalein as indicator.

$$\text{Acidity \%} = \frac{\text{Titre value x Normality of alkali x 90 x 100}}{\text{Weight of sample taken x1000}}$$

3.4.1.3. pH

Five gram samples of yoghurt was homogenized for 30 seconds in 100 ml of hot distilled water and vacuum filtered through Whatman filter paper. A 25 ml aliquot was pipetted into a beaker and the pH was measured using a pH meter (AOAC, 1980).

3.4.1.4. Water holding capacity

The water-holding capacity was determined according to the procedure suggested by Guzman-Gonzalez *et al.,* (1999). A weighed amount of sample (20g), (Y) was centrifuged at 1250 rpm for 10 min at 4 °C. The whey expelled (W) was removed and weighed again. The water holding capacity (WHC, g kg−1) was calculated as

$$WHC = \frac{(Y - W) \times 100}{Y}$$

3.4.1.5. Syneresis

Spontaneous syneresis of undisturbed set curd was determined using siphon method designed by Lucey (2001) with slight modifications. The cup of curd was taken out from the refrigerator and weighed (W1). It was then kept at an angle of 45°for ten minutes to allow whey seperation. Liquid whey from the surface of sample was siphoned out carefully using syringe. Siphoning was carried out within 10 seconds to avoid further leakage of whey from curd. The sample was weighed again after removal of whey (W2). The syneresis was expressed as the per cent weight of whey over the initial weight of curd sample.

$$\text{Syneresis } \% = \frac{W1 - W2}{W1} \times 100$$

3.4.1.6. Viscosity

Brookfield viscometer model BM type was used to measure the yoghurt viscosity. The reported value is an average of three readings. The readings were taken at 10ºC (the temperature at which the yoghurt is consumed). The spindle speed was adjusted according to the firmness of the sample. The specification combination used in this case was speed 12 (revolutions/ second) and spindle number 4. To calculate the final viscosity in centipoises, a factor of 500 was used to multiply the obtained figure.

3.4.1.7. Curd tension

The curd tension was measured by using stainless steel cone penetrometer and was expressed as mm/5sec. A higher the penetration value implicates lower hardness or curd tension of the product. The product temperature of 5±2°C was maintained prior to firmness measurement. A cone and test rod (probe) weighing 32g was allowed to penetrate the sample for a fixed time (5 seconds). The average of three readings was taken as millimeter of penetration.

3.4.2. Nutritional properties

3.4.2. 1. TSS

Total soluble solids were recorded using a hand refractometer (Erma, Japan) of brix ranging from 0 to 32° at room temperature and values were expressed in degree brix (Ranganna, 1986).

3.4.2. 2. Total sugar

The total sugar was determined using the method given by Ranganna (1986). From the clarified solution used for the estimation of reducing sugar, 50 ml was taken and boiled gently after adding citric acid and water. It was then neutralized with sodium hydroxide and the volume was made up to 250ml.An aliquot of this solution was titrated against Fehling's solution A and B. The total sugar content was expressed as percentage.

$$\text{Total sugars (\%)} = \frac{\text{Fehling's factor x 250 x dilution x 100}}{\text{Titre value x 50 x weight of the sample}}$$

3.4.2. 3. Reducing sugar

Twentyfive gram of yoghurt was ground with100 ml of distilled water and transferred to a conical flask. It was neutralized with1N sodium hydroxide in the presence of phenolphthalein. For the clarification of the neutralized mixture, 2 ml of lead acetate was added followed by addition of 2 ml of potassium oxalate to neutralize the excess amount of lead acetate. It was then allowed to stand for 10 minutes for the settlement of the precipitate. Filtered the solution through Whatman's No.1 filter paper which was made upto 250 ml. Aliquot of the solution was titrated against a boiling mixture of Fehling's solution A and B using methylene blue as indicator until the appears of brick red colour indicator (Ranganna,1986). The reducing sugars present in yoghurt were computed using the formula as follows.

$$\text{Reducing sugar (\%)} = \frac{\text{Fehling's factor x dilution x100}}{\text{Titre value x weight of the sample}}$$

3.4.2.4. Energy

Energy content of selected yoghurts were calculated according to Gopalan *et al*. (1989) and expressed as kilocalories (Kcal). The energy present in sample was calculated as per the formula given below.

Energy (Kcal) = (CHO x 4) + (Protein x 4) + (Fat x 9)

3.4.2.5. Carbohydrate

The total carbohydrate content was analysed colourimetrically using anthrone reagent (Sadasivam and Manikam, 1992). Yoghurt sample of 0.1 g was hydrolysed with 5 ml of 2.5 N Hcl and then cooled to room temperature. Later the residue was neutralized with solid carbonate until the effervescence ceases and the volume was made up to 100 ml and centrifuged. Pipetted 0.1 ml of supernatant and made up to 1 ml, added 4 ml anthrone reagent, heated for eight minutes, cooled rapidly and the intensity of green to dark green colour was read at 630 nm.

A graph was prepared using serial dilutions of standard glucose. From the standard graph the amount of total carbohydrate present in the sample was estimated and expressed in grams.

3.4.2.6. Lactose

Add to 10ml or 25ml of Fehling solution, 15 ml of the test solution and heat to boiling over the wire gauge. Boil for about 15 seconds and add rapidly further quantities of the solution until only faintest perceptible blue colour remains. Then add 2 to 5 drops of methylene blue and complete the titration by adding the test solution drop wise. For higher precision, repeat the titration.

3.4.2.7. Protein

Protein was estimated by the method of A.O.A.C. (1980). Sample (0.2 g) was digested with six ml Cone. H_2SO_4after adding 0.4 g of $CUSO_4$and 3.5 g K_2SO_4in a digestion flask until the colour of sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. The distillate was collected in two per cent boric acid containing mixed indicators and then titrated with 0.2N HCl to determine the nitrogen content. The nitrogen content thus estimated was multiplied with a factor of 6.25 to get the protein content.

3.4.2.8. Fat

The fat content was estimated by Gerber method suggested by Aggrawal and Sharma (1961). The sample was heated to about 38 to 40°C, mixed thoroughly and cooled to 20 °C and five gram of this sample was used for estimation. Ten ml of Gerber sulphuric acid was transferred to milk butyrometer and the weighed sample was poured down the butyrometer and one ml of iso-amyl alcohol was added. Butyrometer was stoppered and shaken after placing in water bath (65°C) for five minutes. The sample was centrifuged in Gerber centrifuge. The butyrometer was immersed again in a water bath and the reading was taken from the graduated scale. Difference was noted (upper level and lower level) which gave the per cent of fat in the sample.

3.4.2.9. Vitamin A

The standard for vitamin A was prepared by is using vitamin A acetate and it was estimated by using HPLC.

A known weight of the sample was taken. To this was added 100 g BHT, 5 g ascorbic acid, 50 ml EDTA and 75 ml ethanol and the mixture was refused 30 minutes. 30 ml 50 per cent potassium hydroxide was added and refluxed 1 hour. Then it was cooled and washed four times using petroleum ether (40-60) followed by water using phenolphthalein indicator to remove any potassium hydroxide.

Vitamin A derivative present along with the petroleum ether was dried to evaporate ether and then made up to 25 ml with ethanol. From this aliquot, 1 ml was taken and made up to 50 ml with ethanol from this 20 was injected in to HPLC using a C18 reversed phase column.

3.4.2.10. Vitamin C

The vitamin C content was estimated by the method suggested by Sadasivam and Manikam (1992). An exact amount of three grams of fresh sample was extracted with 4 per cent oxalic acid, made up to 100 ml with oxalic acid and supernatant was titrated against the dye solution 2,6dichlorophenol indophenol until the appearance of a pink colour which persisted for a few seconds. Vitamin C content was expressed in mg $100g^{-1}$ of the sample.

3.4.2.11. Calcium

Calcium content was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid was prepared by mixing 70 per cent perchloric acid in the ratio 9:4. Two gram of yoghurt samples was digested in this diacid and the extract was made up to 100 ml. This solution was read directlyin atomic absorption spectrophotometer. Calcium content was expressed in mg 100 g of the sample.

3.4.2.12. Iron

Iron content of the sample was estimated by atomic absorption spectrophotometric method using the diacid extract prepared from the sample (Perkin and Elmer, 1982). The diacid solution was directly read in atomic absorption spectrophotometer to find the iron content and expressed in mg per 100 g sample.

3.4.2.13. Potassium

Potassium present in yoghurt was estimated using method suggested by Jackson (1973) with the help of Flame Photometer. One gram of the yoghurt sample was digested using diacid solution. The pre-digested sample was used to measure potassium content in flame photometer and it was expressed as mg per 100g of the sample.

3.4.2.14. Total ash

The ash content of the yoghurts were estimated using the method given by ISI (1980). Five gram of sample was taken in a crucible and then was ignited at 550-600°Cin a muffle furnace for 5-6 hours. Cooled in a desiccator at room temperature and weighed. The ash content of sample was expressed in percentage.

3.4.3. Shelf life studies

The selected six treatments was packed in the food grade plastic containers and stored for fifteen days under refrigerated conditions. The above mentioned quality aspects was studied for fifteen days at five days intervals throughout the storage period. Minerals were analyzed initially and at the end of storage period. Microbial enumeration was also done at 5 days interval for fifteen days.

3.4.3.1. Total count of contaminating bacteria, yeast and moulds

The total count of contaminating microbes of selected fruit pulp based yoghurts was enumerated using serial dilution and plate count method as described by Agarwal and Hasija (1986). One gram of sample was added to nine ml sterile water and agitated for 20 minutes. One ml of this solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2}dilution and similarly 10^{-3}, 10^{-4}, $10^{-5}$and 10^{-6} dilutions were also prepared.

Enumeration of total count was carried out using nutrient agar media for contaminating bacteria, potato dextrose agar media for mold and sabouraud's dextrose agar media for yeast, which was obtained from Himedia Lab, Mumbai. The dilution used for bacteria was 10^{-5} and for yeast and molds 10^{-3} dilutions were used.

3.5. Standardisation of selected yoghurts by incorporating functional ingredients

Pre gelatinized flax seed powder was incorporated at 2% level and 4% level, garden cress seed powder was incorporated at 0.5% and 1% level in all the treatments.

Table No: 2 Details of treatments used for the standardisation of functional ingredient incorporated yoghurts

Treatments	Combination
T_0 (Control)	M100% + 2% FS
T_1	M 90% + JFP 10% + 2% FS
T_2	M 90% + BP 10% + 2% FS
T_3	M 90% + PP 10% + 2% FS
T_4	M 90% + GP 10% + 2% FS
T_5	M 90% + SP 10% + 2% FS

The above experiment were repeated by replacing 4% FS powder and also with 0.5% and 1% GCS powder. GCS – garden cress seed, FS – flax seed, JFP – jackfruit pulp, BP – Banana pulp (*Palayankodan*), PP – papaya pulp, GP – guava pulp, SP – sapota pulp.

Fig.2. Flow chart for the preparation of functional ingredients incorporated yoghurts

Preheated milk at 55^0C

Addition of skimmed milk powder (1%) + sugar (8%)

Pasteurisation

Cooling 55 ^{0}C

↓

Addition of fruit pulp + functional ingredients

↓

Inoculating with 2% Yoghurt culture (42 ^{0}C)

↓

Mix gently

↓

Incubation (42^{0}C for 4 hours)

↓

Refrigeration

3.5.2. Organoleptic evaluation of functional ingredients incorporated yoghurts

Organoleptic evaluation of functional ingredients incorporated yoghurts including control was conducted by using score cards by a panel of fifteen judges.

3.5.3. Selection of the most acceptable product

Based on the organoleptic scores, the best treatments most suitable for functional ingredients incorporated yoghurts with control were selected for further studies.

3.6. Quality evaluation of selected functional ingredients incorporated yoghurts

3.6.1. Physicochemical composition

The physico chemical constituents like moisture, acidity, pH, water holding capacity, syneresis, viscosity and curd tension were done initially and at five days interval for a period of fifteen days as explained in 3.4.1.1 to 3.4.1.6, respectively.

3.6.2. Nutritional properties

The nutritional properties like TSS, total sugar, reducing sugar, energy, carbohydrate, lactose, protein, fat, vitamin A and vitamin C was estimated initially and at five days interval for a period of fifteen days as indicated in 3.4.2.1 to 3.4.2.10, respectively. The mineral constituents (calcium, potassium and iron) and total ash content of functional ingredient incorporated yoghurts were estimated initially and at the end of storage period (15 days). The procedures for estimation is detailed in 3.4.2.11 to 3.4.2.14.

3.6.3. Shelf life studies

The selected twelve treatments was packed in the food grade plastic containers and stored for fifteen days under refrigerated conditions, as explained in 3.4.3.

3.6.3.1. Total count of contaminating bacteria, yeast and moulds

Microbial enumeration was done at 5 days intervals for fifteen days of storage as explained in 3.4.3.1.

3.7. Cost of production of selected products

Cost analysis of the products was done to assess the extent of expenses incurred for the preparation of products. The cost of production was worked out based on the market rates of different ingredients used for the preparation of the products. The cost was calculated for 100 g of the product and compared with the price of similar product available in the market.

3.8. Statistical analysis of the data

The observations were tabulated and analysed statistically as completely randomised design (CRD). The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance. The physico-chemical and nutritional qualities of the each treatment were compared using one way ANNOVA (DMRT).

Results

4. Results

The results of the study entitled **"Process optimisation and quality evaluation of fruit pulp based yoghurts."** are presented under the following headings.

4.1. Standardisation of fruit pulp based yoghurts (FPBY) and selection of most acceptable products.

4.2. Quality evaluation of selected FPBY

4.3. Organoleptic qualities of functional ingredient incorporated FPBY

4.4. Quality evaluation of selected functional ingredient incorporated FPBY

4.5. Cost of selected FPBY and functional ingredient incorporated FPBY

4.1. Standardisation of fruit pulp based yoghurts

Fruit pulp based yoghurts were prepared by replacing milk with fruit pulp at various levels. Fruit pulps of sapota, Banana *(Palayankodan)*, jackfruit *(Koozha type)*, guava and papaya were used for the preparation of yoghurts. Twenty-six treatments including the control (T_0) were evaluated organoleptically for various quality attributes like appearance, colour, flavour, texture, odour, taste and overall acceptability. The different quality attributes for each fruit pulps were evaluated separately and were ranked based on their mean scores using Kendall's (W) test.

4.1.1. Organoleptic qualities of sapota pulp based yoghurts (SPBY)

The mean scores and the mean rank scores for different quality attributes of SPBY and its comparison with plain yoghurt are presented in Table 3.

Table – 3 Mean scores for organoleptic qualities of sapota based yoghurt

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Total score
T_0 (100 % M)	8.84 (5.57)	8.75 (5.57)	8.64 (5.43)	8.86 (5.63)	8.80 (5.90)	8.68 (5.67)	52.57
T_1 (90%M+10%SP)	8.66 (5.00)	8.57 (5.07)	8.46 (4.77)	8.66 (5.27)	8.35 (4.93)	8.53 (5.20)	51.23
T_2 (85%M+15%SP)	8.46 (4.40)	7.93 (4.17)	8.26 (4.17)	7.91 (3.80)	7.71 (3.80)	7.86 (3.87)	48.13
T_3 (80% M+20%SP)	7.62 (3.00)	7.24 (3.00)	8.02 (3.33)	7.46 (3.23)	7.42 (3.30)	7.46 (3.27)	45.22
T_4 (75% M+25%SP)	6.91 (1.83)	6.86 (2.17)	7.53 2.20)	6.64 (1.80)	6.73 (2.03)	6.42 (1.67)	41.09
T_5 (70% M+30%SP)	6.40 (1.20)	5.60 (1.03)	6.77 (1.10)	6.35 (1.27)	6.02 (1.03)	6.28 (1.33)	37.42
Kendall's (W)	**0.928****	**0.895****	**0.810****	**0.919****	**0.939****	**0.940****	

Figures in parenthesis indicate mean rank scores; ** significant at 1% level. M – Milk, SP – Sapota pulp

Yoghurt prepared using 100 per cent cow's milk (control) got the highest score for all sensory attributes. The total score attained for control was 52.57.

Among different treatments tried for the preparation of sapota pulp based yoghurts the highest mean and rank scores were attained for the treatment T_1, which was prepared using 90% milk and 10% sapota pulp.

The mean and rank scores for appearance of sapota pulp based yoghurts (T_1 to T_5) varied from 8.66 to 6.40 and 5.00 to 1.20, respectively. The highest score for colour and flavour of sapota pulp based yoghurts were 8.57 and 8.46 for treatment T_1. The rank score of colour varied from 5.07 to 1.03 for T_1 to T_5 and for flavour it was 4.77 to 1.10. The mean scores for taste in sapota pulp based yoghurts was highest in T_1 (8.66) followed by T_2 (7.91), T_3 (7.46), T_4 (6.64) and T_5 (6.35). The same decreasing trend was observed for texture, ranging from 8.35 to 6.02. The highest mean score for overall acceptability was observed for control (8.68) followed by T_1, T_2, T_3, T_4 and T_5. The mean rank scores was in the range of 1.33 to 5.67.

Based on the total scores T_1 (51.23) along with control (52.57) were selected for further studies.

4.1.2. Organoleptic qualities of guava pulp based yoghurts (GPBY)

The mean scores and the mean rank scores for different quality attributes of GPBY and its composition with plain yoghurt are presented in Table 4.

Table - 4 Mean scores for organoleptic qualities of guava based yoghurt

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Total score
T_0 (100% M)	8.37 (5.07)	8.93 (5.93)	8.88 (5.87)	8.71 (5.20)	8.77 (5.90)	8.57 (5.93)	52.23
T_1 (90%M+10%GP)	8.97 (5.93)	8.06 (4.97)	8.08 (5.13)	8.91 (5.80)	8.26 (5.10)	8.06 (5.00)	50.34
T_2 (85%M+15%GP)	7.73 (3.97)	7.73 (4.10)	7.48 (4.00)	7.42 (4.00)	7.37 (3.67)	7.46 (4.07)	45.19
T_3 (80% M+20%GP)	7.31 (3.03)	7.31 (3.00)	7.00 (3.00)	6.84 (2.73)	7.24 (3.33)	7.02 (2.53)	42.72
T_4 (75% M+25%GP)	6.95 (1.97)	6.91 (1.97)	6.26 (1.47)	6.48 (2.07)	6.57 (1.67)	6.91 (2.40)	40.08
T_5 (70% M+30%GP)	6.35 (1.03)	5.73 (1.03)	6.33 (1.53)	5.77 (1.10)	6.42 (1.33)	5.93 (1.07)	36.53
Kendall's (W)	**0.989****	**0.986****	**0.985****	**0.968****	**0.959****	**0.972****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, GP – Guava pulp

Yoghurt prepared using 100 per cent cow's milk (control) got the highest score for all sensory attributes. The total score attained for control was 52.23.

Among different treatments tried for the preparation of guava pulp based yoghurts, the highest mean and rank scores was attained for the treatment T_1, which was prepared using 90% milk and 10% guava pulp.

Based on the organoleptic evaluation, treatment T_1 to T_5 had a mean scores ranging from 8.97 to 6.35 and the mean rank scores of 5.93 to 1.03 in terms of appearance. For colour the mean scores varied from 5.73 to 8.06 with the mean rank scores of 1.03 to 4.97. In case of flavour the mean scores and mean rank scores varied from 6.33 to 8.08 and 1.53 to 5.13. For taste the mean score and mean rank differs from 5.77 to 8.91 and 1.10 to 5.80. For texture, mean scores ranges from 6.42 to 8.26 and mean rank was 1.33 to 5.10 respectively. The overall acceptability had a mean scores and mean rank scores ranging from 5.93 to 8.06 and 1.07 to 5.93.

Based on the total scores, T_1 (50.34) along with control (52.23) were selected for further studies.

4.1.3. Organoleptic qualities of Banana pulp based yoghurts (BPBY)

The mean score and the mean rank scores for different quality attributes of BPBY and its composition with plain yoghurt are presented in Table 5.

Table – 5. Mean scores for organoleptic qualities of Banana *(Palayankodan)* based yoghurt

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Total score
T_0 (100% M)	8.64 (5.03)	9.00 (6.00)	8.88 (5.87)	8.71 (5.20)	8.91 (5.93)	8.57 (5.93)	52.71
T_1 (90%M+10%BP)	8.97 (5.97)	8.13 (4.93)	8.08 (5.13)	8.06 (5.00)	8.91 (5.80)	8.06 (5.07)	50.21
T_2 (85%M+15%BP)	7.84 (3.97)	7.73 (4.07)	7.48 (4.00)	7.42 (3.97)	7.42 (3.67)	7.46 (4.07)	45.35
T_3 (80% M+20%BP)	7.33 (3.03)	7.31 (3.00)	7.00 (3.00)	7.00 (3.03)	7.28 (3.33)	7.02 (2.53)	42.93
T_4 (75% M+20%BP)	6.95 (1.87)	6.91 (1.97)	6.26 (1.47)	6.60 (1.93)	6.60 (1.93)	6.91 (2.40)	40.23
T_5 (70% M+30%BP)	6.62 (1.13)	5.73 (1.03)	6.33 (1.53)	6.33 (1.07)	6.06 (1.07)	5.93 (1.07)	37.00
Kendall's (W)	**0.991****	**0.995****	**0.985****	**0.980****	**0.979****	**0.972****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, BP – Banana pulp

Yoghurt prepared using 100 per cent cow's milk (control) got the highest score for all sensory attributes. The total score attained for control was 52.71.

Among different treatments tried for the preparation of Banana pulp based yoghurts the highest mean and rank scores was attained for the treatment T_1, which was prepared using 90% milk and 10% Banana pulp.

The mean scores for appearance and colour of Banana pulp based yoghurt (T_1 to T_5) varied from 8.97 to 6.62 and 8.13 to 5.73, respectively. The mean rank scores for appearance was in the range of 1.13 to 5.97 and for colour it varied from 1.03 to 4.93. Among the different treatments tried for the preparation of Banana pulp based yoghurts, the highest mean scores for flavour (8.08) and the mean rank scores (5.13) were noticed in T_1. For taste the mean scores and mean rank scores varied from 6.33 to 8.06 and 1.07 to 5.00. The texture had a mean scores of 6.06 to 8.91 and for rank scores it ranged from 1.07 to 5.80. The mean scores for overall acceptability was highest in control (8.57) followed by T_1 (8.06), T_2 (7.46), T_3 (7.02), T_4 (6.91) and T_5 (5.93).

Based on the total scores T_1 (50.21) along with control (52.71) were selected for further studies.

4.1.4. Organoleptic qualities of papaya pulp based yoghurts (PPBY)

The mean score and the mean rank scores for different quality attributes of PPBY and its composition with plain yoghurt are presented in Table 6.

Table – 6. Mean scores for organoleptic qualities of papaya based yoghurt

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Total score
T_0 (100% M)	8.97 (4.67)	8.06 (3.40)	8.08 (3.63)	8.91 (4.63)	8.06 (3.63)	8.06 (3.63)	49.87
T_1 (90%M+10%PP)	8.37 (3.93)	8.37 (3.70)	8.22 (3.70)	8.22 (3.43)	8.22 (4.03)	8.37 (4.23)	49.77
T_2 (85%M+15%PP)	8.28 (3.40)	8.28 (3.64)	7.93 (3.63)	8.28 (4.23)	8.11 (3.63)	8.11 (3.63)	48.99
T_3 (80% M+20%PP)	8.46 (3.60)	8.46 (4.47)	8.11 (4.23)	7.75 (3.50)	7.75 (3.70)	7.93 (4.23)	48.46
T_4 (75% M+25%PP)	7.57 (2.70)	7.57 (2.90)	7.75 (3.17)	7.40 (2.70)	7.40 (2.90)	7.40 (3.17)	44.91
T_5 (70% M+30%PP)	7.57 (2.70)	7.57 (2.90)	7.40 (2.63)	7.40 (2.70)	7.40 (2.90)	7.40 (2.63)	44.74
Kendall's (W)	**0.227****	**0.118****	**0.098****	**0.225****	**0.090****	**0.090****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, PP – Papaya pulp

Among different treatments tried for the preparation of papaya pulp based yoghurts, the highest mean score of 8.37 for appearance was noticed in T_1. The mean score of control (8.97) was found to be higher than T_1. The lowest mean score of appearance was observed inT_4 and T_5 (7.57).

In control, the mean score for colour and flavour was found to be 8.06 and 8.08 with mean rank score of 3.40 and 3.63, respectively. The mean scores for colour and flavour of papaya pulp added yoghurts varied from 7.57 to 8.37 and 7.40 to 8.22 and the mean rank score varied from 2.90 to 3.70 and 2.63 to 3.70.

Organoleptic scores for taste of control was found to be higher than T_1. Among different treatments tried for the preparation of papaya pulp based yoghurts the total scores of T_1 to T_5 varied from 7.40 to 8.22. The treatments T_1 and T_2 attainedslightly higher scores for texture compared to control. The mean scores for T_1 and T_2 were 8.33 and 8.11, and for control it was 8.06. The mean scores and rank scores of overall acceptability of PPBY varied from 7.40 to 8.37 and mean rank scores varied from 2.63 to 4.23.

Based on the total scores, T_1 (49.77) along with control (49.87) were selected for further studies.

4.1.5. Organoleptic qualities of jackfruit (*Koozha type*) pulp based yoghurts (JFPBY)

The mean score and the mean rank scores for different quality attributes of JFPBY and its composition with plain yoghurt are presented in Table 7.

Table – 7. Mean scores for organoleptic qualities of Jackfruit based yoghurt

Treatments	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	Total score
T_0 (100% M)	9.00 (5.60)	7.68 (2.33)	8.51 (5.03)	8.93 (6.00)	8.97 (5.73)	8.91 (5.67)	52.00
T_1 (90%M+10%JFP)	8.84 (5.40)	7.68 (2.33)	8.17 (4.93)	8.17 (4.93)	8.64 (5.13)	8.80 (5.33)	49.90
T_2 (85%M+15%JFP)	7.42 (3.70)	7.68 (2.33)	7.82 (2.27)	7.80 (3.93)	7.86 (4.10)	7.55 (2.20)	46.13
T_3 (80% M+20%JFP)	6.79 (2.90)	7.73 (2.90)	7.86 (4.37)	7.726 (3.13)	6.71 (2.77)	7.55 (1.90)	44.02
T_4 (75% M+25%JFP)	6.53 (2.13)	8.55 (5.13)	8.31 (5.33)	6.48 (2.00)	6.20 (2.20)	7.55 (1.90)	44.62
T_5 (70% M+30%JFP)	6.13 (1.27)	8.73 (5.70)	8.62 (5.53)	5.82 (1.00)	5.26 (1.07)	7.55 (1.90)	42.11
Kendall's (W)	**0.924****	**0.728****	**0.774****	**0.982****	**0.955****	**0.955****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, JFP – Jackfruit pulp

Yoghurt prepared using 100 per cent cow's milk (control) got the highest score for all sensory attributes. The total score attained for control was 52.00.

Among different treatments tried for the preparation of jackfruit pulp based yoghurts the highest mean and rank scores was attained for the treatment T_1, which was prepared using 90% milk and 10% jackfruit pulp.

The mean and rank scores for appearance of jackfruit pulp based yoghurts (T_1 to T_5) varied from 8.84 to 6.13 and 5.40 to 1.27, respectively. The highest score for colour and flavour of jackfruit pulp based yoghurts were observed in treatment T_5 (8.73, 8.62) respectively. The rank score of colour varied from 2.33 to 5.70 for T_1 to T_5 and for flavour it was 5.53 to 2.20. The mean scores for taste in jackfruit pulp based yoghurts was highest in T_1 (8.17) followed by T_2 (7.80), T_3 (7.26), T_4 (6.48) and T_5 (5.82). The same decreasing trend was observed for texture, ranging from 8.64 to 5.26. The highest mean score for overall acceptability was observed for control (8.91) followed by T_1, T_2, T_3, T_4 and T_5. The mean rank scores was in the range of 1.90 to 5.33 for T_1toT_5.

Based on the total scores T_1 (49.90) along with control (52.00) were selected for further studies.

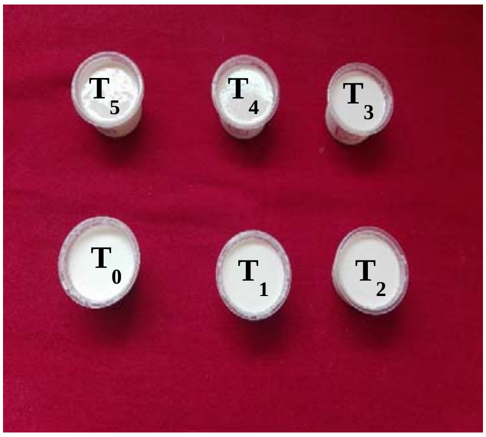

Plate 1. Sapota pulp based yoghurts

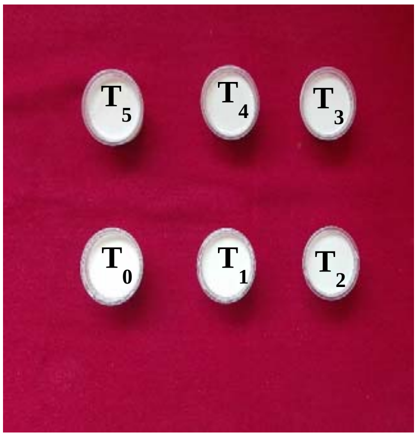

Plate 2. Guava pulp based yoghurts

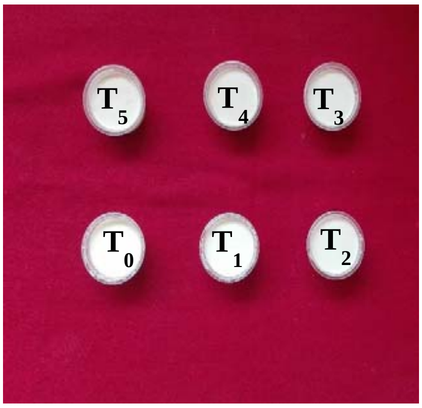

Plate 3. Banana pulp based yoghurts

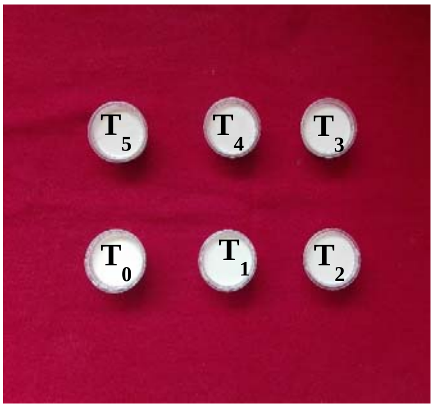

Plate 4. Papaya pulp based yoghurts

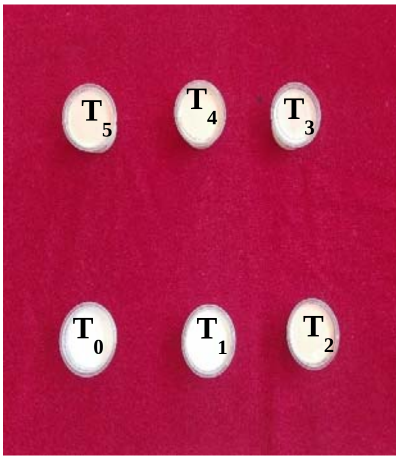

Plate 5. Jackfruit *(Koozha)* pulp based yoghurts

4.2. Quality evaluation of selected FPBY

4.2.1. Physicochemical properties

4.2.1.1. Moisture

The moisture content of selected FPBY with control was tabulated and is presented in Table 8.

Moisture content of yoghurts decreased with days of storage. The initial moisture content of plain yoghurt (T_0) was 78.05 per cent which decreased to 70 per cent at the end of 15^{th} day of storage. A significant difference in moisture content was observed at an interval of 5 days in plain yoghurt. The same decreasing trend was observed in SPBY, GPBY, JFPBY, BPBY and PPBY.

In sapota pulp based yoghurts, the moisture content varied from 79.58 per cent to 72.07 per cent from freshly prepared to 15^{th} day of storage. In guava pulp based yoghurts it varied from 79.40 to 76.00, 74.22 and 73.04 per cent from freshly prepared to 5^{th}, 10^{th} and 15^{th} day, respectively. In JFPBY, BPBY and PPBY it varied from 78.05 to 70.00 per cent, 80.16 to 72.00 per cent and 81.18 to 73.00 per cent respectively. On statistical interpretation a significant difference was observed in all treatments from initial to the end of storage.

Table 8. Effect of storage on moisture content (%) of yoghurts

Treatments	Moisture (%)				
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	CD (0.5)
T_0 (100%M)	78.05[a] (62.06)	75.01[b] (60.01)	72.11[c] (58.12)	70.00[d] (56.79)	1.23
T_1 (90%M+10%SP)	79.58[a] (63.14)	76.03[b] (60.68)	74.56[b] (59.71)	72.07[c] (58.09)	1.26
T_2 (90%M+10%GP)	79.40[a] (63.01)	76.00[b] (60.66)	74.22[bc] (59.71)	73.04[c] (58.72)	1.26
T_3 (90%M+10%JFP)	78.05[a] (62.06)	75.44[b] (60.29)	73.00[c] (58.69)	70.00[d] (56.79)	1.23
T_4 (90%M+10%BP)	80.16[a] (63.55)	77.03[b] (60.00)	74.06[b] (59.38)	72.00[c] (58.05)	1.09
T_5 (90%M+10%PP)	81.18[a] (64.29)	78.00[b] (62.03)	75.01[c] (60.01)	73.00[d] (58.69)	1.08

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.2.1.2. pH

The pH of selected FPBY with control was tabulated and is presented in Table 9.

The initial pH of yoghurts varied from 4.49 to 4.68. A decreasing trend in pH with days of storage was observed among all yoghurts. A significant decrease in pH was observed among the freshly prepared yoghurts and at the end of 15th day of storage. The initial pH of T_0, T_1, T_2, T_3, T_4 and T_5 were 4.52, 4.68, 4.57, 4.53, 4.61 and 4.49, respectively. At the end of storage, it decreased to 4.27, 4.37, 4.15, 4.27, 4.46 and 4.15 for T_0, T_1, T_2, T_3, T_4 and T_5, respectively.

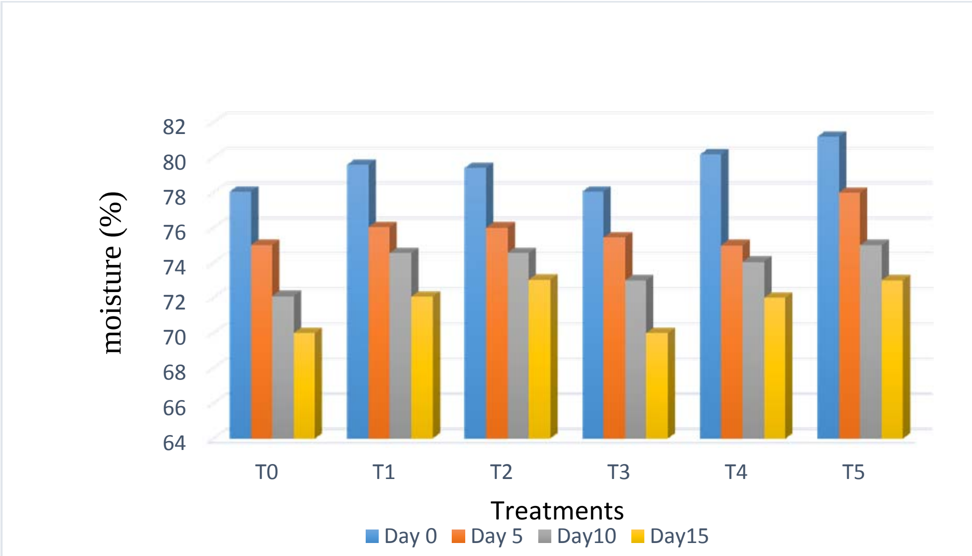

Fig. 3. Effect of storage on moisture content of yoghurts

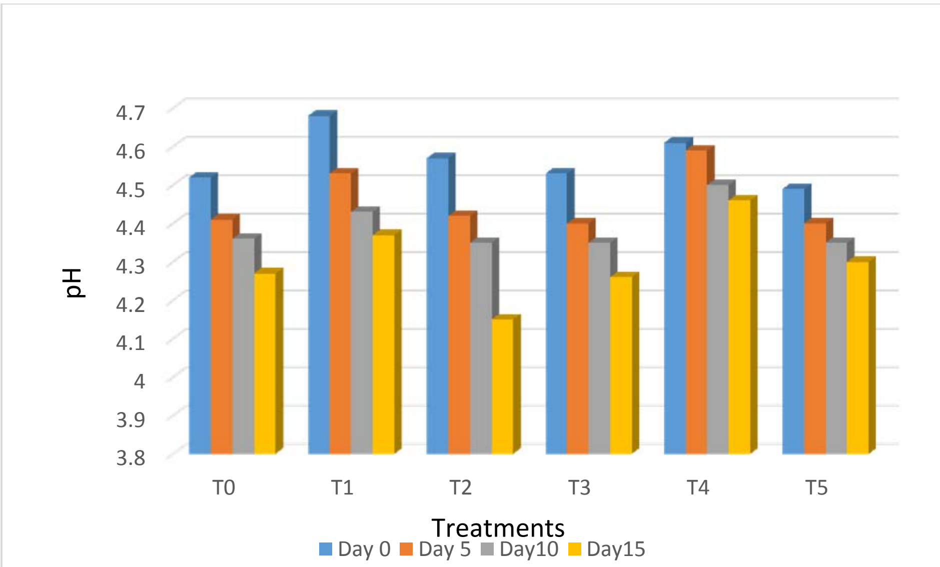

Fig. 4. Effect of storage on pH of yoghurts

Table 9. Effect of storage on pH of yoghurts

Treatments	pH				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (100% M)	4.52[a]	4.41[b]	4.36[c]	4.27[d]	0.053
T_1 (90%M+10%SP)	4.68[a]	4.53[b]	4.43[c]	4.37[d]	0.052
T_2 (90%M+10%GP)	4.57[a]	4.42[b]	4.35[c]	4.15[d]	0.041
T_3 (90%M+10%JFP)	4.53[a]	4.40[b]	4.36[c]	4.27[d]	0.038
T_4 (90%M+10%BP)	4.61[a]	4.59[a]	4.50[b]	4.46[c]	0.034
T_5 (90%M+10%PP)	4.49[a]	4.40[b]	4.35[c]	4.15[d]	0.019

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.2.1.3. Acidity

The acidity of selected FPBY with control was tabulated and is presented in Table 10.

The initial acidity of control yoghurt was 0.68 which increased with every five days of interval, it reaches up to 0.76 on 15th day of storage. Among the FPBY the highest per cent acidity was observed in BPBY, it ranged from 0.69 to 0.90 per cent on 15th day of storage. The lowest value of acidity was found to be in PPBY (0.57 to 0.64).

The acidity increased in all samples with advancement of storage. The maximum amount of acidity was observed on 15th day of storage. Based on DMRT no significant difference in acidity was observed in sapota pulp incorporated yoghurts. The same increasing trend in acidity was observed in all treatments. A significant difference in five days interval was observed in all other fruit pulp incorporated yoghurts (GPBY, JFPBY, BPBY and PPBY).

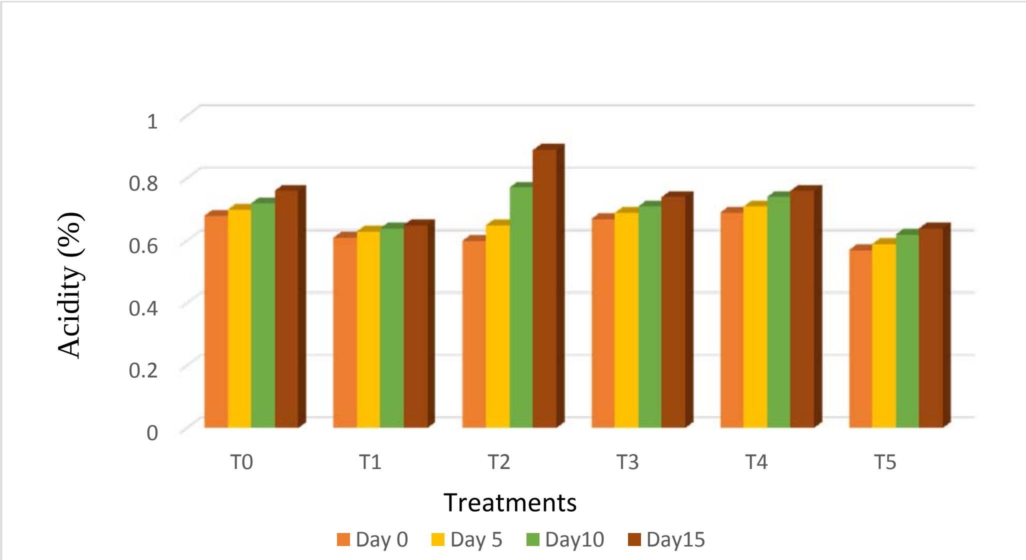

Fig. 5. Effect of storage on acidity of yoghurts

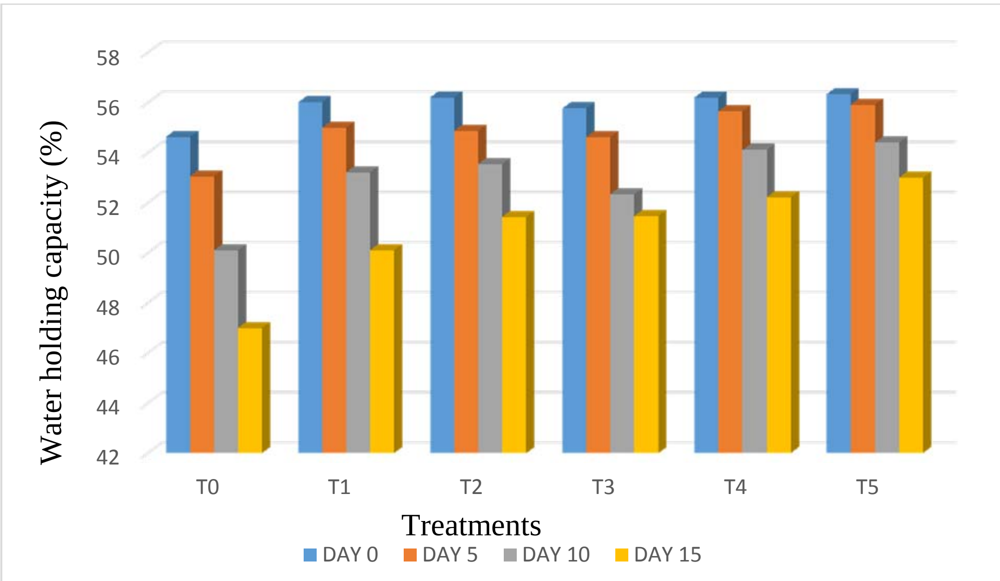

Fig. 6. Effect of storage on water holding capacityof yoghurts

Table 10. Effect of storage on acidity (%) of yoghurts

Treatments	Acidity (%)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (100% M)	0.68^{c}	0.70^{bc}	0.72^{b}	0.76^{a}	0.093
T_1 (90%M+10%SP)	0.61^{NS}	0.63^{NS}	0.64^{NS}	0.65^{NS}	NS
T_2 (90%M+10%GP)	0.60^{d}	0.65^{c}	0.77^{b}	0.89^{a}	0.084
T_3 (90%M+10%JFP)	0.67^{d}	0.69^{c}	0.71^{b}	0.74^{a}	0.065
T_4 (90%M+10%BP)	0.69^{d}	0.70^{c}	0.77^{b}	0.90^{a}	0.064
T_5 (90%M+10%PP)	0.57^{d}	0.59^{c}	0.62^{b}	0.64^{a}	0.070

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

5.4.1.4. Water holding capacity

The water holding capacity of selected FPBY with control was tabulated and is presented in Table 11.

Initial water holding capacity of control yoghurt was 54.63 which decreased during storage. On 15th day it was about 47.00 per cent. Among the FPBY the highest WHC were observed in PPBY that is 56.34 per cent (initial) and during storage it declined to 53.00 per cent. A significant difference in water holding capacity at five days interval was observed in plain yoghurt. No significant difference in water holding capacity were observed in JFPBY, BPBY and PPBY.

Table 11. Effect of storage on water holding capacity (%) of yoghurts

Treatments	WHC (%)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (100% M)	54.63^{a}	53.06^{b}	50.10^{c}	47.00^{d}	1.328
T_1 (90%M+10%SP)	56.01^{a}	55.00^{a}	53.22^{ab}	50.11^{b}	1.332
T_2 (90%M+10%GP)	56.21^{a}	54.88^{ab}	53.55^{bc}	51.44^{c}	1.371
T_3 (90%M+10%JFP)	55.77^{NS}	54.63^{NS}	52.35^{NS}	51.48^{NS}	-
T_4 (90%M+10%BP)	56.21^{NS}	55.66^{NS}	54.11^{NS}	52.22^{NS}	-
T_5 (90%M+10%PP)	56.34^{NS}	55.92^{NS}	54.40^{NS}	53.00^{NS}	-

5% significant level; Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

5.4.1.5. Syneresis

The syneresis of selected FPBY with control was tabulated and is presented in Table 12.

Syneresis is collection of whey from yoghurt. It is one of the key quality parameter for yoghurt. Higher level of syneresis shows that yoghurt is of low quality. An increasing trend in syneresis was observed in all treatments, but was non-significant. In plain yoghurt, syneresis increased from 1.00 per cent to 2.6 per cent. Followed by PPBY (0.9 to 2.2), BPBY (0.8 to 2.4), SPBY (0.7 to 1.8) and the lowest per cent of syneresis was obtained in both GPBY and JFPBY 0.6 per cent (initial) to 1.7 and 1.1 per cent (15th day of storage).

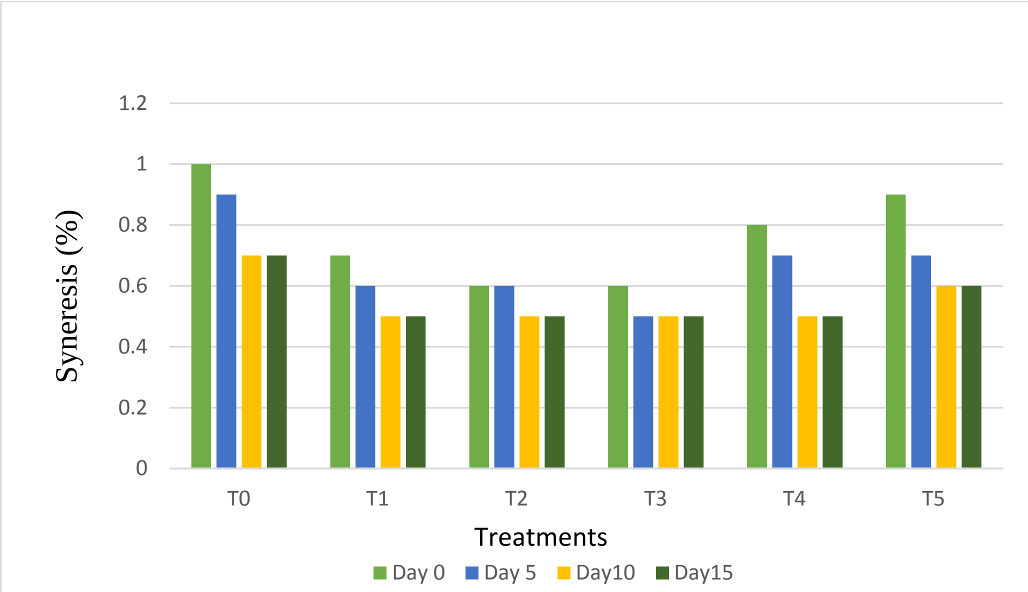

Fig. 7. Effect of storage on syneresis of yoghurts

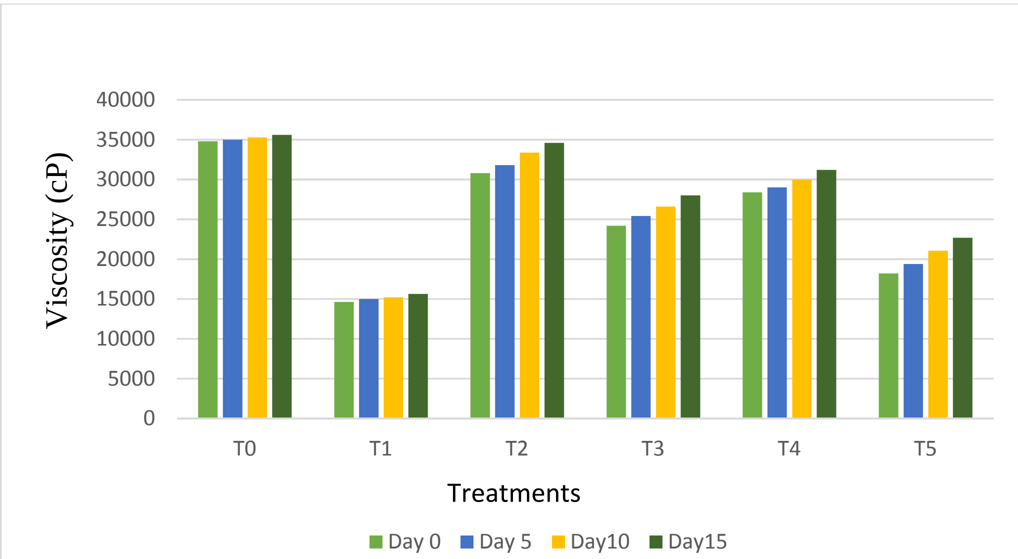

Fig. 8. Effect of storage on viscosity of yoghurts

Table 12. Effect of storage on syneresis (%) of yoghurts

Treatments	Syneresis (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	1.00^{NS} (5.73)	1.9^{NS} (7.72)	2.6^{NS} (9.16)	2.6^{NS} (9.16)
T_1 (90%M+10%SP)	0.7^{NS} (5.73)	1.3^{NS} (7.72)	1.8^{NS} (9.16)	1.8^{NS} (9.16)
T_2 (90%M+10%GP)	0.6^{NS} (4.43)	1.2^{NS} (5.79)	1.7^{NS} (7.25)	1.7^{NS} (7.25)
T_3 (90%M+10%JFP)	0.6^{NS} (4.34)	1.1^{NS} (4.65)	1.1^{NS} (4.65)	1.1^{NS} (4.65)
T_4 (90%M+10%BP)	0.8^{NS} (5.12)	1.5^{NS} (6.72)	2.00^{NS} (7.94)	2.4^{NS} (8.74)
T_5 (90%M+10%PP)	0.9^{NS} (5.43)	1.6^{NS} (6.99)	2.2^{NS} (8.37)	2.2^{NS} (8.37)

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

5.4.1.6. Viscosity

The viscosity of selected FPBY with control was tabulated and is presented in Table 13.

The viscosity of plain yoghurt had 34800 cP initially and a slight increase was noticed in every 5 days of interval and it reached up to 35600 cP. In GPBY initially it was 30800 cP and reached to 34600 cP at the end of storage. The lowest measure of viscosity was noticed in SPBY, initially it was 14620 cP and during 15th day of storage the level of viscosity were increased up to 15640 cP. No significant difference in viscosity were observed in T_0 and SPBY. A significant difference in viscosity was observed in GPBY, JFPBY, BPBY and PPBY between the freshly prepared yoghurts and at the end of storage.

Table 13. Effect of storage on viscosity (cP) of yoghurts

Treatments	Viscosity (cP)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (100% M)	34800^{NS}	35000^{NS}	35280^{NS}	35600^{NS}	-
T_1 (90%M+10%SP)	14620^{NS}	15000^{NS}	15200^{NS}	15640^{NS}	-
T_2 (90%M+10%GP)	30800^{c}	31800^{bc}	33360^{ab}	34600^{a}	0.025
T_3 (90%M+10%JFP)	24200^{c}	25400^{bc}	26604^{ab}	28000^{a}	0.032
T_4 (90%M+10%BP)	28400^{c}	29000^{bc}	30000^{ab}	31200^{a}	0.028
T_5 (90%M+10%PP)	18200^{c}	19400^{bc}	21060^{ab}	22680^{a}	0.041

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

5.4.1.7. Curd tension

The curd tension of selected FPBY with control was tabulated and is presented in Table 14.

Curd tension of yoghurts increased with days of storage. The initial curd tension of plain yoghurt T_0 was 54.00 g which increased to 60.00 g at the end of 15th day of storage. A significant increase in curd tension was observed at an interval of 5 days in plain yoghurt. The same increasing trend was observed in SPBY, GPBY, JFPBY, BPBY and PPBY.

In sapota pulp based yoghurt, the curd tension varied from 38.60 g to 45.60 g from freshly prepared to 15th day of storage. In guava pulp based yoghurt it varied from 38.66gg to 45.66 g. In JFPY, BPBY and PPBY it varied from 36.50g to 40.41 g, 37.68 g to 41.90 g and 36.00 g to 41.85 g respectively.

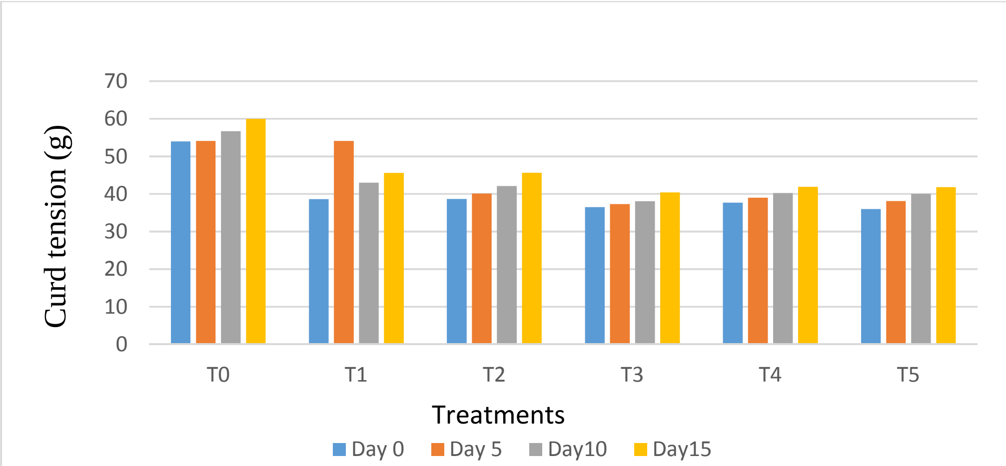

Fig. 9. Effect of storage on curd tension of yoghurts

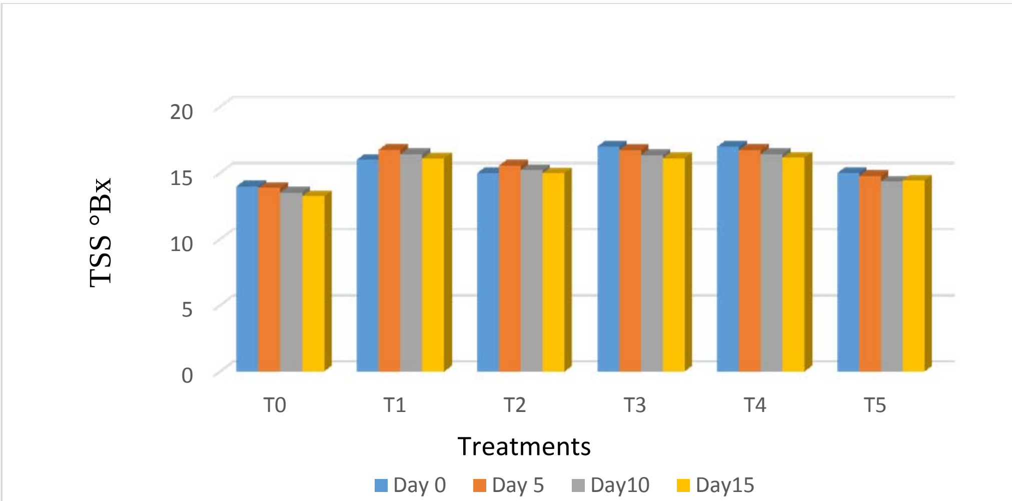

Fig. 10. Effect of storage on TSS content of yoghurts

Table 14. Effect of storage on curd tension (g) of yoghurts

Treatments	Curd tension (g)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (100% M)	54.00[c]	54.11[c]	56.70[b]	60.00[a]	1.631
T_1 (90%M+10%SP)	38.60[d]	41.00[a]	43.00[c]	45.60[b]	1.331
T_2 (90%M+10%GP)	38.66[d]	40.11[c]	42.11[b]	45.66[a]	0.019
T_3 (90%M+10%JFP)	36.50[b]	37.31[b]	38.05[b]	40.41[a]	1.641
T_4 (90%M+10%BP)	37.68[c]	39.01[bc]	40.25[ab]	41.90[a]	1.883
T_5 (90%M+10%PP)	36.00[c]	38.11[b]	40.00[a]	41.85[a]	1.883

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2. Nutritional properties

4.3.2.1. TSS

The TSS of selected FPBY with control was tabulated and presented in Table 15.

The initial TSS of control yoghurt was 14.00 which decreased in every five days of interval, it declined to 13.24 on 15 days of storage. Among the FPBY the highest TSS content was observed in BPBY and JFPBY, it ranged from 17.00 to 16.16 and 17.00 to 16.11 on 15th day of storage. The lowest value of TSS content was found to be in PPBY and GPBY (15.00 to 13.42 and 15.00 to 13.99). The TSS content decreased in all samples with advancement of storage. The lowest content of TSS was observed on 15th day of storage. Based on DMRT there was no significant difference in all yoghurt during storage.

Table 15. Effect of storage on TSS content of yoghurts

Treatments	TSS ° (Bx)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	14.00^{NS}	13.87^{NS}	13.53^{NS}	13.24^{NS}
T_1 (90%M+10%SP)	16.00^{NS}	15.76^{NS}	15.43^{NS}	15.10^{NS}
T_2 (90%M+10%GP)	15.00^{NS}	14.56^{NS}	14.21^{NS}	13.99^{NS}
T_3 (90%M+10%JFP)	17.00^{NS}	16.73^{NS}	16.34^{NS}	16.11^{NS}
T_4 (90%M+10%BP)	17.00^{NS}	16.74^{NS}	16.44^{NS}	16.16^{NS}
T_5 (90%M+10%PP)	15.00^{NS}	14.78^{NS}	14.35^{NS}	13.42^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.2. Total sugar

The total sugar content of selected FPBY with control was tabulated and presented in Table 16.

The control yoghurt had 11.88 per cent of total sugar (initial) and it decreased to 11.71 per cent (15th day). Among all the treatments, the initial total sugar content was high in JFPBY with 17.29 per cent followed by BPBY with 16.62 per cent. JFBY had highest total sugar content throughout the storage period (17.25, 17.22 and 17.00 per cent) and the lowest total sugar content was found in PPBY during storage. As per DMRT, there was no significant variation between control and FPBY noticed throughout the storage period.

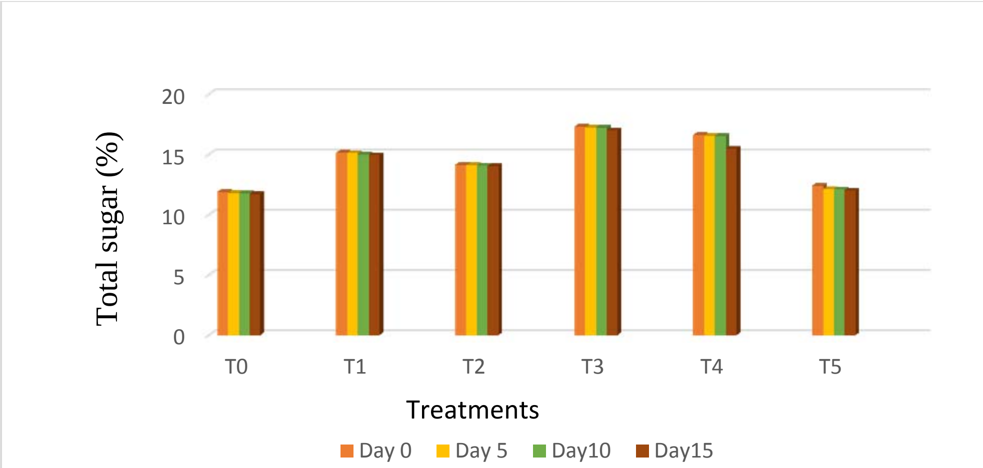

Fig. 11. Effect of storage on total sugar content of yoghurts

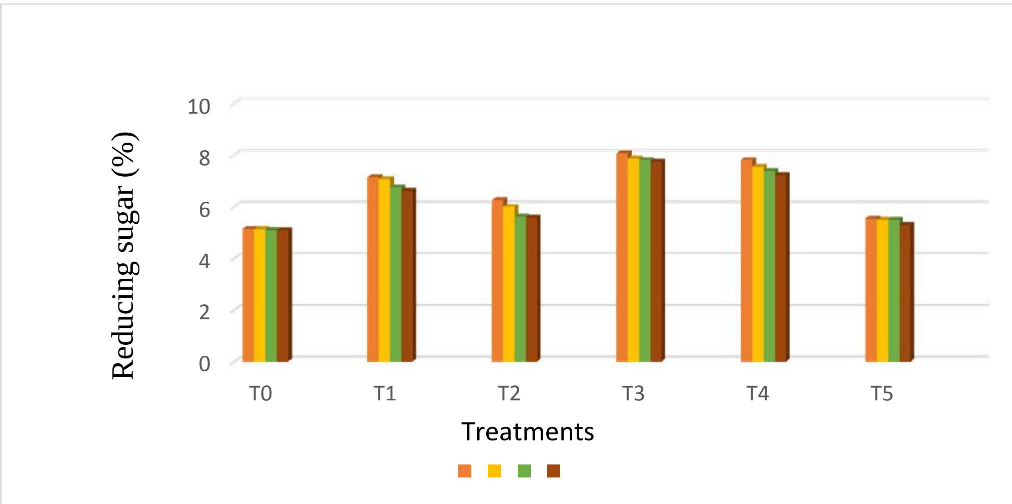

Fig. 12. Effect of storage on reducing sugar content of yoghurts

Table 16. Effect of storage on total sugar content (%) of yoghurts

Treatments	Total sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (100% M)	11.88^{NS} (11.29)	11.82^{NS} (11.20)	11.77^{NS} (11.13)	11.71^{NS} (11.03)
T_1 (90%M+10%SP)	15.14^{NS} (2.89)	15.11^{NS} (22.86)	15.01^{NS} (22.78)	14.94^{NS} (23.52)
T_2 (90%M+10%GP)	14.14^{NS} (22.08)	14.10^{NS} (22.04)	14.07^{NS} (22.02)	14.02^{NS} (21.98)
T_3 (90%M+10%JFP)	17.29^{NS} (24.56)	17.25^{NS} (24.53)	17.22^{NS} (24.51)	17.00^{NS} (24.34)
T_4 (90%M+10%BP)	16.62^{NS} (24.05)	16.56^{NS} (24.76)	16.51^{NS} (24.73)	15.47^{NS} (23.15)
T_5 (90%M+10%PP)	12.42^{NS} (20.62)	12.11^{NS} (20.35)	12.09^{NS} (20.33)	12.00^{NS} (20.25)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10%Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.3. Reducing sugar

The reducing sugar of selected FPBY with control was tabulated and presented in Table 17.

Among all treatments reducing sugar content was found to be highest in JFPBY (8.06) followed by BPBY (7.81 %), SPBY (7.14 %), GPBY (6.25 %), PPBY (5.55 %) and the lowest reducing sugar content were observed in control yoghurt (5.15 %) and it declined to 5.08 per cent. During 15th day of storage reducing sugar content decreased as 7.74 in JFPY, 7.23 for BPBY, 6.63 for SPBY, 5.58 for GPBY, 5.31 for PPBY. There was no significant difference between FPBY and control yoghurt throughout the storage period.

Table 17. Effect of storage on reducing sugar content (%) of yoghurts

Treatments	Reducing sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (100% M)	5.15^{NS} (7.15)	5.13^{NS} (7.04)	5.10^{NS} (6.94)	5.08^{NS} (6.50)
T_1 (90%M+10%SP)	7.14^{NS} (15.47)	7.08^{NS} (15.40)	6.76^{NS} (15.04)	6.63^{NS} (14.89)
T_2 (90%M+10%GP)	6.25^{NS} (14.44)	6.00^{NS} (14.14)	5.61^{NS} (14.87)	5.58^{NS} (14.83)
T_3 (90%M+10%JFP)	8.06^{NS} (16.47)	7.86^{NS} (16.26)	7.81^{NS} (16.20)	7.74^{NS} (16.13)
T_4 (90%M+10%BP)	7.81^{NS} (16.20)	7.56^{NS} (15.93)	7.39^{NS} (15.75)	7.23^{NS} (15.57)
T_5 (90%M+10%PP)	5.55^{NS} (13.59)	5.50^{NS} (13.52)	5.49^{NS} (13.51)	5.31^{NS} (13.28)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.4. Energy

Energy of selected FPBY with control was tabulated and presented in Table 18.

Initially, control yoghurt had the energy value of 82.68 to 55.20 Kcal during 15th day of storage. High energy was noticed in SPBY (73.54 Kcal) whereas in JFPBY had a low energy value of 52.88 Kcal initially. A gradual decline in energy value was noticed in each 5 days of storage.

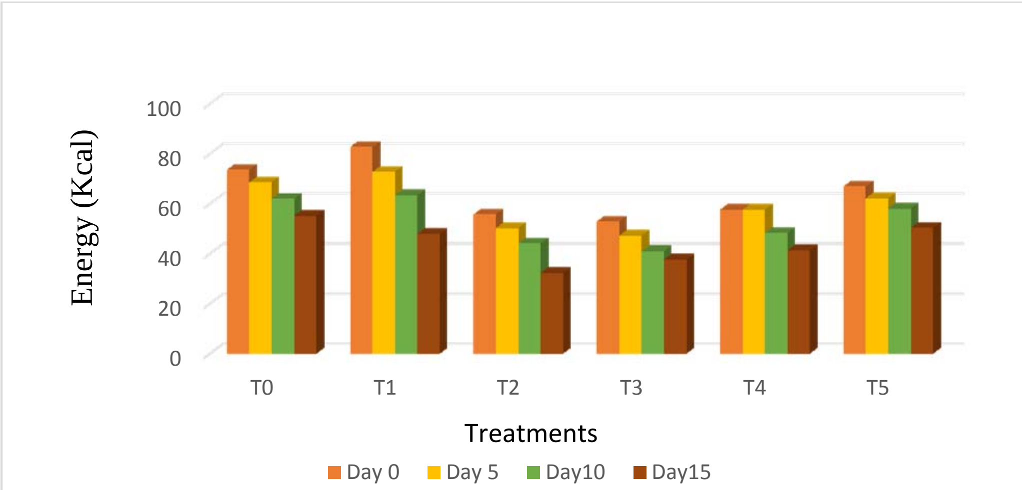

Fig. 13. Effect of storage on energy of yoghurts

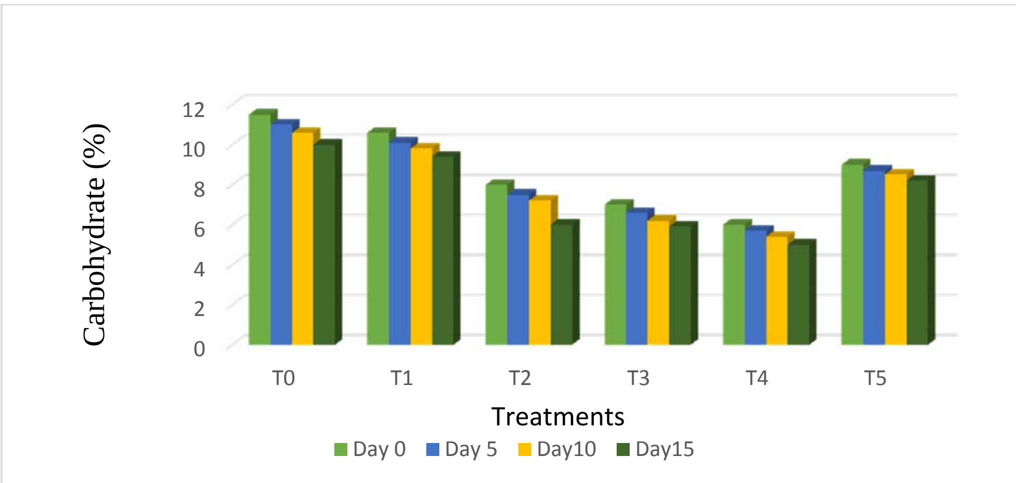

Fig. 14. Effect of storage on carbohydrate content of yoghurts

Table 18. Effect of storage on energy (Kcal) of yoghurts

Treatments	Energy (Kcal)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (100% M)	82.68^a	72.68^b	63.32^c	55.20^d	1.14
T_1 (90%M+10%SP)	73.54^a	68.52^b	61.95^c	50.35^d	1.21
T_2 (90%M+10%GP)	55.72^a	50.24^b	44.13^c	37.65^d	1.88
T_3 (90%M+10%JFP)	52.88^a	47.17^b	40.99^c	32.33^d	1.88
T_4 (90%M+10%BP)	57.64^a	54.41^a	48.34^b	41.32^c	1.88
T_5 (90%M+10%PP)	66.92^a	62.19^b	58.10^c	47.94^d	1.88

5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 100% M, T_1 90% M+10% Sapota pulp, T_2 90% M+10% Guava pulp, T_3 90% M+10% Jackfruit pulp, T_4 90% M+10% Banana pulp, T_5 90%M+10% Papaya pulp

4.3.2.5. Carbohydrate

The carbohydrate content of selected FPBY with control was tabulated and presented in Table 19.

Initial carbohydrate content of control yoghurt was 11.5 which was decreased during storage. On 15th day it was about 10.00 per cent. The initial carbohydrate content of SPBY was 10.6 % followed by PPBY with 9.00 per cent. For GPBY it was 8.00 per cent for JFPBY it was 7.00 per cent and BPBY had the lowest value of carbohydrate content of 6.00 per cent. A gradual decrease in carbohydrate content during storage was observed in all samples. On 15th day of storage, it reaches about 9.4 per cent for SPBY, 8.20 per cent for PPBY, 6.00 per cent for GPBY, 5.90 per cent for JFPBY and 5.00 per cent for BPBY. A decrease in trend of carbohydrate content was observed in all yoghurt samples. No significant difference in carbohydrate content were observed among all the samples.

Table 19. Effect of storage on carbohydrate content (%) of yoghurts

Treatments	Carbohydrate (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	11.5^{NS} (19.81)	11.00^{NS} (19.35)	10.58^{NS} (18.96)	10.00^{NS} (18.42)
T_1 (90%M+10%SP)	10.6^{NS} (18.98)	10.10^{NS} (18.51)	9.80^{NS} (18.22)	9.4^{NS} (17.83)
T_2 (90%M+10%GP)	8.0^{NS} (16.41)	7.50^{NS} (15.87)	7.20^{NS} (15.54)	6.00^{NS} (14.14)
T_3 (90%M+10%JFP)	7.0^{NS} (15.31)	6.60^{NS} (14.85)	6.20^{NS} (14.38)	5.90^{NS} (14.02)
T_4 (90%M+10%BP)	6.0^{NS} (14.14)	5.70^{NS} (13.77)	5.40^{NS} (13.40)	5.00^{NS} (12.87)
T_5 (90%M+10%PP)	9.0^{NS} (17.44)	8.70^{NS} (17.13)	8.50^{NS} (16.93)	8.20^{NS} (16.62)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.6. Lactose

The lactose content of selected FPBY with control was tabulated and presented in Table 20.

The lactose content of control yoghurt was found to be 2.94 to 2.82 per cent during storage. Among FPBY the highest amount of lactose was present in SPBY initially it was 2.72 per cent and it reduced in to 2.62 per cent at 15th day of storage followed by BPBY. In BPBY it was about 1.77 to 1.66 per cent on 15th day of storage. For JFPBY it ranged from 1.71 (initial) to 1.60 (15th day) followed by PPBY which was 1.52 to 1.41 per cent. GPBY shows lowest content of lactose that is 1.44 on fresh sample and the end of the storage it was 1.33. As per DMRT, the lactose content was found to be non-significant during storage.

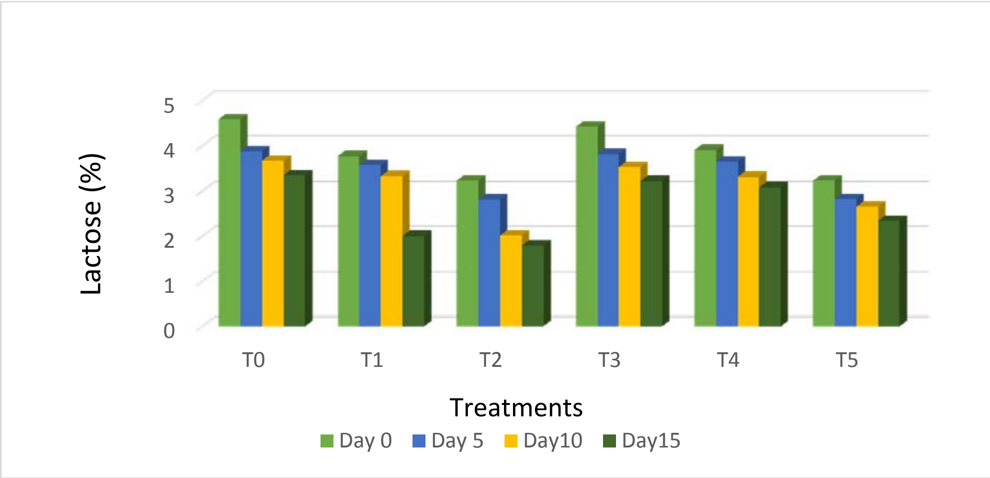

Fig. 15. Effect of storage on lactose content of yoghurts

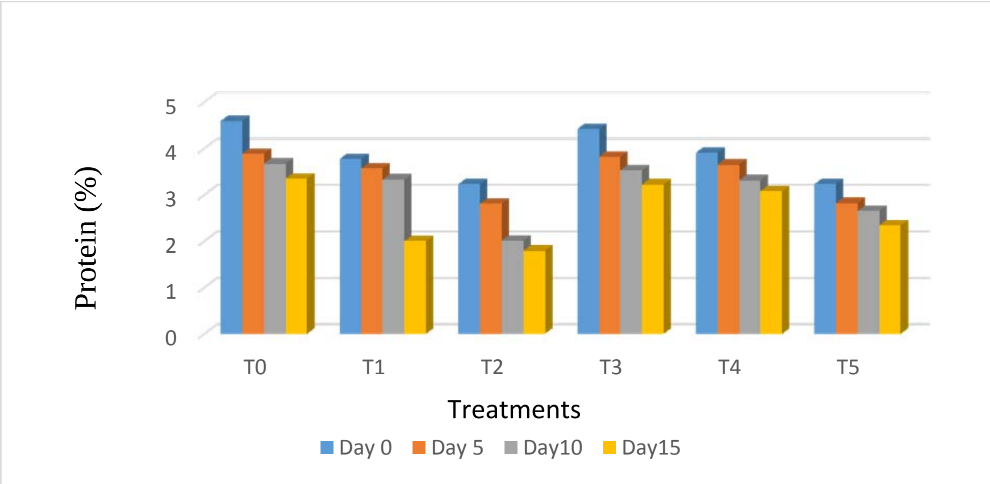

Fig. 16. Effect of storage on protein content of yoghurts

Table 20. Effect of storage on lactose content (%) of yoghurts

Treatments	Lactose (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	2.94 ^{NS} (9.77)	2.90 ^{NS} (9.70)	2.86 ^{NS} (9.81)	2.82 ^{NS} (9.47)
T_1 (90%M+10%SP)	2.72 ^{NS} (9.38)	2.68 ^{NS} (9.31)	2.65 ^{NS} (9.25)	2.62 ^{NS} (9.19)
T_2 (90%M+10%GP)	1.44 ^{NS} (6.89)	1.40 ^{NS} (6.79)	1.37 ^{NS} (6.72)	1.33 ^{NS} (6.62)
T_3 (90%M+10%JFP)	1.71 ^{NS} (7.27)	1.69 ^{NS} (7.22)	1.66 ^{NS} (7.15)	1.60 ^{NS} (7.26)
T_4 (90%M+10%BP)	1.77 ^{NS} (7.42)	1.74 ^{NS} (7.34)	1.71 ^{NS} (7.27)	1.66 ^{NS} (7.15)
T_5 (90%M+10%PP)	1.52 ^{NS} (6.78)	1.49 ^{NS} (6.70)	1.45 ^{NS} (6.58)	1.41 ^{NS} (6.47)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.7. Protein

The protein content of selected FPBY with control is tabulated and presented in Table 21.

Protein content of yoghurts decreased with days of storage. The initial protein content of plain yoghurt (T_0) was 4.59 per cent which decreased to 3.35 per cent at the end of 15th day of storage. A significant difference in protein content was observed at an interval of 5 days in plain yoghurt. The same decreasing trend was observed in SPBY, GPBY, JFPBY, BPBY and PPBY.

In sapota based yoghurts, the protein content varied from 3.77 per cent to 2.71 per cent from freshly prepared to 15th day of storage. In guava pulp based yoghurts it varied from 3.23 to 2.61 per cent. In JFPBY, BPBY and PPBY it varied from 4.42 to 3.22per cent, 3.91to 3.08per cent and 3.23to 2.34per cent respectively. On statistical interpretation there was no significant difference observed in all treatments from initial to the end of storage.

Table 21. Effect of storage on protein content (%) of yoghurts

Treatments	Protein (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	4.59 ^{NS} (12.32)	3.88 ^{NS} (11.29)	3.67 ^{NS} (10.96)	3.35 ^{NS} (10.46)
T_1 (90%M+10%SP)	3.77 ^{NS} (11.13)	3.57 ^{NS} (10.82)	3.33 ^{NS} (10.43)	2.71 ^{NS} (7.94)
T_2 (90%M+10%GP)	3.23 ^{NS} (10.27)	3.11 ^{NS} (9.54)	3.00 ^{NS} (7.97)	2.61 ^{NS} (7.46)
T_3 (90%M+10%JFP)	4.42 ^{NS} (12.08)	3.82 ^{NS} (11.20)	3.53 ^{NS} (10.75)	3.22 ^{NS} (10.25)
T_4 (90%M+10%BP)	3.91 ^{NS} (11.34)	3.65 ^{NS} (10.94)	3.31 ^{NS} (10.40)	3.08 ^{NS} (10.01)
T_5 (90%M+10%PP)	3.23 ^{NS} (10.27)	2.82 ^{NS} (9.56)	2.65 ^{NS} (9.25)	2.34 ^{NS} (8.65)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.8. Fat

The fat content of selected FPBY with control was tabulated and is presented in Table 22.

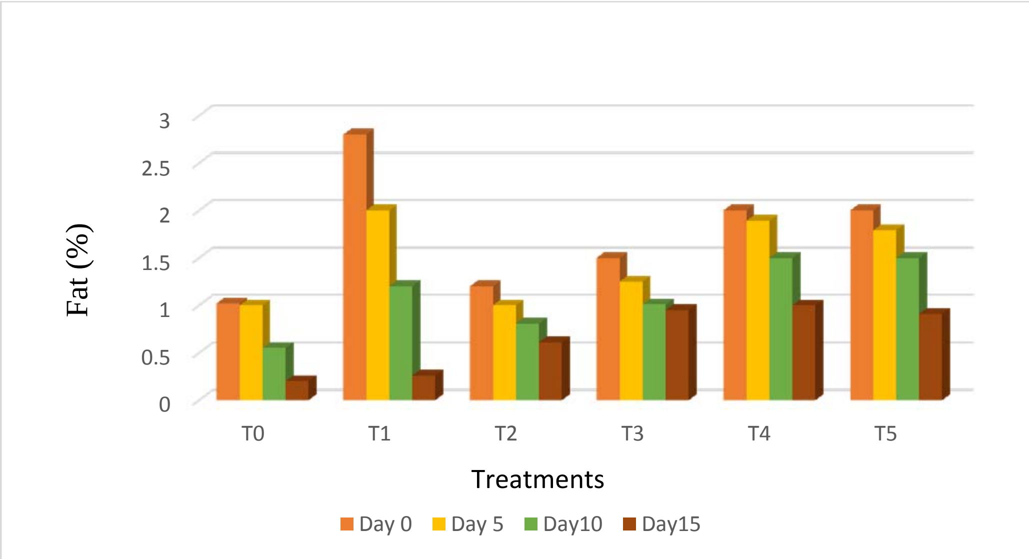

Fig. 17. Effect of storage on fat content of yoghurts

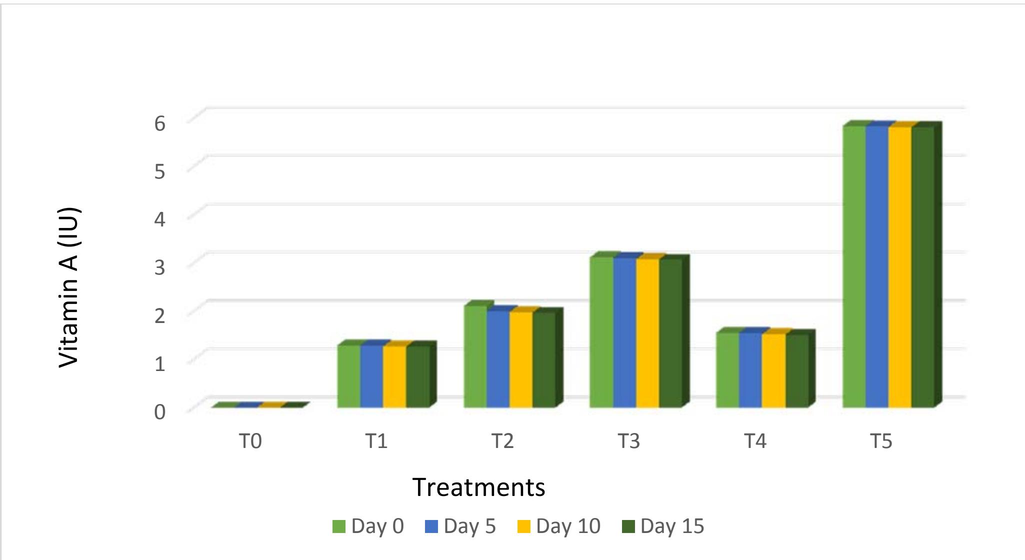

Fig. 18. Effect of storage on vitamin A content of yoghurts

Fat content of yoghurts decreased with days of storage. The initial fat content of plain yoghurt T_0 was 2.8 which decreased to 1.00 per cent at the end of 15th day of storage. A significant decrease in fat content was observed for each 5 days of interval during storage. The same decreasing trend was observed in SPBY, GPBY, JFPBY, BPBY and PPBY.

In sapota pulp based yoghurt, the fat content varied from 1.02 to 0.20 percent from freshly prepared to 15th day of storage. In guava pulp based yoghurt it varied from 1.2 to 0.51 per cent. In JFPY, BPBY and PPBY it varied from 1.5 to 0.95, 2.00 to 1.00 and 2.00 to 0.91 per cent respectively. A significant difference was observed in control yoghurt during storage. In FPBY there was no significant difference during storage.

Table 22. Effect of storage on fat content (%) of yoghurts

Treatments	Fat				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (100% M)	2.8^{a} (9.52)	2.00^{ab} (7.94)	1.2^{b} (6.28)	1.00^{c} (2.92)	2.61
T_1 (90%M+10%SP)	1.02^{NS} (4.92)	1.00^{NS} (5.73)	0.55^{NS} (4.25)	0.20^{NS} (2.50)	-
T_2 (90%M+10%GP)	1.2^{NS} (5.79)	1.00^{NS} (5.73)	0.71^{NS} (5.16)	0.51^{NS} (4.47)	-
T_3 (90%M+10%JFP)	1.5^{NS} (7.03)	1.25^{NS} (5.97)	1.01^{NS} (5.76)	0.95^{NS} (5.59)	-
T_4 (90%M+10%BP)	2.00^{NS} (7.94)	1.89^{NS} (7.70)	1.5^{NS} (6.72)	1.00^{NS} (5.73)	-
T_5 (90%M+10%PP)	2.00^{NS} (8.13)	1.79^{NS} (7.46)	1.5^{NS} (7.03)	0.91^{NS} (5.47)	-

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.9. Vitamin A

The vitamin A content of selected FPBY with control was tabulated and presented in Table 23.

Vitamin A was not detected in control yoghurt throughout the storage period. But vitamin A content was detected in FPBY this may due to the presence of ß carotene content of fruits. The highest amount of vitamin A was present in PPBY (5.83 IU) and it decreased to (5.80 IU) on 15th day of storage followed by JFPBY (3.11 to 3.06 IU), for GPBY (2.1 to 1.96 IU) and for BPBY (1.55 to 1.50 IU). The lowest amount of vitamin A was found to be in SPBY (1.29 to 1.26 IU). There was significant difference observed in treatment JFPBY, BPBY and PPBY during storage.

Table 23. Effect of storage on vitamin A (IU) of yoghurts

Treatments	Vitamin A (IU)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (100% M)	ND	ND	ND	ND	-
T_1 (90%M+10%SP)	1.29^{NS} (6.10)	1.28^{NS} (6.07)	1.27^{NS} (6.03)	1.26^{NS} (6.00)	-
T_2 (90%M+10%GP)	2.1^{NS} (8.33)	2.00^{NS} (8.12)	1.98^{NS} (8.08)	1.96^{NS} (8.04)	-
T_3 (90%M+10%JFP)	3.11^{a} (10.15)	3.09^{b} (10.12)	3.07^{c} (10.09)	3.06^{c} (10.07)	.031
T_4 (90%M+10%BP)	1.55^{a} (7.15)	1.54^{a} (7.12)	1.52^{b} (7.08)	1.50^{c} (7.03)	.044
T_5 (90%M+10%PP)	5.83^{a} (13.97)	5.82^{ab} (13.96)	5.81^{bc} (13.94)	5.80^{c} (13.93)	.023

ND – Not detected

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.10. Vitamin C

The Vitamin C content of selected FPBY with control is tabulated and presented in Table 24.

Vitamin C content of FPBY were found to be higher than plain yoghurt. A significant decrease in vitamin C was observed in 15 days of storage period. The

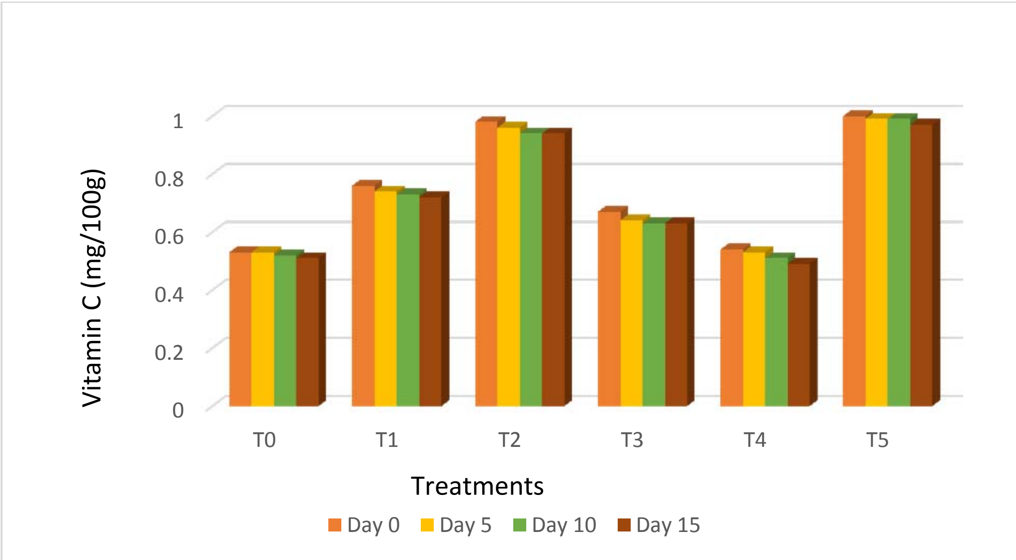

Fig. 19. Effect of storage on vitamin C content of yoghurts

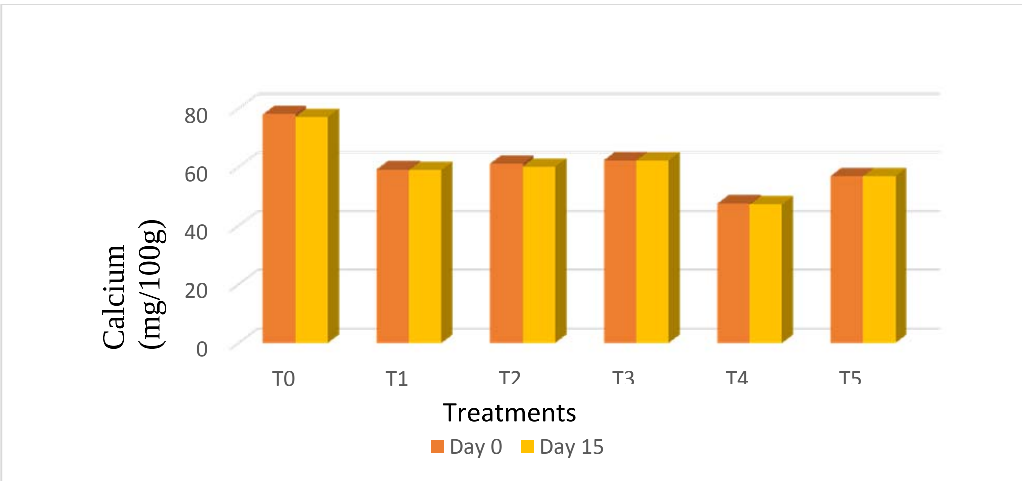

Fig. 20. Effect of storage on calcium content of yoghurts

highest amount of vitamin C of 1.00 mg/ 100g was noticed in freshly prepared PPBY and it decreased in to 0.51mg/ 100g during 15th day of storage followed by GPBY 0.85 mg/100g (initial) to 0.75 mg/100g (15th day), for SPBY 0.76 mg/100g (initial) to 0.72 mg/100g (15th day), for JFPBY (0.67 mg/100g) and for BPBY 0.54 mg/100g to 0.49 mg/100g on 15th day of storage. There was no significant difference observed in control yoghurt. A significant difference was observed in all FPBY between the freshly prepared and at the end of storage.

Table 24. Effect of storage on vitamin C content (mg/100 g) of yoghurts

Treatments	**Vitamin C (mg/100 g)**				**CD (0.5)**
	Day of storage				
	Day 0	**Day 5**	**Day 10**	**Day 15**	
T_0 (100% M)	0.53^{NS} (4.17)	0.53^{NS} (4.17)	0.52^{NS} (4.13)	0.51^{NS} (4.09)	-
T_1 (90%M+10%SP)	0.76^{a} (5.00)	0.74^{b} (4.93)	0.73^{bc} (4.90)	0.72^{c} (4.86)	0.063
T_2 (90%M+10%GP)	0.85^{a} (5.68)	0.82^{b} (5.02)	0.80^{c} (5.56)	0.75^{c} (5.56)	0.055
T_3 (90%M+10%JFP)	0.67^{a} (4.69)	0.64^{b} (4.58)	0.63^{b} (4.55)	0.63^{b} (4.55)	0.068
T_4 (90%M+10%BP)	0.54^{a} (4.21)	0.53^{a} (4.17)	0.51^{b} (4.09)	0.49^{c} (4.01)	0.075
T_5 (90%M+10%PP)	1.00^{a} (5.73)	0.99^{a} (5.71)	0.99^{a} (5.71)	0.97^{b} (5.65)	0.508

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.11. Calcium

The calcium content of selected FPBY with control is tabulated and presented in Table 25.

The initial calcium content of control yoghurt varied from 78.00 mg/100g to 77.12 mg/100g during 15th day of storage. A decreasing trend in calcium content with days of storage was observed among all the treatments. A significant decrease in calcium content was observed among the freshly prepared yoghurts and at the end of 15th day of storage. The initial calcium content of T_1, T_2, T_3, T_4 and T_5 were 59.19, 61.24, 62.35, 47.54 and 56.99 mg/100g respectively. At the end of storage it decreased to 59.00, 60.15, 62.26, 47.25 and 56.90 mg/100g for T_1, T_2, T_3, T_4 and T_5 respectively on 15th day of storage period. No significant difference was observed in calcium content during storage.

Table 25. Effect of storage on calcium content (mg/100g) of yoghurts

Treatments	Calcium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (100% M)	78.00^{NS}	77.12^{NS}
T_1 (90%M+10%SP)	59.19^{NS}	59.00^{NS}
T_2 (90%M+10%GP)	61.24^{NS}	60.15^{NS}
T_3 (90%M+10%JFP)	62.35^{NS}	62.26^{NS}
T_4 (90%M+10%BP)	47.54^{NS}	47.25^{NS}
T_5 (90%M+10%PP)	56.99^{NS}	56.90^{NS}

Values having different superscripts differ significantly in DMRT
T_0 100% M, T_1 90%M+10%Sapota pulp, T_2 90%M+10% Guava pulp, T_3 90% M+10% Jackfruit pulp, T_4 90%M+10% Banana pulp, T_5 90%M+10% Papaya pulp

4.3.2.12. Iron

The iron content of selected FPBY with control is tabulated and presented is Table 26.

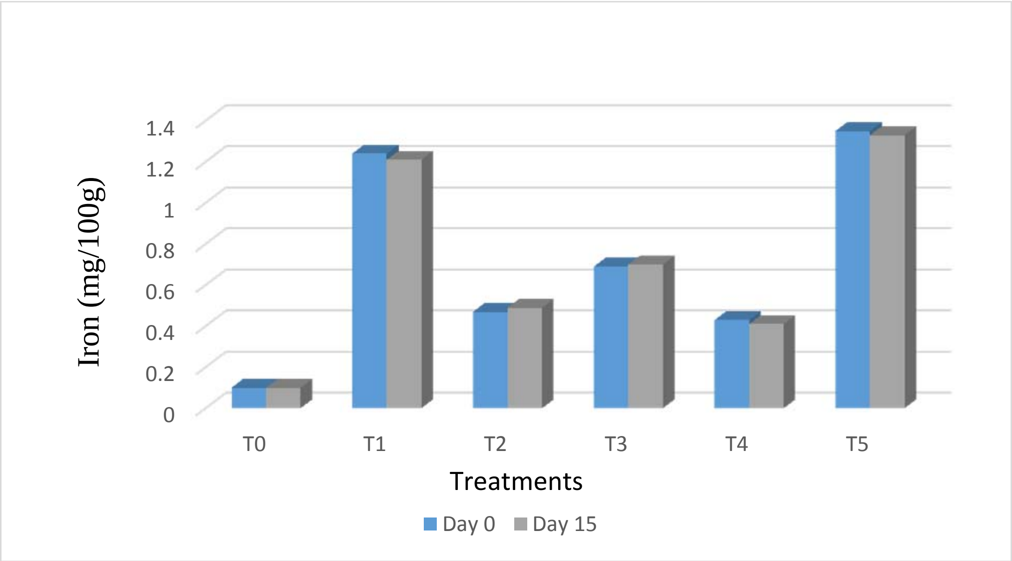

Fig. 21. Effect of storage on iron content of yoghurts

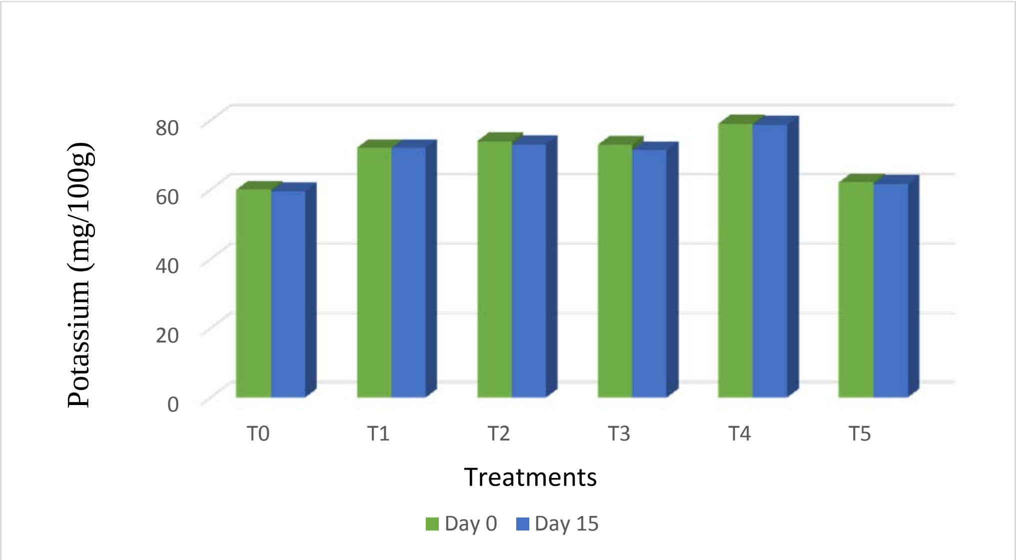

Fig. 22. Effect of storage on potassium content of yoghurts

The iron content of control yoghurt was 0.10 mg/100g, initially and at the end of the storage period under the study. Compared to control, FPBY was found have more iron content in both periods of the study. PPBY had highest value of iron content (1.35 mg/100g to 1.33 mg/100g) followed by SPBY (1.24 to 1.21 mg/100g). Jackfruit pulp based yoghurt had an iron content of (0.70 to 0.69 mg/100g), for GPBY (0.49 to 0.47 mg/100g), and the lowest value of iron content was found to be in BPBY that is about 0.43 to 0.41 mg/100g. Statistically there was no significant difference observed in treatments during storage.

Table 26. Effect of storage on iron content (mg/100g) of yoghurts

Treatments	Iron (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (100% M)	0.10^{NS} (1.45)	0.10^{NS} (1.45)
T_1 (90%M+10%SP)	1.24^{NS} (5.93)	1.21^{NS} (5.83)
T_2 (90%M+10%GP)	0.49^{NS} (4.01)	0.47^{NS} (3.93)
T_3 (90%M+10%JFP)	0.70^{NS} (4.76)	0.69^{NS} (4.79)
T_4 (90%M+10%BP)	0.43^{NS} (3.76)	0.41^{NS} (3.67)
T_5 (90%M+10%PP)	1.35^{NS} (6.29)	1.33^{NS} (6.23)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.13. Potassium

The potassium content of selected FPBY with control was tabulated and presented is Table 27.

Among all the treatments potassium content was highest in BPBY (79.06 mg 100 g^{-1}) with a variation in potassium content level of 78.70 mg 100 g^{-1} on 15th day of storage. The potassium content of GPBY was 74.03 mg 100 g^{-1}

(initial) to 73.09 mg 100 g^{-1} (15^{th} day). Compared to FPBY, control yoghurt had the lowest content of potassium (60.01 to 59.50 mg 100 g^{-1}) in freshly prepared and during storage. There was a reduction in potassium content during storage period. Based on DMRT, there was no significant difference observed in treatments during storage.

Table 27. Effect of storage on potassium content (mg/100g) of yoghurts

Treatments	Potassium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (100% M)	60.01^{NS} (60.01)	59.50^{NS} (59.50)
T_1 (90%M+10%SP)	72.06^{NS} (58.09)	72.01^{NS} (58.06)
T_2 (90%M+10%GP)	74.03^{NS} (59.36)	73.09^{NS} (58.75)
T_3 (90%M+10%JFP)	72.98^{NS} (58.68)	71.41^{NS} (57.67)
T_4 (90%M+10%BP)	79.06^{NS} (62.77)	78.70^{NS} (62.51)
T_5 (90%M+10%PP)	62.14^{NS} (52.02)	61.62^{NS} (51.72)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.2.14. Total ash

The total ash of selected FPBY with control was tabulated and is presented in Table 28.

The present study revealed a decreasing trend in ash content in all treatments. GPBY had the highest content of total ash of 1.71 to 0.80 per cent and the lowest content was observed in PPBY. It ranged from 1.58 to 0.68 per cent. No significant difference in total ash content was observed during storage of yoghurts.

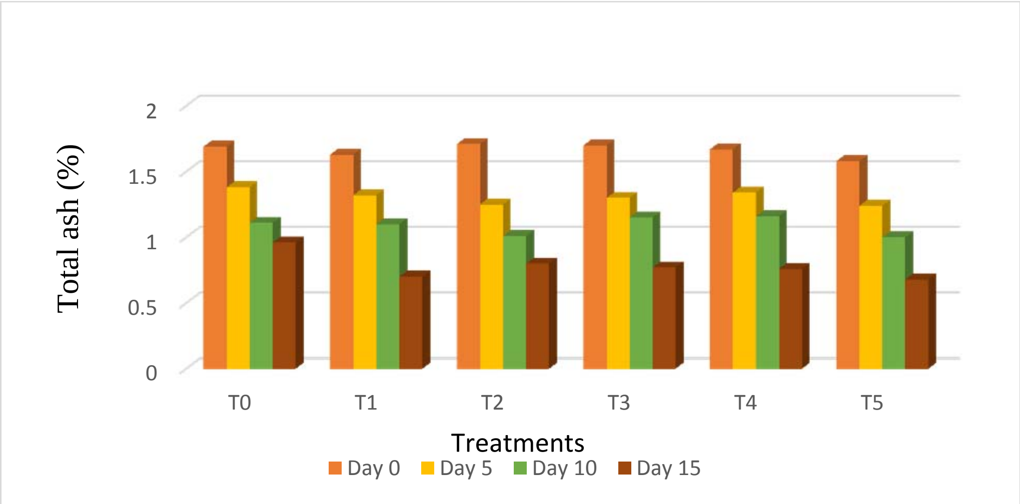

Fig. 23. Effect of storage on total ash content of yoghurts

Table 28. Effect of storage on total ash (%) of yoghurts

Treatments	Total ash (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	1.69 ^{NS} (7.22)	1.38 ^{NS} (6.38)	1.11 ^{NS} (5.43)	0.96 ^{NS} (5.62)
T_1 (90%M+10%SP)	1.63 ^{NS} (7.07)	1.32 ^{NS} (6.20)	1.10 ^{NS} (6.01)	0.70 ^{NS} (4.79)
T_2 (90%M+10%GP)	1.71 ^{NS} (7.27)	1.25 ^{NS} (5.97)	1.01 ^{NS} (5.76)	0.80 ^{NS} (5.12)
T_3 (90%M+10%JFP)	1.70 ^{NS} (7.48)	1.30 ^{NS} (6.54)	1.15 ^{NS} (5.60)	0.77 ^{NS} (5.03)
T_4 (90%M+10%BP)	1.67 ^{NS} (7.15)	1.34 ^{NS} (6.26)	1.16 ^{NS} (6.18)	0.76 ^{NS} (5.00)
T_5 (90%M+10%PP)	1.58 ^{NS} (6.94)	1.24 ^{NS} (5.93)	1.00 ^{NS} (5.73)	0.68 ^{NS} (4.73)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.4.2.4. Microbial qualities

4.4.2.4.1. *E coli*

The E coli count of FPBY with control was tabulated and is presented in Table 29.

E coli count was not detected in any of samples during storage.

Table 29. Effect of storage on *E coli count* (10^1cfu/g) of yoghurts

Treatments	*E coli*count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	ND	ND	ND	ND
T_1 (90%M+10%SP)	ND	ND	ND	ND
T_2 (90%M+10%GP)	ND	ND	ND	ND
T_3 (90%M+10%JFP)	ND	ND	ND	ND
T_4 (90%M+10%BP)	ND	ND	ND	ND
T_5 (90%M+10%PP)	ND	ND	ND	ND

ND – Not detected

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.4.2.4.2. *Coliform bacteria*

The Coliform bacteria count of FPBY with control was tabulated and is presented in Table 30.

Coliform bacterial count was detected only in SPBY throughout the storage period.

Table 30. Effect of storage on *coliform* bacterial count (10^1cfu/g) of yoghurts

Treatments	*Coliform* bacterial count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	ND	ND	ND	ND
T_1 (90%M+10%SP)	1.00	1.1	1.3	1.5
T_2 (90%M+10%GP)	ND	ND	ND	ND
T_3 (90%M+10%JFP)	ND	ND	ND	ND
T_4 (90%M+10%BP)	ND	ND	ND	ND
T_5 (90%M+10%PP)	ND	ND	ND	ND

ND – Not detected

T_0 100% M, T_1 90%M+10% Sapota pulp, T_2 90%M+10% Guava pulp, T_3 90%M+10% Jackfruit pulp, T_4 90%M+10% Banana pulp, T_5 90%M+10% Papaya pulp

4.4.2.4.3. Yeast

The yeast count of FPBY with control was tabulated and is presented in Table 31.

The initial and up to 10^{th} day of storage yeast count was not detected in the selected yoghurts. Presence of yeast was observed at 15^{th} day of storage.

Table 31. Effect of storage on yeast count (10^3cfu/g) of yoghurts

Treatments	Yeast count (10^3cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	ND	ND	ND	2.00
T_1 (90%M+10%SP)	ND	ND	ND	1.5
T_2 (90%M+10%GP)	ND	ND	ND	1.2
T_3 (90%M+10%JFP)	ND	ND	ND	1.00
T_4 (90%M+10%BP)	ND	ND	ND	0.6
T_5 (90%M+10%PP)	ND	ND	ND	1.00

ND – Not detected

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.4.2.4.4. Fungi

The fungal count of FPBY with control was tabulated and is presented in Table 32.

The fungal count of the selected treatments (T_0 to T_5) was assessed 15th day of storage.

Table 32. Effect of storage on fungal count (10^3cfu/g) of yoghurts

Treatments	Fungal count (10^3cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	ND	ND	ND	1.60
T_1 (90%M+10%SP)	ND	ND	ND	1.10
T_2 (90%M+10%GP)	ND	ND	ND	1.11
T_3 (90%M+10%JFP)	ND	ND	ND	1.00
T_4 (90%M+10%BP)	ND	ND	ND	0.07
T_5 (90%M+10%PP)	ND	ND	ND	1.00

ND – Not detected

T_0 -100% Milk, T_1 -90% Milk+10% Sapota pulp, T_2 -90% Milk+10% Guava pulp, T_3-90% Milk+10% Jackfruit pulp, T_4-90% Milk+10% Banana pulp, T_5-90% Milk+10% Papaya pulp

4.3.3. Organoleptic evaluation of yoghurts on storage

The mean scores for the appearance of PPBY to SPBY varied from 8.46 to 8.97 which gradually decreased during 5th, 10th and 15 days of storage. The control (T_0) had an initial score of 9.00 which decreased to 7.37 at the end of storage. The colour of the FPBY varied from 8.57 (T_1) to 8.46 (T_5) initially and that of control (T_0) was 8.75. During the storage treatment, T_2 and T_4 was found to have high mean scores of 6.91.

The initial highest mean score for the flavour in FPBY initially was 8.46 in SPBY and lowest in GPBY and BPBY (8.08). Whereas at the end of storage, the mean scores was highest in SPBY and JFPBY (6.77). The mean score for control ranged from 8.88 to 7.08.

The taste and texture of FPBY (T_1 to T_5) varied from 8.66 to 8.28 and 8.35 to 8.22 (initially) and 6.35 to 6.22 and 6.02 to 6.15 (15^{th} day) respectively. The taste and texture of control yoghurt, showed a mean score which varied from 8.86 to 7.81 and 8.91 to 7.55 during storage.

During the storage period, the overall acceptability was found to be high in treatment T_5 (8.80, 7.55, 7.01 and 6.91) and lowest was in GPBY and BPBY (8.06, 7.46, 7.02 and 6.91). The control (T_0) was high in all the sensory parameters in comparison with FPBY. All the treatments attained a mean score of above 6.

Table 33. Mean scores for organoleptic evaluation of yoghurts on storage

Treatments	Appearance				Colour				Flavour			
	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15
T_0 (100% M)	9.00	8.84	8.64	7.37	8.75	8.06	7.68	7.00	8.88	8.64	8.51	7.08
T_1 (90%M+10%SP)	8.97	8.46	7.69	6.91	8.57	7.93	7.24	6.86	8.46	8.26	7.53	6.77
T_2 (90%M+10%GP)	8.97	7.73	7.31	6.35	8.06	7.73	7.31	6.91	8.08	7.48	7.00	6.26
T_3 (90%M+10%JFP)	8.84	7.42	6.97	6.53	8.06	8.55	7.73	6.68	8.62	8.31	7.82	6.77
T_4 (90%M+10%BP)	8.66	7.84	6.95	6.62	8.13	7.73	7.31	6.91	8.08	7.48	7.00	6.26
T_5 (90%M+10%PP)	8.46	8.37	7.28	6.57	8.46	8.37	8.28	6.57	8.22	7.93	7.74	6.00

T_0-100%Milk, T_1-90%Milk+10%Sapotapulp, T_2-90%Milk+10%Guavapulp, T_3-90%Milk+10%Jackfruitpulp, T_4-90%Milk+10%Bananapulp, T_5-90%Mil+10%Papayapulp

Table 33. Mean scores for organoleptic evaluation of yoghurts on storage

Treatments	Overall acceptability				Taste				Texture			
	Day 0	**Day 5**	**Day 10**	**Day 15**	**Day 0**	**Day 5**	**Day 10**	**Day 15**	**Day 0**	**Day 5**	**Day 10**	**Day 15**
T_0 (100% M)	8.68	8.57	8.06	7.00	8.86	8.71	8.00	7.81	8.91	8.77	8.06	7.55
T_1 (90%M+10%SP)	8.80	7.55	7.01	6.91	8.66	7.91	7.46	6.35	8.35	7.71	6.73	6.02
T_2 (90%M+10%GP)	8.53	7.86	7.46	6.22	8.06	7.42	6.60	6.33	8.26	7.37	7.24	6.57
T_3 (90%M+10%JFP)	8.06	7.46	7.02	6.28	8.17	7.80	7.26	6.48	8.64	7.86	6.71	6.20
T_4 (90%M+10%BP)	8.06	7.46	7.02	6.91	8.06	7.42	7.00	6.60	8.80	7.42	7.28	6.60
T_5 (90%M+10%PP)	8.37	8.11	7.40	6.22	8.28	8.11	7.50	6.22	8.22	8.11	7.40	6.15

T_0-100%Milk, T_1-90%Milk+10%Sapotapulp, T_2-90%Milk+10%Guavapulp, T_3-90%Milk+10%Jackfruitpulp, T_4-90%Milk+10%Bananapulp, T_5-90%Mil+10%Papayapulp

4.3. Organoleptic qualities of functional ingredients incorporated yoghurts

Functional ingredient incorporated yoghurts were prepared by incorporating garden cress seed and flax seed. Garden cress seeds and flax seeds were incorporated at two and four per cent levels. Fruit pulps of sapota, Banana *(Palayankodan)*, jackfruit *(Koozha type),* guava and papaya were used for the preparation of yoghurts. Twentyfour treatments including four control (T_0) were evaluated organoleptically for various quality attributes like appearance, colour, flavour, texture, odour, taste and overall acceptability. The different quality attributes for each fruit pulps were evaluated separately and were ranked based on their mean scores using Kendall's (W) test.

4.3.1. Organoleptic qualities of functional ingredient (GCS) incorporated yoghurts

Garden cress seeds were incorporated at two and four per cent levels and were subjected to organoleptic evaluation. Since all the organoleptic attributes for control and GCS incorporated FPBY attained scores less than five, they were not selected for further studies.

The mean scores and the mean rank scores for different quality attributes of GCS incorporated FPBY and its comparison with plain yoghurt are presented in Table 34a to 34b.

Table – 34a Mean scores for organoleptic qualities of functional ingredient (2% GCS) incorporated yoghurts

Treatments	Appearance	Colour	Flavour	Overall acceptability	Taste	Texture	Total score
T_0 (98% M + 2% GCS)	4.13 (2.97)	3.91 (2.77)	3.91 (2.77)	3.91 (2.77)	3.55 (1.43)	3.91 (2.77)	23.32
T_1 (88%M+2%GCS+10%JFP)	3.24 (1.77)	3.11 (1.67)	2.37 (1.73)	2.40 (1.87)	2.26 (1.57)	2.35 (1.77)	15.73
T_2 (88%M+2%GCS+10%PP)	3.18 (1.73)	3.02 (1.57)	2.28 (1.70)	2.31 (1.63)	1.53 (1.95)	1.80 (2.35)	14.12
T_3 (88%M+2%GCS+10%BP)	3.24 (1.77)	3.11 (1.67)	2.37 (1.73)	2.40 (1.87)	2.26 (1.57)	2.35 (1.77)	15.73
T_4 (88%M+2%GCS+10%GP)	3.11 (1.40)	3.15 (1.53)	2.44 (1.50)	2.42 (1.53)	2.46 (1.50)	2.40 (1.50)	16.07
T_5 (88%M+2%GCS+10%SP)	3.55 (1.43)	3.39 (1.20)	3.91 (2.77)	3.39 (1.20)	3.55 (1.43)	3.39 (1.20)	21.18
Kendall's (W)	.645**	.516**	.422**	.516**	.500**	.516**	

Figures in parenthesis indicate mean rank scores; ** significant at 1%, M – Milk, JFP– Jackfruit pulp, PP-Papaya pulp, BP-Banana pulp, GP-Guava pulp, SP- Sapota pulp, GCS – Garden cress seed

Table – 34b Mean scores for organoleptic qualities of functional ingredient (4% GCS) incorporated yoghurts

Treatments	Appearance	Colour	Flavour	Overall acceptability	Taste	Texture	Total score
T_0 (96% M + 4% GCS)	3.55 (1.43)	3.42 (1.07)	2.42 (1.00)	3.42 (1.07)	3.39 (1.20)	3.42 (1.07)	19.62
T_1 (86%M+4%GCS+10%JFP)	2.97 (1.23)	2.93 (1.33)	2.11 (1.27)	2.31 (1.13)	2.02 (1.43)	2.04 (1.23)	14.37
T_2 (86%M+4%GCS+10%PP)	2.88 (1.27)	2.93 (1.43)	2.02 (1.30)	2.27 (1.37)	1.88 (1.47)	1.88 (1.20)	13.86
T_3 (86%M+4%GCS+10%BP)	2.97 (1.23)	2.93 (1.33)	2.11 (1.27)	2.31 (1.13)	2.02 (1.43)	2.04 (1.23)	14.38
T_4 (86%M+4%GCS+10%GP)	3.20 (1.40)	3.13 (1.47)	1.50 (1.37)	1.47 (1.35)	1.50 (1.42)	2.4 (1.40)	13.2
T_5 (86%M+4%GCS+10%SP)	3.55 (1.43)	3.33 (1.23)	2.42 (1.00)	3.33 (1.23)	3.39 (1.20)	3.33 (1.23)	19.35
Kendall's (W)	.645**	.516**	.422**	.516**	.500**	.516**	

Figures in parenthesis indicate mean rank scores; ** significant at 1%, M – Milk, JFP– Jackfruit pulp, PP-Papaya pulp, BP-Banana pulp, GP-Guava pulp, SP- Sapota pulp, GCS – Garden cress seed

4.3.2. Organoleptic qualities of functional ingredient (GCS) incorporated yoghurts

Yoghurts were then experimented with 0.5 and 1 per cent levels of GCS and the results are furnished in table 35a to 35b.

The appearance of functional ingredient (GCS) incorporated JFPBY of various treatments T_1 from table 33a and T_1 from table 33b had a mean score and mean rank score of 8.00 to 7.86 and the mean rank score of 3.07 to 1.63 respectively. In GCS incorporated PPBY, T_2 from table 33a and T_2 from table 33b the mean score of appearance was 8.09 and 8.01 and the mean rank score was 3.07 to 1.63 respectively. The appearance of GCS incorporated BPBY (T_3) from table 33a and 33b had a mean score of 8.28 and 8.11 respectively. For, GPBY (T_4) from table 33a and the table 33b the mean score was 8.57 and 8.20 in appearance respectively. Functional ingredient (GCS) incorporated SPBY (T_5) had a mean score 8.48 and 8.33.

In case of colour, the mean score for T_1 was 7.88 and 8.14, for T_2 it was 7.28 and 7.55, for T_3 it was 7.48 and 7.71, for T_4 it was 7.32 and 8.06 and for T_5 it was about 7.31 and 7.33. The mean score for flavour of was 8.23 and 8.53, T_2 (7.31 and 7.51), T_3 (7.42 and 7.77), T_4 (8.17 and 8.37) and T_5 (7.28 and 7.53). In case of overall acceptability and taste, the mean score was 8.60 and 8.80 and 7.33 and 7.35respectively for T_1. For, T_2 it was 6.60 and 7.73 and 6.11 and 6.20. For, T_3 the score of overall acceptability and taste was 8.28 and 8.68 and 6.40 and 6.60. For, $T_4$the mean scores was 8.11 and 8.51 and 7.42 and 7.88. The overall acceptability and taste of T_5 was 8.26 and 8.75 and 7.89 and 7.91. The texture of GCS incorporated JFPBY had a score of 6.22 and 7.00, and in PPBY the score was 6.20 and 6.70. In BPBY mean score was 6.60 and 7.53, GPBY it was 7.71 and 7.80 and for SPBY it was 7.66 and 8.33. The treatments T_1 to T_5 incorporated with 0.5% GCS and T0 (99.9% M + 0.5% GCS) got the highest total score.

Table – 35a Mean score for organoleptic qualities of functional ingredient (GCS – 0.5%) incorporated yoghurts

Treatments	Appearance	Colour	Flavour	Overall acceptability	Taste	Texture	Total score
T_0 (99.5% M+ 0.5 % GCS)	8.91 (3.27)	8.31 (3.27)	8.77 (3.73)	9.00 (3.77)	8.42 (3.90)	8.26 (3.40)	51.67
T_1 (89.5% M+ 0.5 % GCS +10%JFP)	8.00 (3.07)	8.14 (2.10)	8.53 (1.67)	8.80 (2.23)	7.34 (1.60)	7.00 (1.97)	47.81
T_2 (89.5% M+ 0.5 % GCS + 10% PP)	8.09 (3.07)	7.55 (2.10)	7.51 (1.67)	7.73 (2.23)	6.11 (1.60)	6.78 (1.97)	43.72
T_3 (89.5% M+ 0.5 %GCS +10%BP)	8.28 (3.03)	7.71 (2.07)	7.77 (1.97)	8.68 (2.77)	6.40 (1.73)	7.53 (2.47)	46.73
T_4 (89.5% M+ 0.5 % GCS +10%GP)	8.57 (2.57)	8.06 (2.90)	8.37 (2.47)	8.51 (2.80)	7.88 (2.23)	7.80 (2.60)	48.45
T_5 (89.5% M+ 0.5 % GCS + 10%SP)	8.48 (2.83)	7.33 (1.27)	7.53 (1.83)	8.75 (3.03)	7.91 (2.87)	8.33 (3.33)	48.33
Kendall's (W)	**.451****	**.733****	**.909****	**.852****	**.836****	**.728****	

Figures in parenthesis indicate mean rank scores; ** significant at 1% level. M – Milk, JFP– Jackfruit pulp, PP-Papaya pulp, BP-Banana pulp, GP-Guava pulp, SP- Sapota pulp, GCS – Garden cress seed

Table – 35b Mean score for organoleptic qualities of functional ingredient (GCS – 1%) incorporated yoghurts

Treatments	Appearance	Colour	Flavour	Overall acceptability	Taste	Texture	Total score
T_0 (99% M+ 1% GCS)	8.51 (2.17)	8.41 (2.20)	8.40 (3.27)	8.00 (1.23)	8.39 (1.97)	7.35 (1.23)	49.06
T_1 (89% M+ 1% GCS +10%JFP)	7.86 (1.63)	7.88 (1.33)	8.28 (1.37)	8.6 (1.00)	7.33 (1.40)	6.22 (1.20)	46.17
T_2 (89% M+ 1% GCS + 10% PP)	8.04 (1.63)	7.28 (1.33)	7.31 (1.37)	6.60 (1.00)	6.00 (1.40)	6.20 (1.20)	41.48
T_3 (89% M+ 1%GCS +10%BP)	8.11 (1.57)	7.48 (1.53)	7.42 (1.20)	8.28 (2.20)	6.22 (1.27)	6.60 (1.53)	44.11
T_4 (89% M+ 1% GCS +10%GP)	8.20 (1.50)	7.32 (2.13)	8.17 (1.70)	8.11 (1.80)	7.42 (1.77)	7.71 (2.40)	47.67
T_5 (89% M+ 1% GCS + 10%SP)	8.33 (1.73)	7.31 (3.27)	7.28 (1.17)	8.26 (1.97)	7.89 (1.27)	7.66 (2.03)	46.80
Kendall's (W)	**.451****	**.733****	**.909****	**.852****	**.836****	**.728****	

Figures in parenthesis indicate mean rank scores; ** significant at 1% level. M – Milk, JFP– Jackfruit pulp, PP-Papaya pulp, BP-Banana pulp, GP-Guava pulp, SP- Sapota pulp, GCS – Garden cress seed

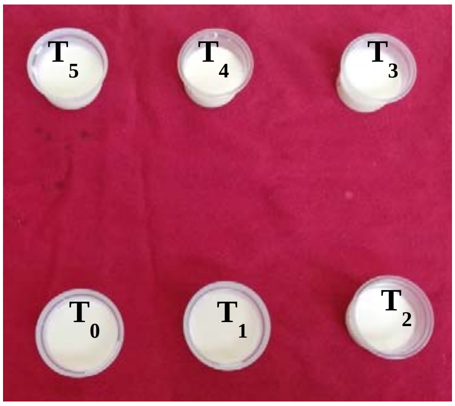

Plate 6. Functional ingredient (GCS – 0.5%) incorporated FPBY

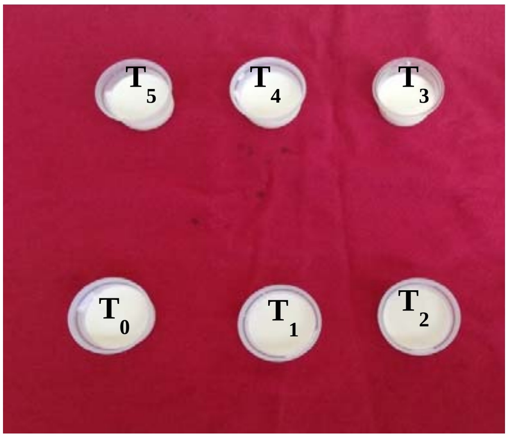

Plate 7. Functional ingredient (GCS – 1%) incorporated FPBY

4.4. Quality evaluation of selected functional ingredient incorporated (GCS) yoghurts

4.4.1. Physicochemical properties

4.4.1.1. Moisture

The moisture content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 36.

Moisture content of yoghurts decreased with days of storage. The initial moisture content of plain yoghurt (T_0) was 80.44 per cent which decreased to 75.00 per cent at the end of 15th day of storage. A significant difference in moisture content was observed at an interval of 5 days in plain yoghurt. The same decreasing trend was observed in functional ingredient (GCS) incorporated SPBY, GPBY, JFPBY, BPBY and PPBY.

In functional ingredient incorporated (GCS) sapota pulp based yoghurt, the moisture content varied from 80.01 per cent to 74.32 per cent from freshly prepared to 15th day of storage. In GCS incorporated guava pulp based yoghurts it varied from 81.11 to 79.57, 77.42 and 75.63 per cent from freshly prepared to 5th, 10th and 15th day, respectively. In GCS incorporated JFPBY, BPBY and PPBY it varied from 80.64 to 74.21 per cent, 81.78 to 78.00 per cent and 81.42 to 76.99 per cent respectively. On statistical interpretation a significant difference was observed in all treatments from initial to the end of storage.

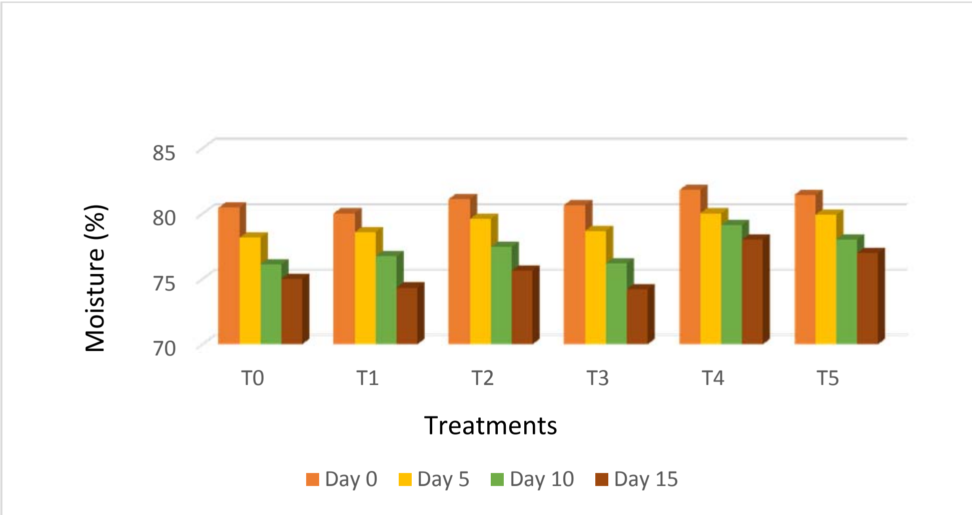

Fig. 24. Effect of storage on moisture content of GCS incorporated yoghurts

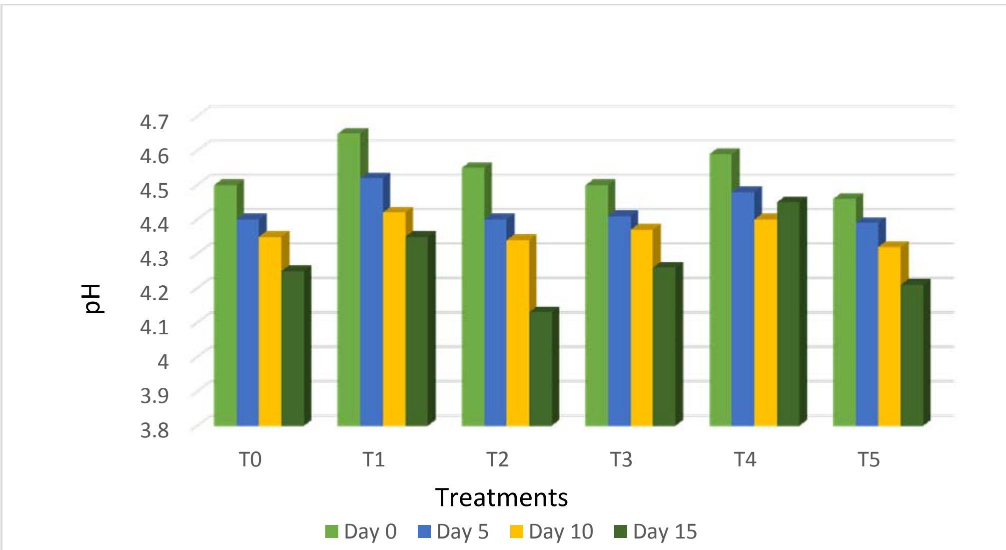

Fig. 25. Effect of storage on pH of functional ingredient GCS incorporated yoghurts

Table 36. Effect of storage on moisture content (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Moisture (%)				
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	CD (0.5)
T_0 (99.5% M + 0.5 % GCS)	80.44^{a} (63.75)	78.14^{b} (62.12)	76.11^{c} (60.74)	75.00^{c} (60.00)	1.29
T_1 (89.5% M + 10% SP + 0.5 % GCS)	80.01^{a} (63.44)	78.56^{ab} (62.42)	76.72^{b} (61.15)	74.32^{c} (59.55)	1.28
T_2 (89.5% M + 10% GP + 0.5 % GCS)	81.11^{a} (64.24)	79.57^{a} (63.13)	77.42^{b} (61.63)	75.63^{c} (60.42)	1.31
T_3 (89.5% M + 10% JFP + 0.5 %GCS)	80.64^{a} (63.90)	78.66^{b} (62.49)	76.20^{c} (60.80)	74.21^{d} (59.48)	1.27
T_4 (89.5% M + 10% BP+ 0.5 %GCS)	81.78^{a} (64.73)	80.01^{ab} (63.44)	79.11^{bc} (62.80)	78.00^{c} (62.03)	1.34
T_5 (89.5% M + 10% PP + 0.5 % GCS)	81.42^{a} (64.47)	79.89^{ab} (63.36)	78.02^{bc} (62.04)	76.99^{c} (61.33)	1.33

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.1.2. pH

The pH of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 37.

A decreasing trend in pH with days of storage was observed among all yoghurts. A significant decrease in pH was observed among the freshly prepared yoghurts and at the end of 15th day of storage. The initial pH of T_0, T_1, T_2, T_3, T_4 and T_5 were 4.50, 4.65, 4.55, 4.50, 4.59 and 4.46, respectively. At the end of storage it decreased to 4.25, 4.35, 4.13, 4.26, 4.45 and 4.21 for T_0, T_1, T_2, T_3, T_4 and T_5, respectively.

Table 37. Effect of storage on pH of functional ingredient (GCS) incorporated yoghurts

Treatments	pH			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5 % M + 0.5 % GCS)	4.50^{NS}	4.40^{NS}	4.35^{NS}	4.25^{NS}
T_1 (89.5 % M + 10% SP + 0.5 % GCS)	4.65^{NS}	4.52^{NS}	4.42^{NS}	4.35^{NS}
T_2 (89.5% M + 10% GP + 0.5 % GCS)	4.55^{NS}	4.40^{NS}	4.34^{NS}	4.13^{NS}
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	4.50^{NS}	4.41^{NS}	4.37^{NS}	4.26^{NS}
T_4 (89.5%M + 10% BPP + 0.5%GCS)	4.59^{NS}	4.48^{NS}	4.40^{NS}	4.45^{NS}
T_5 (89.5% M + 10% PP + 0.5 % GCS)	4.46^{NS}	4.39^{NS}	4.32^{NS}	4.21^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.1.3. Acidity

The acidity of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 38.

The initial acidity of control yoghurt was 0.70 which increased with every five days of interval, it reaches up to 0.78 on 15 days of storage. Among the functional ingredient (GCS) incorporated FPBY the highest per cent acidity was observed in BPBY, it ranged from 0.72 to 0.91 per cent on 15th day of storage. The lowest value of acidity was found to be in PPBY (0.60 to 0.70).

The acidity increased in all samples with advancement of storage. The maximum amount of acidity was observed on 15th day of storage. Based on DMRT no significant difference in acidity was observed in PP incorporated yoghurts. The same increasing trend in acidity was observed in all treatments. A significant difference in five days interval was observed in all other functional

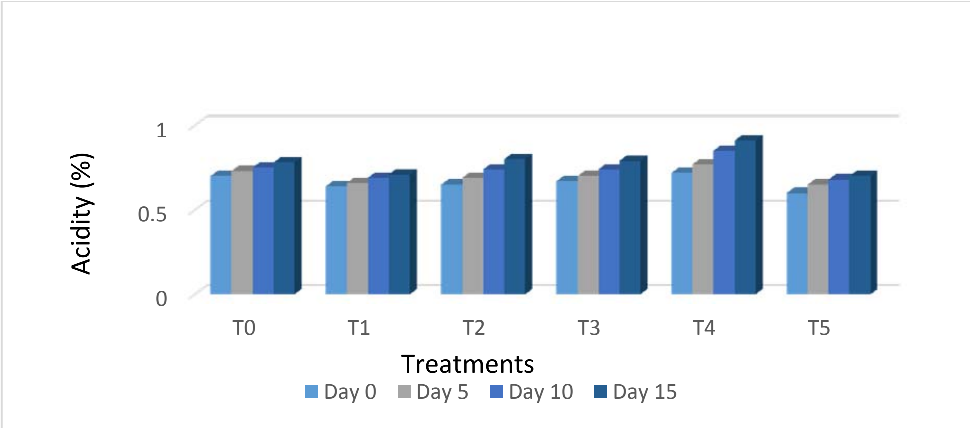

Fig. 26. Effect of storage on acidity of functional ingredient GCS incorporated FPBY

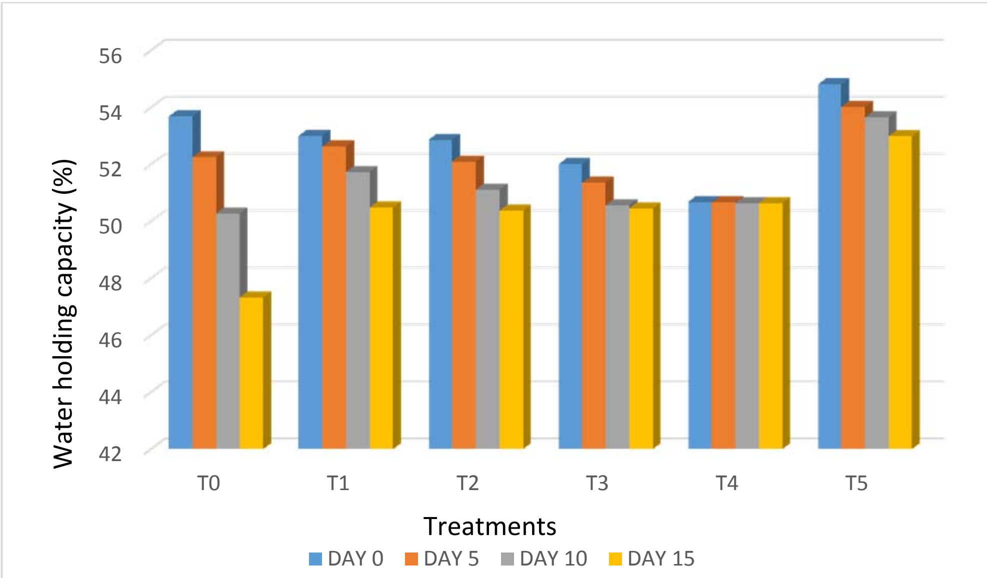

Fig. 27. Effect of storage on water holding capacity of functional ingredient GCS incorporated yoghurts

ingredient (GCS) incorporated fruit pulp incorporated yoghurts (SPBY, GPBY, JFPBY and BPBY).

Table 38. Effect of storage on acidity (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Acidity (%)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (99.5% M + 0.5 % GCS)	0.70^{d}	0.73^{c}	0.75^{b}	0.78^{a}	0.063
T_1 (89.5% M + 10% SP + 0.5 % GCS)	0.64^{d}	0.66^{c}	0.69^{b}	0.71^{a}	0.066
T_2 (89.5% M + 10% GP + 0.5 % GCS)	0.65^{d}	0.69^{c}	0.74^{b}	0.80^{a}	0.064
T_3 (89.5% M + 10% JFP + 0.5% GCS)	0.67^{d}	0.70^{c}	0.74^{b}	0.79^{a}	0.064
T_4 (89.5% M +10% BP + 0.5%GCS)	0.72^{d}	0.77^{c}	0.85^{b}	0.91^{a}	0.060
T_5 (89.5% M + 10% PP + 0.5 % GCS)	0.60^{NS}	0.65^{NS}	0.68^{NS}	0.70^{NS}	-

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

5.4.1.4. Water holding capacity

The water holding capacity of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 39.

Initial water holding capacity of control yoghurt was 53.68 per cent which decreased during storage. On 15th day it was about 47.32 per cent. Initially the highest WHC was observed in GCS incorporated PPBY that is 54.80 per cent during storage it declined up to 52.98 per cent. Lowest value were noticed in treatment BPBY (50.68). On 15th day after storage, it reaches about 50.66 per cent.

Table 39. Effect of storage on water holding capacity (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	WHC (%) Day of storage				CD (0.5)
	0	5	10	15	
T_0 (99.5 % M + 0.5 % GCS)	53.68^{a}	52.25^{a}	50.27^{b}	47.32^{c}	1.883
T_1 (89.5% M+10%SP+0.5% GCS)	53.00^{NS}	52.62^{NS}	51.73^{NS}	50.48^{NS}	-
T_2 (89.5%M+10%GP+0.5%GCS)	52.86^{a}	52.10^{ab}	51.11^{bc}	50.37^{c}	1.948
T_3 (89.5%M+10%JFP+0.5%GCS)	52.00^{NS}	51.37^{NS}	50.56^{NS}	50.45^{NS}	-
T_4 (89.5% M+10%BP+0.5%GCS)	50.68^{NS}	50.66^{NS}	50.64^{NS}	50.64^{NS}	-
T_5 (89.5% M +10%PP+0.5%GCS)	54.80^{NS}	54.02^{NS}	53.64^{NS}	52.98^{NS}	-

5% significant level; Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

5.4.1.5. Syneresis

The syneresis of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 40.

An increasing trend in syneresis was observed in all treatments. In plain yoghurt, syneresis increased from 1.10 per cent to 3.00 per cent. For GCS incorporated SPBY it was about 0.80 to 2.10, for GCS incorporated GPBY (0.70 to 1.80), GCS incorporated JFPBY (1.00 to 1.30), GCS incorporated BPBY (1.00 to 2.80) and for GCS incorporated PPBY (1.00 to 2.20).

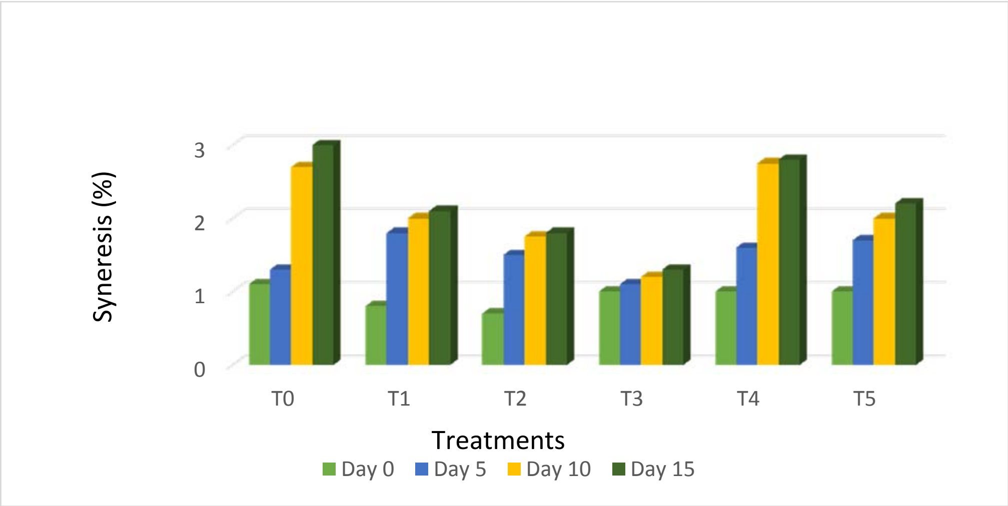

Fig. 28. Effect of storage on syneresis of functional ingredient GCS incorporated yoghurts

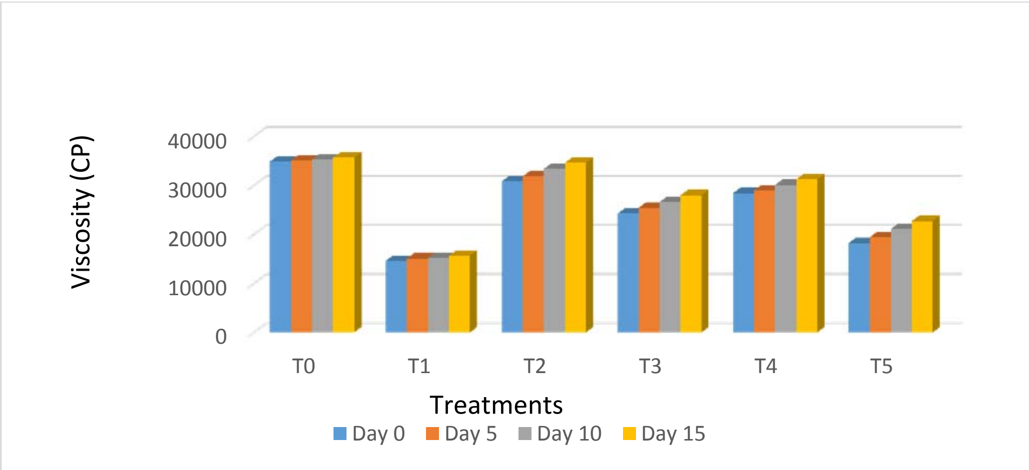

Fig. 29. Effect of storage on viscosity of functional ingredient GCS incorporated yoghurts

Table 40. Effect of storage on syneresis (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Syneresis (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	1.10^{NS} (5.73)	1.30^{NS} (7.72)	2.70^{NS} (9.16)	3.00^{NS} (9.16)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	0.80^{NS} (5.73)	1.8^{NS} (7.72)	2.00^{NS} (9.16)	2.10^{NS} (9.16)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	0.70^{NS} (4.43)	1.5^{NS} (5.79)	1.75^{NS} (7.25)	1.80^{NS} (7.25)
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	1.00^{NS} (4.34)	1.10^{NS} (4.65)	1.20^{NS} (4.65)	1.30^{NS} (4.65)
T_4 (89.5% M + 10% BPP + 0.5 % GCS)	1.00^{NS} (5.12)	1.60^{NS} (6.72)	2.75^{NS} (7.94)	2.80^{NS} (8.74)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	1.00^{NS} (5.43)	1.70^{NS} (6.99)	2.00^{NS} (8.37)	2.20^{NS} (8.37)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

5.4.1.6. Viscosity

The viscosity of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 41.

The viscosity of plain yoghurt had 34850 cP initially and a slight increase was noticed in every 5 days of interval and it reached up to 35640 cP followed by T_2 Initially it was 30800 cP reached to 34600 cP. The lowest measure of viscosity noticed in T_1 initially it was 14630 cP and during 15th day of storage the level of viscosity were increased up to 15640 cP. No significant difference in viscosity were observed in T_0 and T_1. A significant difference in viscosity was observed in T_2, T_3, T_4 and T_5between the freshly prepared yoghurts and at the end of storage.

Table 41. Effect of storage on viscosity (cP) of selected functional ingredient (GCS) incorporated yoghurts

Treatments	Viscosity (cP)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (99.5% M + 0.5 % GCS)	34850^d	35100^c	35280^b	35640^a	0.001
T_1 (89.5% M + 10% SP + 0.5 % GCS)	14630	15100^b	15200^b	15640^a	0.004
T_2 (89.5% M + 10% GP + 0.5 %GCS)	30800^d	31830^c	33370^b	34600^a	0.002
T_3 (89.5% M + 10% JFP + 0.5%GCS)	24230^d	25420^c	26604^b	28000^a	0.001
T_4 (89.5% M + 10% BPP+0.5% GCS)	28410^d	29000^c	30100^b	31200^a	0.002
T_5 (89.5% M + 10% PP + 0.5 % GCS)	18240^d	19400^c	21070^b	22700^a	0.034

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

5.4.1.7. Curd tension

The curd tension of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 42.

Curd tension of yoghurts increased with days of storage. The initial curd tension of plain yoghurt T_0 was 54.00 g which increased to 61.00 g at the end of 15^{th} day of storage. A significant increase in curd tension was observed at an interval of 5 days in plain yoghurt.

The same increasing trend was observed in T_1, T_2, T_3, T_4 and T_5. In sapota pulp based yoghurt (T_1), the curd tension varied from 38.64 g to 45.65 g from freshly prepared to 15th day of storage. In guava pulp based yoghurt (T_2) it varied from 38.68 to 45.66. In jackfruit pulp based yoghurt (T_3), Banana pulp based yoghurt (T_4) and papaya pulp based yoghurt (T_5) it varied from 36.50 to 40.45, 37.70 to 42.00 and 36.50 to 41.90 respectively.

Table 42. Effect of storage on curd tension (g) of functional ingredient (GCS) incorporated yoghurts

Treatments	Curd tension (g)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (99.5% M + 0.5% GCS)	54.00^c	54.15^c	56.70^b	61.00^a	1.883
T_1 (89.5%M+10%SP+0.5% GCS)	38.64^c	41.20^b	43.00^b	45.65^a	1.882
T_2 (89.5%M+10%GP+0.5%GCS)	38.68^c	40.11^b	42.11^b	45.66^a	1.882
T_3 (89.5%M+10%JFP+0.5%GCS)	36.50^b	37.31^b	38.05^b	40.45^a	1.884
T_4 (89.5%M+10%BP+0.5% GCS)	37.70^c	39.01^{bc}	40.30^{ab}	42.00^a	1.885
T_5 (89.5%M+10%PP + 0.5%GCS)	36.50^c	38.15^{bc}	40.00^b	41.90^a	1.884

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

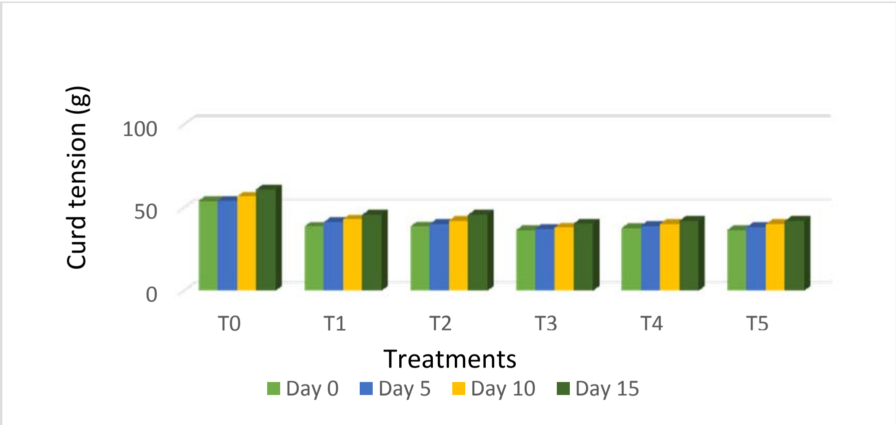

Fig. 30. Effect of storage on curd tension of functional ingredient GCS incorporated yoghurts

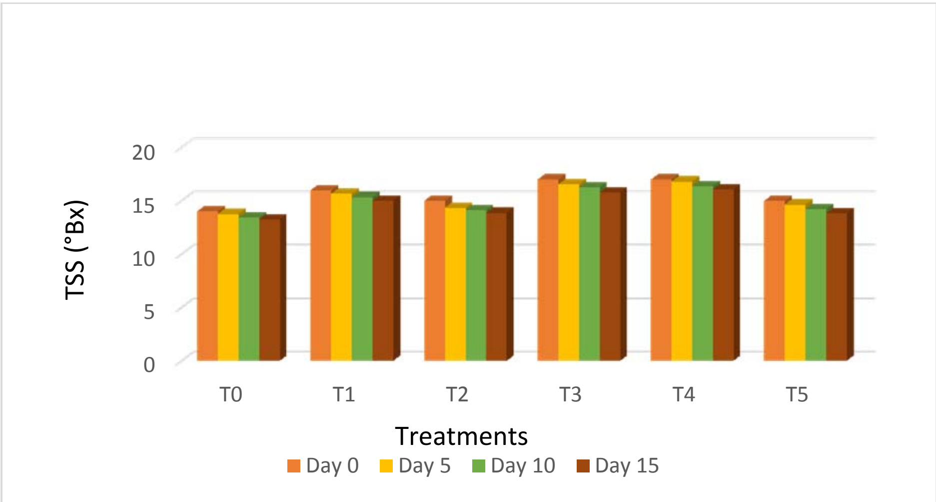

Fig. 31. Effect of storage on TSS content of functional ingredient GCS incorporated yoghurts

4.4.2. Nutritional properties

4.4.2.1. TSS

The TSS of selected functional ingredient (GCS) incorporated FPBY with control was tabulated and presented in Table 43.

The initial TSS of control yoghurt was 14.00 which decreased in every five days of interval, it declined to 13.25 on 15 days of storage. Among the functional ingredient (GCS) incorporated FPBY the highest TSS content was observed in $T_4$and T_3, it ranged from 17.00 to 16.06 and 17.00 to 15.77 on 15th day of storage. The lowest value of TSS content was found to be in $T_5$and T_2 (15.00 to 13.82 and 15.00 to 13.87). The TSS content decreased in all samples with advancement of storage. The lowest content of TSS was observed on 15th day of storage. Based on DMRT there was no significant difference in all yoghurt during storage.

Table 43. Effect of storage on TSS content of selected functional ingredient (GCS) incorporated yoghurts

Treatments	TSS ° (Bx)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	14.00^{NS} (21.96)	13.77^{N} (21.77)	13.41^{NS} (21.47)	13.25^{NS} (21.33)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	16.00^{NS} (23.57)	15.66^{NS} (23.30)	15.34^{NS} (23.05)	15.01^{NS} (22.78)
T_2 (89.5% M+ 10% GP + 0.5 % GCS)	15.00^{NS} (22.77)	14.35^{NS} (22.67)	14.12^{NS} (22.25)	13.87^{NS} (22.06)
T_3 (89.5%M + 10% JFP + 0.5 % GCS)	17.00^{NS} (24.34)	16.55^{NS} (24.76)	16.24^{NS} (23.75)	15.77^{NS} (23.39)
T_4 (89.5% M + 10% BP+ 0.5 % GCS)	17.00^{NS} (24.34)	16.80^{NS} (24.19)	16.39^{NS} (23.87)	16.06^{NS} (23.61)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	15.00^{NS} (22.77)	14.65^{NS} (22.49)	14.21^{NS} (22.13)	13.82^{NS} (21.81)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10%

Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.2. Total sugar

The total sugar content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 44.

The control yoghurt had 10.92 per cent of total sugar (initial) and it decreased to 9.56 per cent (15th day). Among all the treatments, the initial total sugar content was high in GCS incorporated JFPBY with 16.05 per cent followed by GCS incorporated BPBY with 15.11. Functional ingredient incorporated JFBY had highest total sugar content throughout the storage period (15.70, 15.20 and 14.70) and the lowest total sugar content was found in PPBY enriched with 0.5 per cent GCS, it was about 11.16 per cent (initial) and it decreased to 10.00 per cent during storage. As per DMRT, there was no significant variation between control and functional ingredient incorporated FPBY throughout the storage period.

Table 44. Effect of storage on total sugar content (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Total sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (99.5%M+0.5%GCS)	10.92^{NS} (19.28)	10.32^{NS} (18.72)	9.92^{NS} (18.34)	9.56^{NS} (17.99)
T_1 (89.5%M+10%SP+0.5%GCS)	13.21^{NS} (21.30)	12.85^{NS} (20.99)	12.44^{NS} (20.64)	12.00^{NS} (20.25)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	12.88^{NS} (20.53)	12.31^{NS} (20.18)	11.92^{NS} (20.02)	10.75^{NS} (19.12)
T_3 (89.5% M + 10% JFP + 0.5% GCS)	16.05^{NS} (23.61)	15.70^{NS} (23.33)	15.20^{NS} (22.93)	14.70^{NS} (22.53)
T_4 (89.5%M+10%BP+0.5%GCS)	15.11^{NS} (22.86)	14.86^{NS} (22.66)	14.42^{NS} (22.31)	14.06^{NS} (22.01)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	11.16^{NS} (19.50)	10.81^{NS} (19.18)	10.31^{NS} (18.71)	10.00^{NS} (18.42)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 –

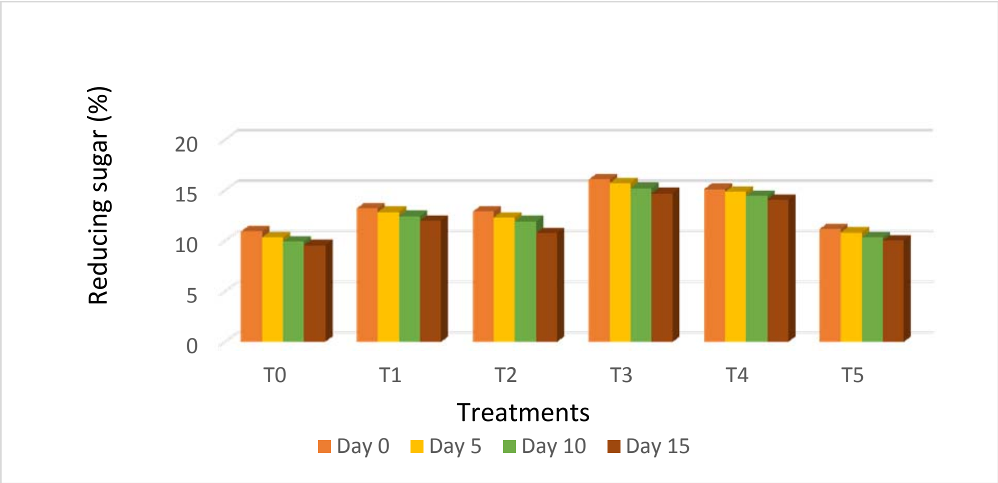

Fig. 32. Effect of storage on total sugar content of functional ingredient GCS incorporated yoghurts

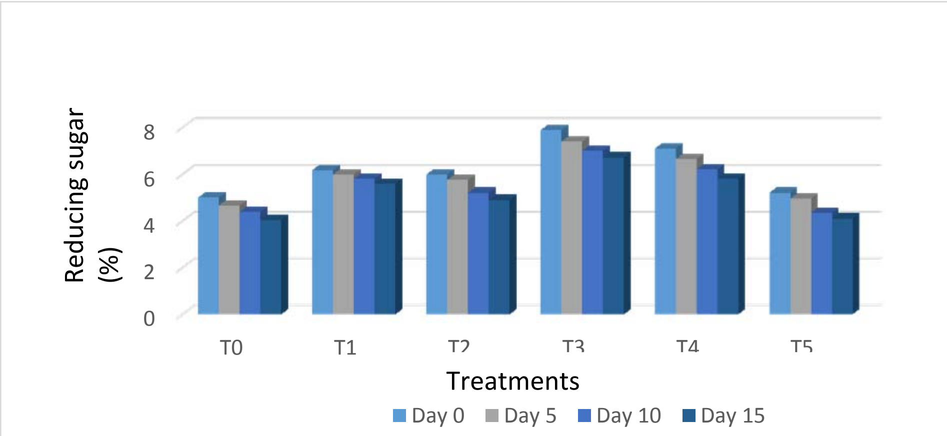

Fig. 33. Effect of storage on reducing sugar content of GCS incorporated yoghurts

89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.3. Reducing sugar

The reducing sugar of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 45.

Among all treatments reducing sugar content was found to be highest in GCS incorporated JFPBY (7.90) followed by BPBY (7.11), SPBY (6.18), GPBY (6.00), PPBY (5.21) and the lowest reducing sugar content was observed in control yoghurt 5.00 and it declined to 4.05 per cent. During 15th day of storage reducing sugar content decreased as 6.72 per cent in GCS incorporated JFPY, 5.81 for BPBY, 6.60 for SPBY, 4.90 for GPBY, 4.10 per cent for PPBY. There was no significant difference between functional ingredients (GCS) incorporated FPBY and control yoghurt throughout the storage period.

Table 45. Effect of storage on reducing sugar content (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Reducing sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (99.5 % M + 0.5 % GCS)	5.00^{NS} (12.87)	4.66^{NS} (13.72)	4.38^{NS} (12.02)	4.05^{NS} (11.55)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	6.18^{NS} (14.36)	6.00^{NS} (14.14)	6.81^{NS} (14.10)	6.60^{NS} (13.85)
T_2 (89.5 % M + 10% GP + 0.5 % GCS)	6.00^{NS} (14.14)	5.75^{NS} (13.84)	5.21^{NS} (13.15)	4.90^{NS} (12.47)
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	7.90^{NS} (16.30)	7.40^{NS} (15.76)	7.00^{NS} (15.3)	6.72^{NS} (14.99)
T_4 (89.5% M + 10% BP + 0.5 % GCS)	7.11^{NS} (15.44)	6.65^{NS} (14.91)	6.20^{NS} (14.38)	5.81^{NS} (13.91)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	5.21^{NS} (13.15)	4.95^{NS} (12.81)	4.35^{NS} (11.98)	4.10^{NS} (11.62)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10%

Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.4. Energy

Energy of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 46.

Initially, control yoghurt had the energy value of 83.57 to 72.88 Kcal during 15^{th} day of storage. High energy was noticed in T_1 (67.53 to 62.41 kcal) whereas T_3 had a low energy value of 56.28 to 51.76 Kcal during storage. A gradual decline in energy value was noticed in each 5 days of storage. Statistically T_0, T_1, T_2 and T_3 are on par with each other during storage.

Table 46. Effect of storage on energy (Kcal) of functional ingredient (GCS) incorporated yoghurts

Treatments	Energy (Kcal)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (99.5% M + 0.5 % GCS)	83.57^{a} (66.09)	80.76^{b} (63.98)	78.64^{c} (62.47)	72.88^{d} (58.61)	1.342
T_1 (89.5%M+10%SP+0.5%GCS)	67.53^{a}	65.67^{ab}	64.03^{bc}	62.41^{c}	1.883
T_2 (89.5%M+10%GP+0.5%GCS)	63.96^{a}	62.5^{b}	60.39^{c}	60.11^{d}	1.883
T_3 (89.5%M+10%JFP+0.5%GCS)	56.28^{a}	55.07^{ab}	53.24^{bc}	51.76^{c}	1.883
T_4 (89.5%M+10%BP+0.5%GCS)	60.99^{NS}	59.2^{NS}	58.83^{NS}	57.78^{NS}	-
T_5 (89.5%M+10%PP+0.5%GCS)	67.49^{NS}	64.64^{NS}	62.33^{NS}	60.56^{NS}	-

Value in parenthesis arc transformed value; 5% level of significance; Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1 – 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

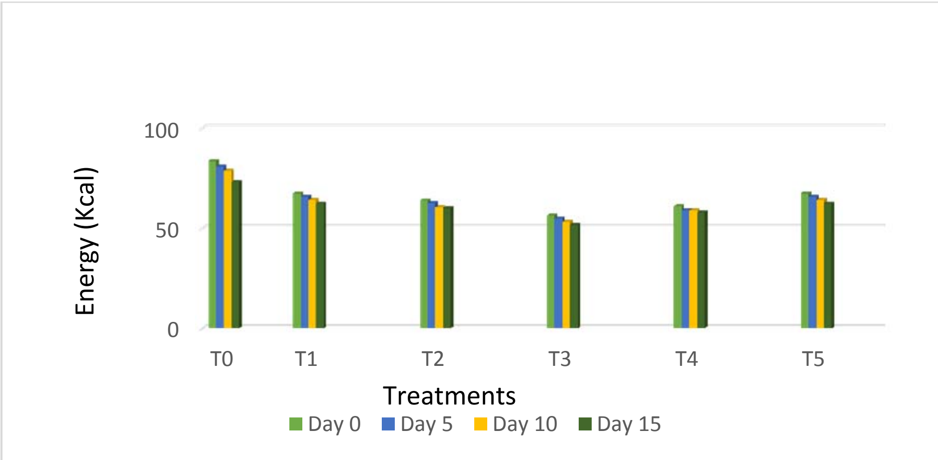

Fig. 34. Effect of storage on energy of functional ingredient GCS incorporated yoghurts

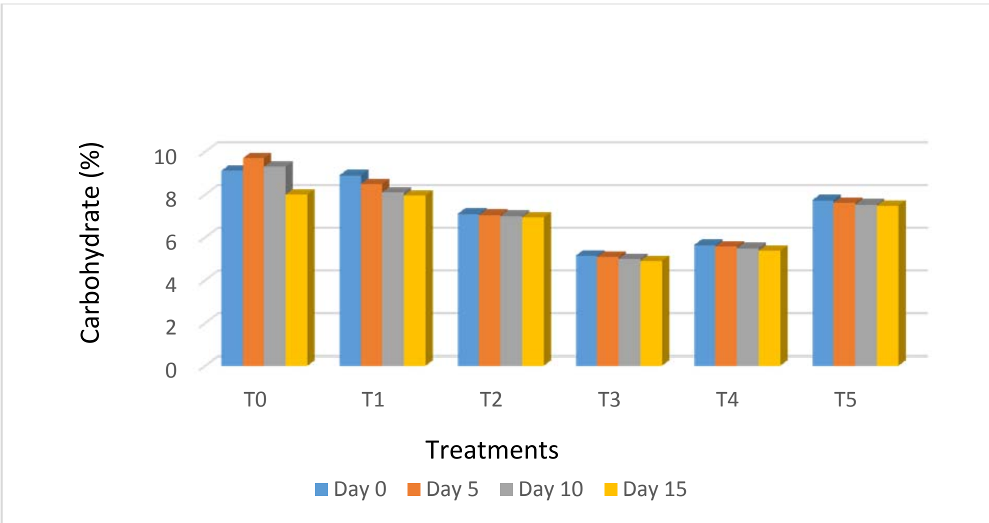

Fig. 35. Effect of storage on carbohydrate content of functional ingredient GCS incorporated yoghurts

4.4.2.1. Carbohydrate

The carbohydrate content of selected functional ingredient incorporated (GCS) yoghurts with control was tabulated and presented in Table 47.

The initial carbohydrate content of control yoghurt was 9.70 which decreased in every five days of interval, it declined to 8.00 on 15 days of storage. Among the FPBY the highest carbohydrate content was observed in T_1, it ranged from 8.90 to 7.96 on 15th day of storage. The lowest value of carbohydrate content was found to be in T_3 (5.15 to 4.90). The carbohydrate content decreased in all samples with advancement of storage. The lowest content of carbohydrate was observed on 15th day of storage. Based on DMRT there was no significant difference in all yoghurt during storage.

Table 47. Effect of storage on carbohydrate content of functional ingredient (GCS) incorporated yoghurts

Treatments	Carbohydrate (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5 % M + 0.5 % GCS)	9.70^{NS} (18.13)	9.30^{NS} (17.74)	9.11^{NS} (17.55)	8.00^{NS} (16.41)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	8.90^{NS} (17.34)	8.50^{NS} (16.93)	8.10^{NS} (16.51)	7.96^{NS} (16.36)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	7.10^{NS} (15.42)	7.05^{NS} (15.37)	7.00^{NS} (15.31)	6.93^{NS} (15.23)
T_3 (89.5 % M + 10% JFP + 0.5%GCS)	5.15^{NS} (14.26)	5.10^{NS} (13.07)	5.00^{NS} (12.87)	4.90^{NS} (12.74)
T_4 (89.5% M + 10% BP + 0.5%GCS)	5.64^{NS} (13.70)	5.58^{NS} (13.62)	5.80^{NS} (13.52)	5.73^{NS} (13.36)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	7.74^{NS} (16.13)	7.62^{NS} (6.00)	7.54^{NS} (15.91)	7.48^{NS} (15.85)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1 – 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.6. Lactose

The lactose content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 48.

The lactose content of control yoghurt was found to be 1.70 to 1.44 per cent during storage. Among functional ingredient (GCS) incorporated FPBY the highest amount of lactose was present in T_1 initially it was 2.40 per cent and it reduced in to 2.17 per cent at 15th day of storage followed by T_3 it is about 1.51 to 1.23 per cent on 15th day of storage. For T_4 it ranged from 1.49 (initial) to 1.22 (15th day) followed by T_5 which was 1.41 to 1.17 per cent respectively. T_2 shows lowest content of lactose that is 1.31 per cent on fresh sample and the end of the storage it was 1.11 per cent. As per DMRT, the lactose content was found to be non-significant during storage.

Table 48. Effect of storage on lactose content (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Lactose (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	1.70^{NS} (7.49)	1.62^{NS} (7.40)	1.50^{NS} (6.72)	1.44^{NS} (6.56)
T_1 (89.5%M+10%SP+0.5%GCS)	2.40^{NS} (8.77)	2.32^{NS} (8.61)	2.23^{NS} (8.43)	2.17^{NS} (8.31)
T_2 (89.5%M+10%GP+0.5%GCS)	1.31^{NS} (6.16)	1.25^{NS} (5.97)	1.19^{NS} (5.75)	1.11^{NS} (5.43)
T_3 (89.5%M+10%JFP+0.5%GCS)	1.51^{NS} (6.75)	1.42^{NS} (6.50)	1.34^{NS} (6.26)	1.23^{NS} (5.90)
T_4 (89.5%M+10%BP+0.5%GCS)	1.49^{NS} (6.70)	1.38^{NS} (6.38)	1.30^{NS} (6.13)	1.22^{NS} (5.86)
T_5 (89.5% M+10%PP+0.5%GCS)	1.41^{NS} (6.47)	1.33^{NS} (6.23)	1.25^{NS} (5.97)	1.17^{NS} (5.68)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10%

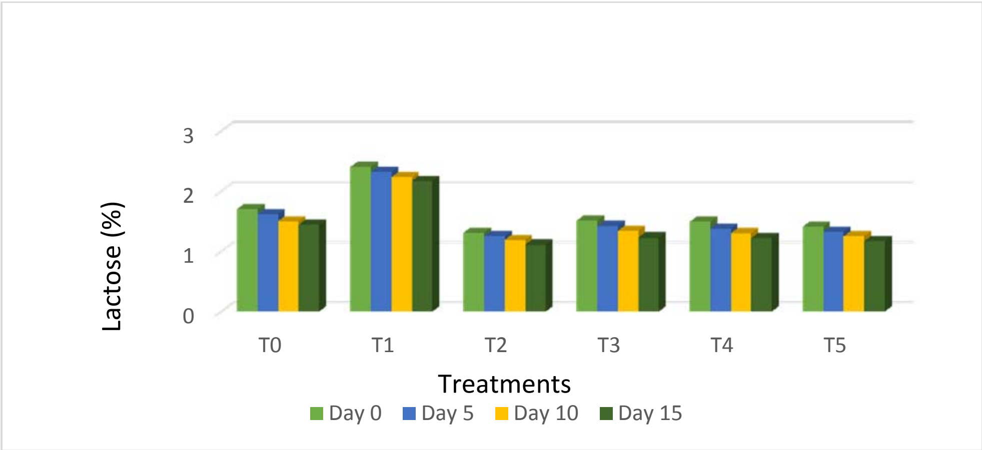

Fig. 36. Effect of storage on lactose content of functional ingredient GCS incorporated yoghurts

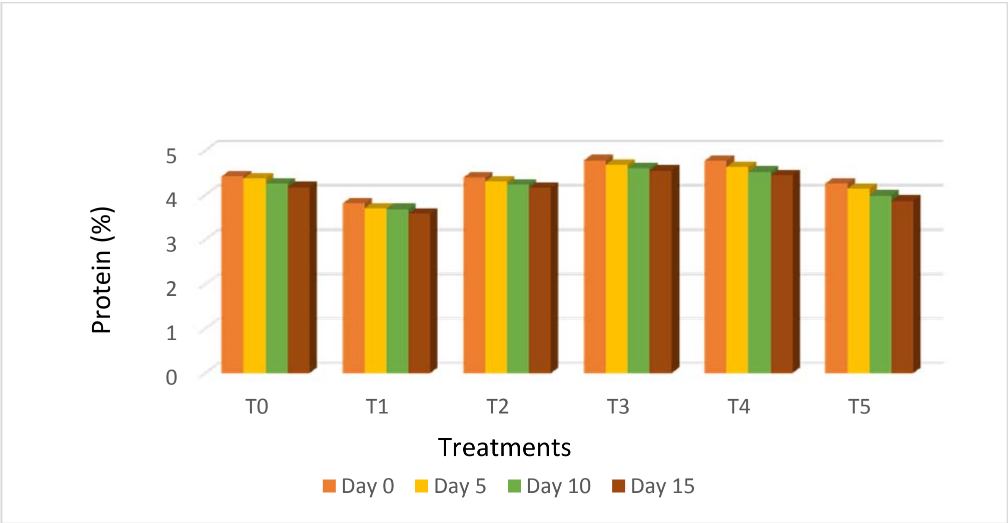

Fig. 37. Effect of storage on protein content of functional ingredient GCS incorporated FPBY

Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.7. Protein

The protein content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 49.

Protein content of yoghurts decreased with days of storage. The initial protein content of plain yoghurt (T_0) was 4.78 per cent which decreased to 4.55 per cent at the end of 15th day of storage. A significant difference in protein content was observed at an interval of 5 days in plain yoghurt. The same decreasing trend was observed in GCS incorporated FPBY.

In T_1, the protein content varied from 3.81 per cent to 3.58 per cent from freshly prepared to 15th day of storage. In T_2 it varied from 4.39 to 4.16 per cent. In T_3, T_4 and T_5 it varied from 4.42 to 4.17per cent, 4.77to 4.44per cent and 4.26to 3.87per cent respectively. On statistical interpretation there was no significant difference observed in all treatments from initial to the end of storage.

Table 49. Effect of storage on protein content (%) of selected functional ingredient (GCS) incorporated yoghurts

Treatments	Protein (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	4.78 ^{NS} (12.32)	4.68 ^{NS} (11.29)	4.61 ^{NS} (10.96)	4.55 ^{NS} (10.46)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	3.81 ^{NS} (11.13)	3.70 ^{NS} (10.82)	3.68^{NS} (10.43)	3.58 ^{NS} (7.94)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	4.39 ^{NS} (10.27)	4.30 ^{NS} (9.54)	4.23 ^{NS} (7.97)	4.16 ^{NS} (7.46)
T_3 (89.5% M+ 10% JFP + 0.5 % GCS)	4.42^{NS} (12.08)	4.37 ^{NS} (11.20)	4.26 ^{NS} (10.75)	4.17 ^{NS} (10.25)
T_4 (89.5% M + 10% BP + 0.5%GCS)	4.77 ^{NS} (11.34)	4.63^{NS} (10.94)	4.52 ^{NS} (10.40)	4.44 ^{NS} (10.01)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	4.26 ^{NS} (10.27)	4.14 ^{NS} (9.56)	3.99 ^{NS} (9.25)	3.87 ^{NS} (8.65)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.8. Fat

The fat content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 50.

Fat content of yoghurts decreased with days of storage. The initial fat content of plain yoghurt T_0 was 2.85 which decreased to 2.52 per cent at the end of 15th day of storage. A significant decrease in fat content was observed for each 5 days of interval during storage. The same decreasing trend was observed in T_1, T_2, T_3, T_4 and T_5.

In T_1, the fat content varied from 1.85 to 1.60 from freshly prepared to 15th day of storage. In T_2 it varied from 2.00 to 1.75 per cent. In T_3, T_4 and T_5 it varied from 2.00 to 1.72, 2.15 to 1.90 and 2.17 to 1.89 per cent respectively. There was no significant difference observed during storage.

Table 50. Effect of storage on fat content (%) of functional ingredient (GCS) incorporated yoghurts

Treatments	Fat (%)			
	Day of storage			
	0	5	10	15
T_0 (99.5% M + 0.5 % GCS)	2.85^{NS} (9.61)	2.76^{NS} (9.45)	2.64^{NS} (9.23)	2.52^{NS} (9.01)
T_1 (89.5% M+10%SP+0.5% GCS)	1.85^{NS} (7.60)	1.76^{NS} (7.39)	1.69^{NS} (7.22)	1.60^{NS} (6.99)
T_2 (89.5%M+10%GP+0.5%GCS)	2.00^{NS} (7.94)	1.90^{NS} (7.72)	1.83^{NS} (7.56)	1.75^{NS} (7.37)
T_3 (89.5% M+10%JFP+0.5%GCS)	2.00^{NS} (7.94)	1.91^{NS} (7.74)	1.80^{NS} (7.49)	1.72^{NS} (7.29)
T_4 (89.5% M+10%BP+0.5%GCS)	2.15^{NS} (8.27)	2.04^{NS} (8.03)	1.95^{NS} (7.83)	1.90^{NS} (7.72)
T_5 (89.5% M+10%PP+0.5%GCS)	2.17^{NS} (8.31)	2.07^{NS} (8.10)	1.99^{NS} (7.92)	1.89^{NS} (7.70)

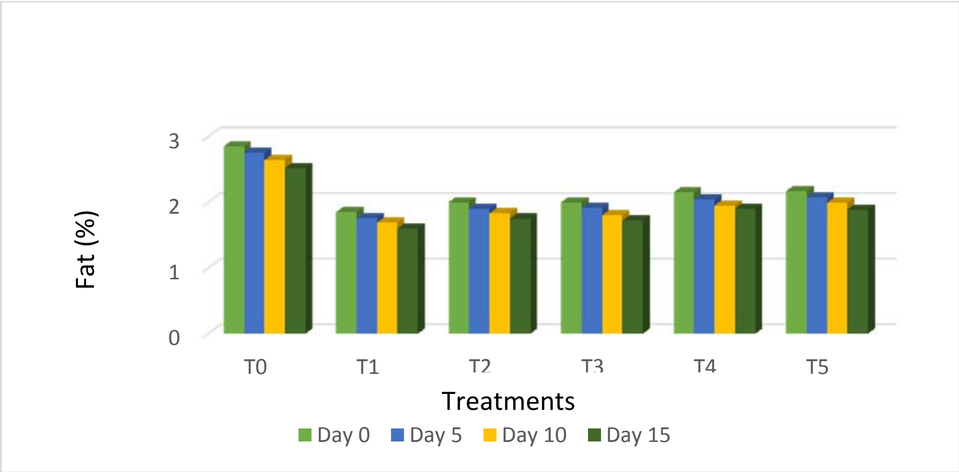

Fig. 38. Effect of storage on fat content of functional ingredient GCS incorporated yoghurts

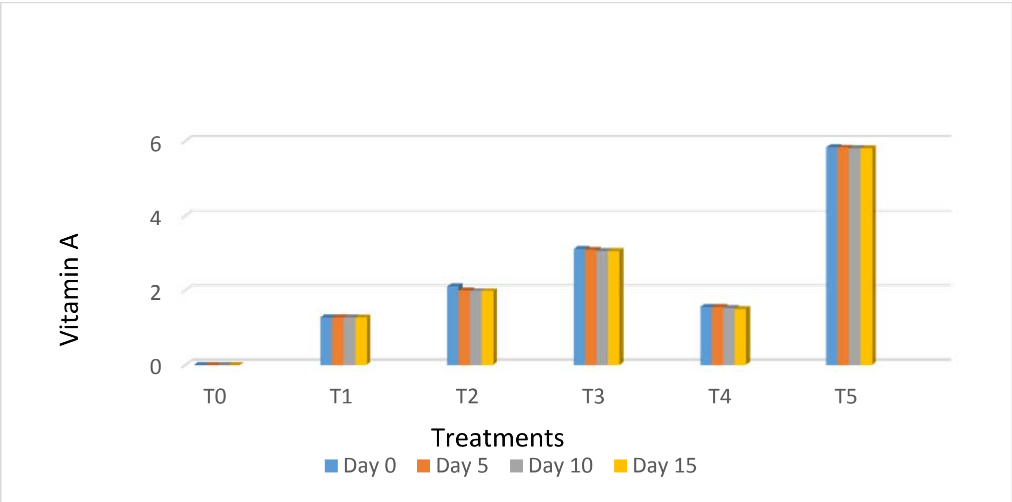

Fig. 39. Effect of storage on vitamin A content of functional ingredient GCS incorporated yoghurts

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.9. Vitamin A

The vitamin A content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 51.

Vitamin A was not detected in control yoghurt throughout the storage period. The highest amount of vitamin A was present in T_5 (5.83 IU) and it decreased to (5.80 IU) on 15th day of storage followed by T_3 (3.11 to 3.06 IU), for T_2 (2.1 to 1.98 IU) and for T_4 (1.55 to 1.50 IU). The lowest amount of vitamin A was found to be in T_1 (1.28 to 1.26 IU). There was significant difference observed in treatment T_3, T_4 and T_4during storage.

Table 52. Effect of storage on vitamin A (IU) of functional ingredient (GCS) incorporated yoghurts

Treatments	Vitamin A (IU)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (99.5% M + 0.5 % GCS)	ND	ND	ND	ND	-
T_1 (89.5% M + 10% SP + 0.5 % GCS)	1.28^{NS} (6.9)	1.27^{NS} (6.03)	1.27^{NS} (6.03)	1.26^{NS} (6.00)	-
T_2 (89.5% M + 10% GP + 0.5 % GCS)	2.1^{NS} (8.33)	2.00^{NS} (8.12)	1.98^{NS} (8.08)	1.98^{NS} (8.08)	-
T_3 (89.5% M + 10% JFP +0.5 % GCS)	3.11^{a} (10.15)	3.09^{b} (10.12)	3.06^{c} (10.09)	3.06^{c} (10.09)	0.30
T_4 (89.5% M + 10% BP + 0.5%GCS)	1.55^{a} (7.15)	1.54^{a} (7.12)	1.53^{b} (7.05)	1.50^{c} (7.03)	0.44
T_5 (89.5% M + 10% PP + 0.5 % GCS)	5.83^{a} (13.97)	5.82^{ab} (13.96)	5.81^{bc} (13.94)	5.80^{c} (13.93)	0.23

ND – Not detected

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.10. Vitamin C

The Vitamin C content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 53.

Vitamin C content of functional ingredient incorporated FPBY were found to be higher than plain yoghurt. A significant decrease in vitamin C was observed in 15 days of storage period. The highest amount of vitamin C of 0.90 mg/ 100g was noticed in freshly prepared PPBY with 0.5% GCS and it decreased in to 0.87mg/ 100g during 15th day of storage followed by GPBY with 0.5% GCS with a content of 0.82 mg/100g (initial) to 0.79 mg/100g (15th day), for SPBY with 0.5% GCS it was 0.73 mg/100g (initial) to 0.69 mg/100g (15th day), for JFPBY with 0.5% GCS (0.63 to 60 mg/100g) and for BPBY with 0.5% GCS 0.53 mg/100g to 0.50 mg/100g on 15th day of storage. There was no significant difference observed in control yoghurt.

Table 53. Effect of storage on vitamin C content (mg/100 g) of selected functional ingredient (GCS) incorporated yoghurts

Treatments	Vitamin C (mg/100 g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	0.52^{NS} (4.13)	0.51^{NS} (4.09)	0.50^{NS} (4.04)	0.50^{NS} (4.04)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	0.73^{NS} (4.90)	0.71^{NS} (4.83)	0.70^{NS} (4.79)	0.69^{NS} (4.76)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	0.82^{NS} (4.90)	0.81^{NS} (4.83)	0.80^{NS} (4.79)	0.79^{NS} (5.56)
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	0.63^{NS} (5.19)	0.62^{NS} (5.16)	0.61^{NS} (5.13)	0.60^{NS} (5.09)
T_4 (89.5% M + 10% BP + 0.5%GCS)	0.53^{NS} (4.55)	0.52^{NS} (5.51)	0.51^{NS} (4.47)	0.50^{NS} (4.44)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	0.90^{NS} (4.05)	0.89^{NS} (4.05)	0.88^{NS} (4.01)	0.87^{NS} (3.88)

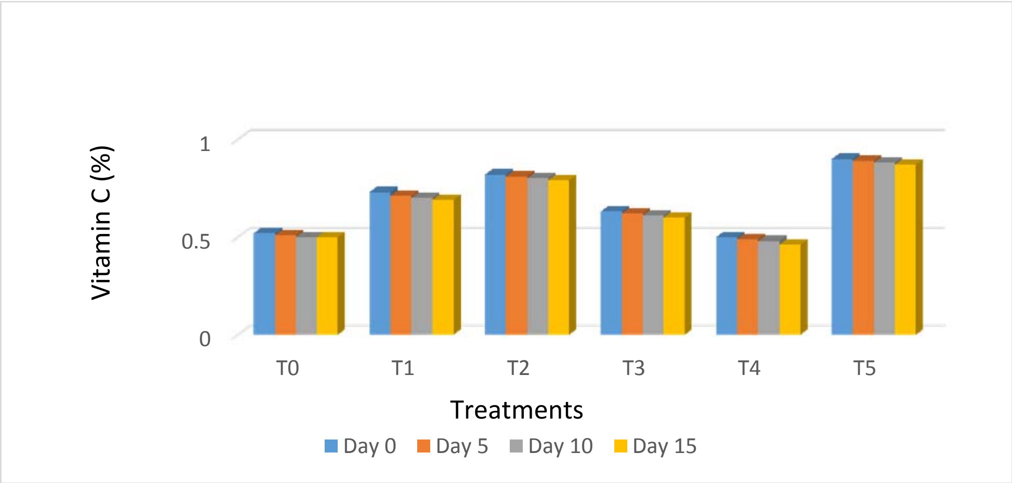

Fig. 40. Effect of storage on vitamin C content of functional ingredient GCS incorporated yoghurts

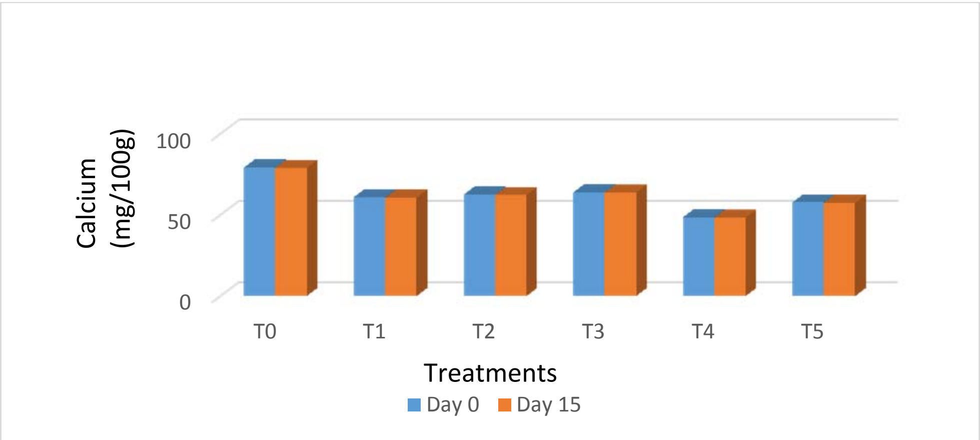

Fig. 41. Effect of storage on calcium content of functional ingredient GCS incorporated yoghurts

Value in parenthesis arc transformed value; 5% level of significance; Values having different superscripts differ significantly in DMRT

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.11. Calcium

The calcium content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 54.

The initial calcium content of control yoghurt varied from 79.21 mg/100g to 79.00 mg/100g during 15th day of storage. A decreasing trend in calcium content with days of storage was observed among all the treatments. A significant decrease in calcium content was observed among the freshly prepared yoghurts and at the end of 15th day of storage. The initial calcium content of T_1, T_2, T_3, T_4 and T_5 were 61.00, 62.52, 64.00, 50.64 and 57.86 mg/100g respectively. At the end of storage it decreased to 60.60, 62.31, 63.73, 50.30 and 57.50 mg/100g for T_1, T_2, T_3, T_4 and T_5 respectively on 15th day of storage period. There was no significant difference observed during storage.

Table 54. Effect of storage on calcium content (mg/100g) of functional ingredient (GCS) incorporated yoghurts

Treatments	Calcium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (99.5% M + 0.5 % GCS)	79.21^{NS} (62.87)	79.00^{NS} (62.72)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	61.00^{NS}	60.60^{NS}
T_2 (89.5% M + 10% GP + 0.5 % GCS)	62.52^{NS}	62.31^{NS}
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	64.00^{NS}	63.73^{NS}
T_4 (89.5% M + 10% BP + 0.5%GCS)	50.64^{NS}	50.30^{NS}
T_5 (89.5% M + 10% PP + 0.5 % GCS)	57.86^{NS}	57.50^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.12. Iron

The iron content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 55.

The iron content of control yoghurt was varied from 0.56 mg/100g (initially) and 0.50 mg/100g at the end of the storage period under the study. Compared to control FPBY was found to have highest value for iron content in both periods of the study. The treatment, T_5 had highest value of iron content (1.75 mg/100g to 1.69 mg/100g) followed by T_1 (1.40 to 1.30 mg/100g), for T_3 (0.78 to 0.70 mg/100g), for T_2 (0.64 to 0.60 mg/100g), and the lowest value of iron content was found to be in T_4 that is about 0.52 to 0.51 mg/100g. Statistically there was no significant difference observed in treatments during storage.

Table 55. Effect of storage on iron content (mg/100g) of functional ingredient (GCS) incorporated yoghurts

Treatments	Iron (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (99.5% M + 0.5 % GCS)	0.56^{NS} (4.29)	0.50^{NS} (4.04)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	1.40^{NS} (6.44)	1.30^{NS} (6.13)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	0.64^{NS} (4.58)	0.60^{NS} (4.43)
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	0.78^{NS} (5.06)	0.70^{NS} (4.79)
T_4 (89.5% M + 10% BP + 0.5%GCS)	0.52^{NS} (4.13)	0.51^{NS} (3.93)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	1.75^{NS} (7.37)	1.69^{NS} (7.22)

5% significant level; Values having different superscripts differ significantly in DMRT

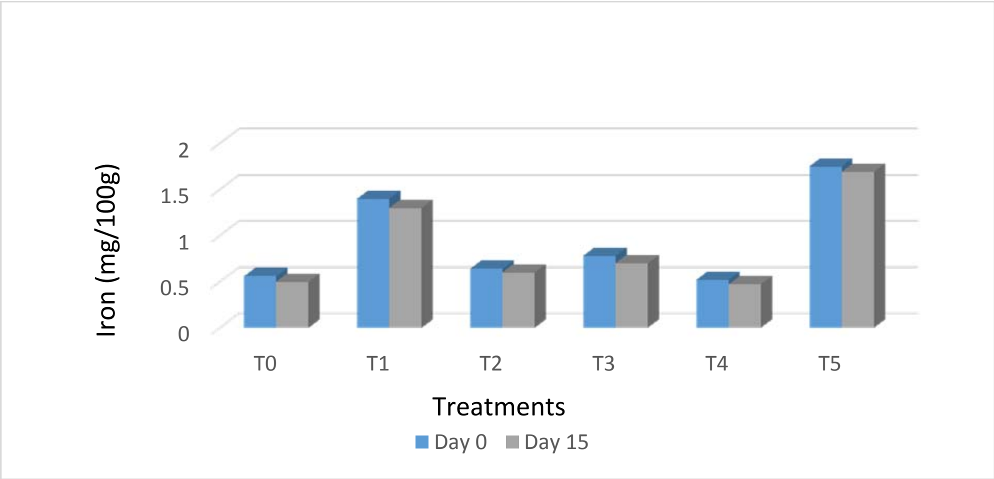

Fig. 42. Effect of storage on iron content of functional ingredient GCS incorporated yoghurts

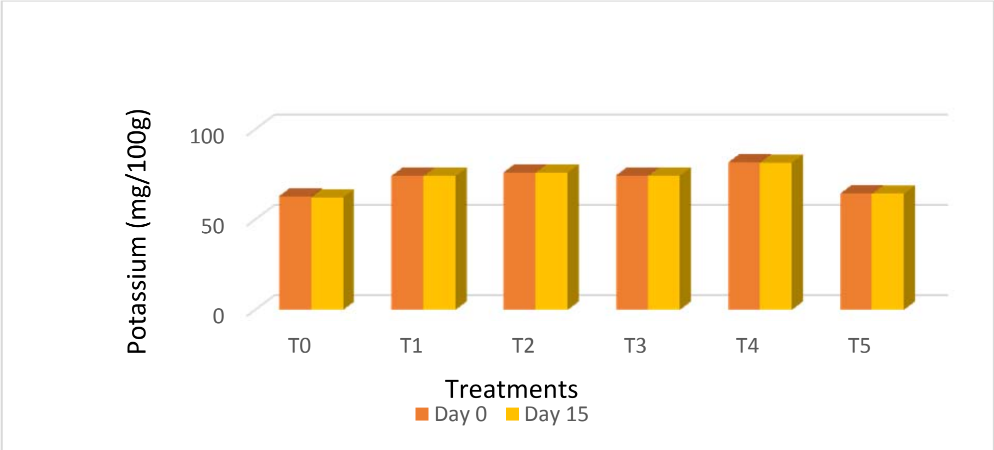

Fig. 43. Effect of storage on potassium content of functional ingredient GCS incorporated yoghurts

Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.13. Potassium

The potassium content of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and presented in Table 56.

Among all the treatments the potassium content was highest in T_4 (81.55 mg 100 g^{-1}) initially, with a variation in potassium content level of 81.47 mg 100 g^{-1} in 15^{th} day of storage followed by T_2 76.25 mg 100 g^{-1} (initial) to 76.10 mg 100 g^{-1} (15^{th} day). Compared to FPBY control yoghurt had the lowest content of potassium (63.00 to 62.40 mg 100 g^{-1}) on storage. There was a reduction in potassium content observed during storage period. Based on DMRT, there was no significant difference observed in treatments during storage.

Table 56. Effect of storage on potassium content (mg/100g) of functional ingredient (GCS) incorporated yoghurts

Treatments	Potassium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (99.5% M + 0.5 % GCS)	63.00^{NS}	62.40^{NS}
T_1 (89.5% M + 10% SP + 0.5 % GCS)	74.21^{NS} (59.47)	74.09^{NS} (59.40)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	76.25^{NS} (61.51)	76.10^{NS} (60.73)
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	74.45^{NS} (59.64)	74.22^{NS} (59.48)
T_4 (89.5% M + 10% BP + 0.5%GCS)	81.55^{NS} (64.56)	81.47^{NS} (64.50)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	64.33^{NS}	64.25^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10%

Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.14. Total ash

The total ash of selected functional ingredient (GCS) incorporated yoghurts with control was tabulated and is presented in Table 57.

A decreasing trend in ash content was observed in all treatments. The control yoghurt had total ash content of 1.60 to 0.95 per cent during storage. T_5 had the highest content of total ash of 1.61 to 1.20 per cent and the lowest content was observed in T_1 it ranged from 1.15 to 0.74 per cent. No significant difference was observed during storage of yoghurts.

Table 57. Effect of storage on total ash (%) of functional ingredient (GCS) incorporated FPBY

Treatments	Total ash (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	1.60^{NS} (6.99)	1.45^{NS} (6.58)	1.27^{NS} (6.03)	0.95^{NS} (5.59)
T_1 (89.5% M + 10% SP + 0.5 % GCS)	1.15^{NS} (6.15)	0.96^{NS} (5.65)	0.82^{NS} (5.19)	0.74^{NS} (4.93)
T_2 (89.5% M + 10% GP + 0.5 % GCS)	1.25^{NS} (5.97)	1.10^{NS} (5.38)	0.86^{NS} (5.32)	0.77^{NS} (5.03)
T_3 (89.5% M+ 10% JFP + 0.5 % GCS)	1.52^{NS} (6.78)	1.39^{NS} (6.41)	1.15^{NS} (5.60)	0.82^{NS} (5.19)
T_4 (89.5% M + 10% BP + 0.5%GCS)	1.61^{NS} (7.02)	1.50^{NS} (6.72)	1.39^{NS} (6.41)	1.20^{NS} (5.79)
T_5 (89.5% M + 10% PP + 0.5 % GCS)	1.43^{NS} (6.53)	1.25^{NS} (5.97)	1.02^{NS} (4.92)	0.86^{NS} (5.32)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

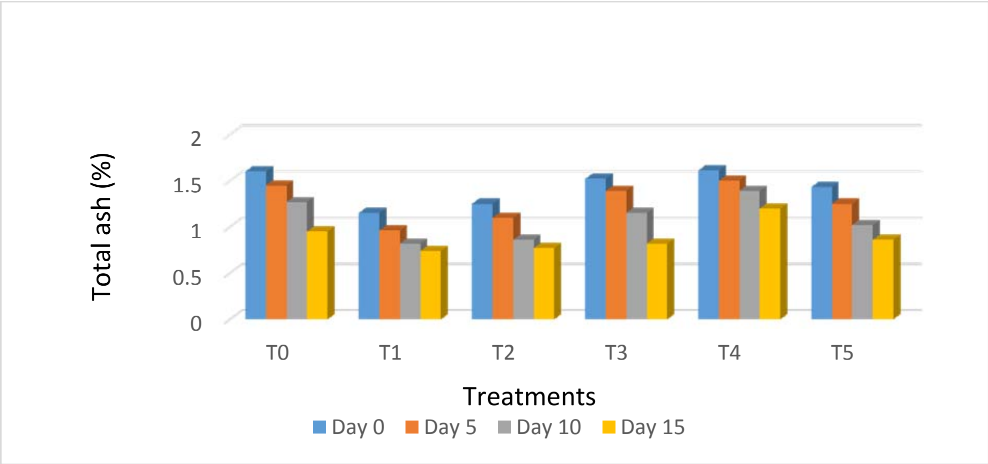

Fig. 44. Effect of storage on total ash content of functional ingredient GCS incorporated yoghurts

4.4.2.4. Microbial qualities

4.4.2.4.1. *E coli*

The E coli count of GCS incorporated yoghurts with control was tabulated and is presented in Table 58.

E coli count was not detected in any of samples during storage.

Table 58. Effect of storage on *E coli* count (10^1cfu/g) of GCS incorporated yoghurts

Treatments	*E coli* count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	ND	ND	ND	ND
T_1 (89.5% M + 10% SP + 0.5 % GCS)	ND	ND	ND	ND
T_2 (89.5% M + 10% GP + 0.5 % GCS)	ND	ND	ND	ND
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	ND	ND	ND	ND
T_4 (89.5% M + 10% BP + 0.5%GCS)	ND	ND	ND	ND
T_5 (89.5% M + 10% PP + 0.5 % GCS)	ND	ND	ND	ND

ND – Not detected

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.4.2. *Coliform bacteria*

The Coliform bacteria count of GCS incorporated yoghurtsalong with control was tabulated and is presented in Table 59.

Coliform bacterial count was not detected.

Table 59. Effect of storage on *coliform bacterial* count (10^1cfu/g) of GCS incorporated FPBY

Treatments	*Coliform bacterial* count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	ND	ND	ND	ND
T_1 (89.5% M + 10% SP + 0.5 % GCS)	ND	ND	ND	ND
T_2 (89.5% M + 10% GP + 0.5 % GCS)	ND	ND	ND	ND
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	ND	ND	ND	ND
T_4 (89.5% M + 10% BP + 0.5%GCS)	ND	ND	ND	ND
T_5 (89.5% M + 10% PP + 0.5 % GCS)	ND	ND	ND	ND

ND – Not detected

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.2.4.3. Yeast

The yeast count of GCS incorporated yoghurts along with control was tabulated and is presented in Table 60.

The yeast count of the selected treatments (T_0 to T_5) was assessed for a period of 15 days at five days interval and the presence of fungi was detected only on the 15th day of storage. The highest fungi count was detected in control yoghurt (2.00 cfu/g) on 15th day of storage. The lowest count was observed for GCS incorporated PPBY (1.00 cfu/g) on the 15th day of storage.

Table 60. Effect of storage on yeast count (10^3cfu/g) of GCS incorporated yoghurts

Treatments	Yeast count (10^3cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (99.5% M + 0.5 % GCS)	ND	ND	ND	2.00
T_1 (89.5% M + 10% SP + 0.5 % GCS)	ND	ND	ND	1.5
T_2 (89.5% M + 10% GP + 0.5 % GCS)	ND	ND	ND	1.2
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	ND	ND	ND	1.00
T_4 (89.5% M + 10% BP + 0.5%GCS)	ND	ND	ND	0.6
T_5 (89.5% M + 10% PP + 0.5 % GCS)	ND	ND	ND	1.00

ND – Not detected

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.4.4.3. Fungi

Fungi count of selected yoghurtsalong with control was tabulated and presented in Table 61.

The fungi count of the selected treatments (T_0 to T_5) was assessed for a period of 15 days at five days interval and the presence of fungi was detected only on the 15th day of storage. The highest fungi count was detected in control yoghurt which was 1.60 cfu/g on 15th day of storage. The lowest count was observed for GCS incorporated PPBY and it was 0.05 cfu/g on the 15th day of storage.

Table 61. Effect of storage on fungi count (10^3cfu/g) of selected functional ingredient (GCS) incorporated yoghurts

Treatments	Fungi (10^3cfu/g)			
	Day of storage			
	0	**5**	**10**	**15**
T_0 (99.5% M + 0.5 % GCS)	ND	ND	ND	1.60
T_1 (89.5% M + 10% SP + 0.5 % GCS)	ND	ND	ND	1.10
T_2 (89.5% M + 10% GP + 0.5 % GCS)	ND	ND	ND	1.11
T_3 (89.5% M + 10% JFP + 0.5 % GCS)	ND	ND	ND	1.00
T_4 (89.5% M + 10% BP + 0.5%GCS)	ND	ND	ND	0.07
T_5 (89.5% M + 10% PP + 0.5 % GCS)	ND	ND	ND	0.05

ND – Not detected

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1– 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

Table 62. Mean scores for organoleptic evaluation of selected GCS incorporated yoghurts on storage

Treatments	Appearance				Colour				Flavour			
	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15
T_0(99.5 % M + 0.5% GCS)	8.91	8.00	7.35	7.00	8.31	8.06	7.58	7.01	8.77	8.44	8.11	7.00
T_1 (89.5% M+ 0.5 % GCS +10%JFPBY)	8.61	7.32	6.88	6.45	8.05	7.60	7.48	6.60	8.55	8.10	7.82	6.60
T_2 (89.5% M+ 0.5 % GCS + 10% PPBY)	8.35	8.29	7.20	6.52	8.00	7.48	7.45	6.50	8.00	7.82	7.42	6.00
T_3 (89.5% M+ 0.5 %GCS +10%BPBY)	8.52	7.70	6.89	6.58	8.02	7.50	7.22	6.85	8.05	7.40	7.00	6.20
T_4 (89.5% M+ 0.5 % GCS +10%GPBY)	8.70	7.69	7.21	6.30	8.22	7.65	7.30	6.70	8.10	8.00	7.50	6.50
T_5 (89.5% M+ 0.5 % GCS + 10%SPBY)	8.80	8.40	7.60	6.75	8.50	7.93	7.20	6.80	8.40	8.20	7.60	6.60

Treatments	Overall acceptability				Taste				Texture			
	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15
T_0 (99.5 % M + 0.5% GCS)	8.80	8.57	8.06	7.00	8.66	8.50	8.00	7.81	8.26	8.77	8.06	7.45
T_1 (89.5% M+ 0.5 % GCS +10%JFPBY)	8.20	7.55	7.01	6.20	8.10	7.35	6.42	6.32	8.64	7.86	6.71	6.15
T_2 (89.5% M+ 0.5 % GCS + 10% PPBY)	8.10	7.35	6.95	6.17	7.97	7.32	6.85	6.14	8.22	7.31	6.20	6.00
T_3 (89.5% M+ 0.5 %GCS +10%BPBY)	8.11	7.46	7.02	6.21	8.05	7.75	7.00	6.42	8.80	7.42	6.28	6.08
T_4 (89.5% M+ 0.5 % GCS +10%GPBY)	8.50	7.46	7.02	6.80	8.32	7.70	6.50	6.25	8.26	7.37	7.24	6.25
T_5 (89.5% M+ 0.5 % GCS + 10%SPBY)	8.61	7.86	7.46	6.28	8.40	7.86	7.35	6.30	8.35	7.71	7.37	6.10

T_0 – 99.5% Milk + 0.5 % Garden cress seed, T_1 – 89.5% Milk + 10% Sapota pulp + 0.5 % Garden cress seed, T_2 – 89.5% Milk + 10% Guava pulp + 0.5 % Garden cress seed, T_3 – 89.5% Milk + 10% Jack fruit pulp + 0.5 % Garden cress seed, T_4 – 89.5% Milk + 10% Banana pulp + 0.5 % Garden cress seed, T_5 – 89.5% Milk + 10% Papaya pulp + 0.5 % Garden cress seed

4.3.3. Organoleptic evaluation of selected GCS incorporated yoghurts on storage

The mean scores for the appearance of T1 to T5 was varied from 8.61 to 8.80 which gradually decreased in the 5th, 10th and 15 days of storage. The control (T_0) had an initial score of 8.91 which decreased to 7.00 at the end of storage. The colour of the FPBY varied from 8.05 (T_1) to 8.50 (T_5) initially and that of control (T_0) was 8.31.

The highest mean scores for the flavor of FPBY was 8.55 to 6.60 in GCS incorporated JFPBY and lowest in GCS incorporated PPBY of 8.00 to 6.00. The taste and texture of FPBY (T_1 to T_5) was varied from 8.10 to 8.40 and 8.64 to 8.35 (initially) and 6.32 to 6.30 and 6.15 to 6.10 (15th day) respectively. The taste and texture of control yoghurt, shows the mean score of 8.66 to 7.81 and 8.26 to 7.45 during storage.

The overall acceptability was high in treatment T_5 (8.80, 7.86, 7.46 and 6.28) respectively, and lowest in T_2 (8.10, 7.35, 6.95 and 6.17) during storage. The control (T_0) was high in all the sensory parameters in comparison with GCS incorporated FPBY. All the treatments maintained a mean score within the acceptable levels during storage.

Table – 63a Mean scores for organoleptic qualities of functional ingredient (FS - 2%) incorporated yoghurts

Treatments	**Appearance**	**Colour**	**Flavour**	**Overall acceptability**	**Taste**	**Texture**	**Total score**
T_0 (98% M + 2%FS)	6.62 (3.07)	6.86 (3.83)	6.91 (2.80)	6.80 (2.70)	6.88 (2.97)	6.71 (2.70)	40.78
T_1 (88%M+2%FS+10%JFP)	6.24 (2.87)	6.64 (3.73)	6.93 (2.77)	6.73 (2.57)	6.80 (2.13)	6.44 (1.70)	39.78
T_2 (88%M+2%FS+10%PP)	6.53 (2.13)	6.20 (2.20)	6.86 (2.47)	6.48 (2.00)	6.20 (2.20)	7.55 (1.90)	39.82
T_3 (88% M+2%FS+10%BP)	6.24 (3.20)	6.68 (3.23)	6.86 (2.47)	6.80 (2.70)	6.86 (2.57)	6.50 (1.76)	39.94
T_4 (88% M+2%FS+10%GP)	6.24 (3.27)	6.80 (2.97)	6.86 (2.57)	6.77 (2.57)	6.80 (2.53)	6.68 (2.50)	40.15
T_5 (88% M+2%FS+10%SP)	6.55 (3.03)	6.50 (2.77)	6.82 (2.40)	6.75 (2.43)	6.84 (2.70)	6.68 (2.57)	40.14
Kendall's (W)	**0.292****	**0.744****	**0.146****	**0.050****	**0.240****	**0.085****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, PP – Papaya pulp

Table – 63b Mean score for organoleptic qualities of functional ingredient (FS - 4%) incorporated yoghurts

Treatments	Appearance	Colour	Flavour	Overall acceptability	Taste	Texture	Total score
T_0 (96% M + 4%FS)	6.65 (2.03)	6.08 (1.80)	6.86 (2.67)	6.75 (2.43)	6.75 (2.17)	6.62 (2.40)	40.03
T_1 (86%M+4%FS+10%JFP)	6.20 (1.57)	6.04 (1.40)	6.82 (2.10)	6.68 (2.30)	6.73 (2.07)	6.42 (1.63)	38.89
T_2 (86%M+4%FS+10%PP)	6.13 (1.27)	6.13 (1.27)	6.64 (2.20)	5.82 (1.00)	5.26 (1.07)	6.40 (1.70)	36.38
T_3 (86% M+4%FS+10%BP)	6.00 (1.97)	6.64 (1.53)	6.64 (2.20)	6.71 (2.20)	6.08 (2.23)	6.40 (1.70)	38.47
T_4 (86% M+4%FS+10%GP)	6.22 (1.73)	6.08 (1.53)	6.80 (2.20)	6.75 (2.30)	6.73 (2.13)	6.51 (1.90)	39.09
T_5 (86% M+4%FS+10%SP)	6.22 (1.87)	6.02 (1.60)	6.77 (2.13)	6.75 (2.43)	6.75 (2.17)	6.64 (2.33)	39.15
Kendall's (W)	**0.478****	**0.418****	**0.078****	**0.074****	**0.140****	**0.319****	

Figures in parenthesis indicate mean rank and rank scores; ** significant at 1% level. M – Milk, PP – Papaya pulp

4.3.2. Organoleptic qualities of functional ingredient (FS) incorporated yoghurts

Yoghurts were then experimented with 2 and 4 per cent levels of FS and the results are furnished in table 63a to 63b.

The appearance of functional ingredient (FS) JFPBY of various treatments T_1 from table 63a and T_1 from table 63b had a mean score and mean rank score of 6.24 to 6.20 and mean rank score of 2.87 to 1.57. In FS incorporated PPBY, T_2 from table 63a and T_2 from table 63b the mean score and mean rank score of appearance was differs from 6.53 to 6.13 and the mean rank score was 2.13 to 1.27. The appearance of FS incorporated BPBY (T_3) from table 63a and 63b mean score ranged from 6.24 to 6.00. For, GPBY (T_4) from table 63a and the table 63b varied from 6.24 to 6.22 in appearance. Functional ingredient (FS) incorporated SPBY (T_5) ranged from 6.55 to 6.22.

In case of colour, the mean score for T_1 was varied from 6.20 to 6.24, for T_2 it was 6.04 to 6.64, for T_3 it was 6.64 to 6.68, for T_4 it was 6.08 to 6.80 and for T_5 it was about 6.02 to 6.50. The flavour of T_1 varied from 6.82 to 6.93, T_2 (6.13 to 6.20), T_3 (6.64 to 6.86), T_4 (6.80 to 6.86) and T_5 (6.77 to 6.82). In case of overall acceptability and taste, the mean score varied from 6.68 to 6.73 and 6.73 to 6.80 for T_1. For, T_2 it varied from 5.82 to 6.48 and 5.26 to 6.20. For, T_3 the overall acceptability and taste ranged from 6.71 to 6.80 and 6.08 to 6.86. For, T_4 it varied from 6.75 to 6.77 and 6.73 to 6.80. The overall acceptability and taste of T_5 was 6.75 and 6.75 to 6.84. The texture of FS incorporated JFPBY ranged from 6.42 to 6.44, PPBY varied from 6.40 to 7.55. BPBY ranged from 6.40 to 6.50, GPBY it was about 6.51 to 6.68 and for SPBY it was about 6.64 to 6.68. The treatments T_1 to T_5 incorporated with 2% FS and T_0 (98% M + 2% FS) got the highest total score.

4.4. Quality evaluation of selected functional ingredient (FS) incorporated yoghurts

4.4.2.2. Physicochemical composition

4.4.2.2.1. Moisture

The moisture content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 64.

The initial moisture content of control yoghurt (T_0) was 80.44 per cent which decreased to 73.11 per cent on 15th day of storage. A significant difference in moisture content was observed every 5 days of interval in all yoghurt samples. In functional ingredient incorporated (FS) SPBY, the initial moisture content varied from 77.88 per cent to 73.11 per cent. In FS incorporated GPBY, it varied from 79.11 to 71.1 per cent respectively. In FS incorporated JFPBY, BPBY and PPBY it varied from 78.90 to 71.00 per cent, 77.00 to 70.00 per cent and 78.56 to 70.00 per cent respectively. On statistical interpretation a significant difference was observed in all treatments from initial to the end of storage.

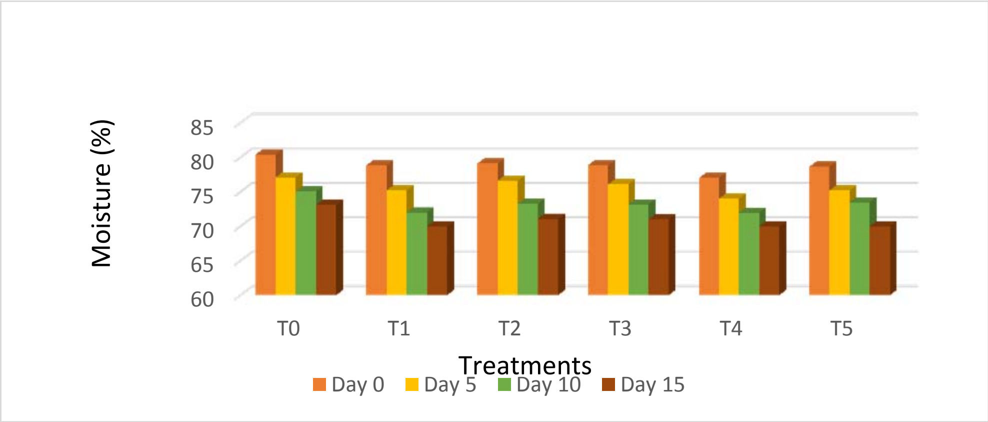

Fig. 45. Effect of storage on moisture content of functional ingredient FS incorporated yoghurts

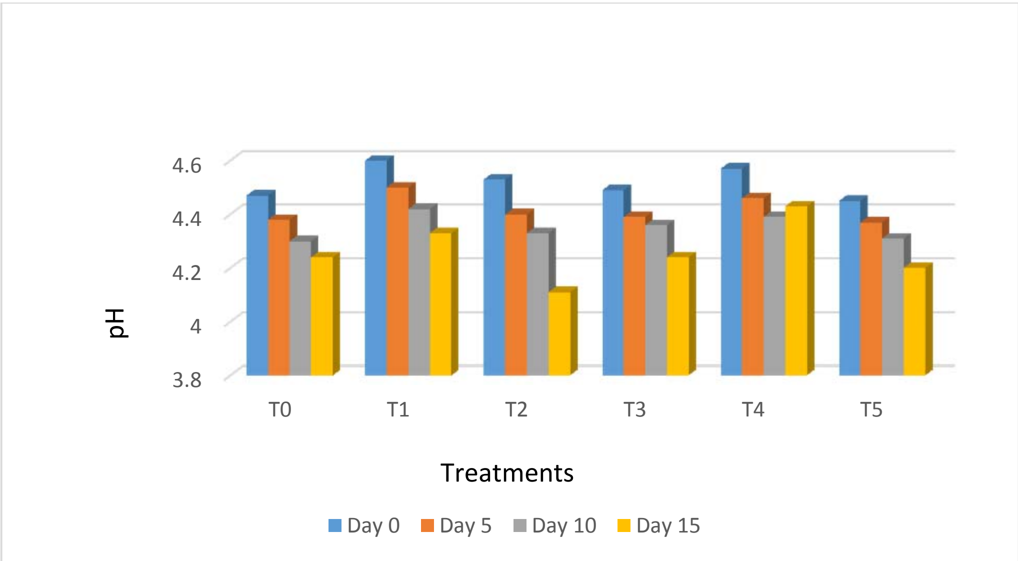

Fig. 46. Effect of storage on pH of functional ingredient FS incorporated yoghurts

Table 64. Effect of storage on moisture content (%) of functional ingredient (FS) incorporated yoghurts

Treatments	Moisture (%)				
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	CD (0.5)
T_0 (98% M + 2 % FS)	80.44[a] (63.75)	77.12[b] (62.12)	75.06[c] (60.74)	73.11[c] (60.00)	1.29
T_1 (88% M + 10% SP + 2 % FS)	77.88[a] (63.44)	75.22[ab] (62.42)	72.01[b] (61.15)	70.00[c] (59.55)	1.28
T_2 (88% M + 10% GP + 2% FS)	79.11[a] (64.24)	76.61[a] (63.13)	73.25[b] (61.63)	71.1[c] (60.42)	1.31
T_3 (88% M + 10% JFP + 2%FS)	78.90[a] (63.90)	76.11[b] (62.49)	73.20[c] (60.80)	71.00[d] (59.48)	1.27
T_4 (88% M + 10% BPP +2% FS)	77.00[a] (64.73)	74.00[ab] (63.44)	72.00[bc] (62.80)	70.00[c] (62.03)	1.34
T_5 (88% M + 10% PP + 2 % FS)	78.65[a] (64.47)	75.21[ab] (63.36)	73.50[bc] (62.04)	70.00[c] (61.33)	1.33

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.2.2. pH

The pH of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 65.

A decreasing trend in pH with days of storage was observed among all yoghurts. A significant decrease in pH was observed among the freshly prepared yoghurts and at the end of storage. The initial pH of T_0, T_1, T_2, T_3, T_4 and T_5 were 4.47, 4.60, 4.53, 4.49, 4.57 and 4.45, respectively. At the end of storage it decreased to 4.24, 4.33, 4.11, 4.24, 4.43 and 4.20 for T_0, T_1, T_2, T_3, T_4 and T_5, respectively.

Table 65. Effect of storage on pH of flax seed incorporated yoghurts

Treatments	pH			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	4.47^{NS}	4.38^{NS}	4.30^{NS}	4.24^{NS}
T_1 (88% M + 10% SP + 2 % FS)	4.60^{NS}	4.50^{NS}	4.42^{NS}	4.33^{NS}
T_2 (88% M + 10% GP + 2% FS)	4.53^{NS}	4.40^{NS}	4.33^{NS}	4.11^{NS}
T_3 (88% M + 10% JFP + 2%FS)	4.49^{NS}	4.39^{NS}	4.36^{NS}	4.24^{NS}
T_4 (88% M + 10% BPP +2% FS)	4.57^{NS}	4.46^{NS}	4.39^{NS}	4.43^{NS}
T_5 (88% M + 10% PP + 2 % FS)	4.45^{NS}	4.37^{NS}	4.31^{NS}	4.20^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.2.3. Acidity

The acidity of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 66.

The initial acidity of control yoghurt was 0.73 which increased with every five days of interval, it reaches up to 0.84 on 15 days of storage. Among the functional ingredient (FS) incorporated FPBY the highest per cent acidity was observed in BPBY, it ranged from 0.76 to 0.92 per cent on 15^{th} day of storage. The lowest value of acidity was found to be in PPBY (0.63 to 0.72).

The acidity increased in all samples with advancement of storage. Based on DMRT no significant difference in acidity was observed in PP incorporated yoghurts. The same increasing trend in acidity was observed in all treatments. A significant difference in five days interval was observed in all other functional

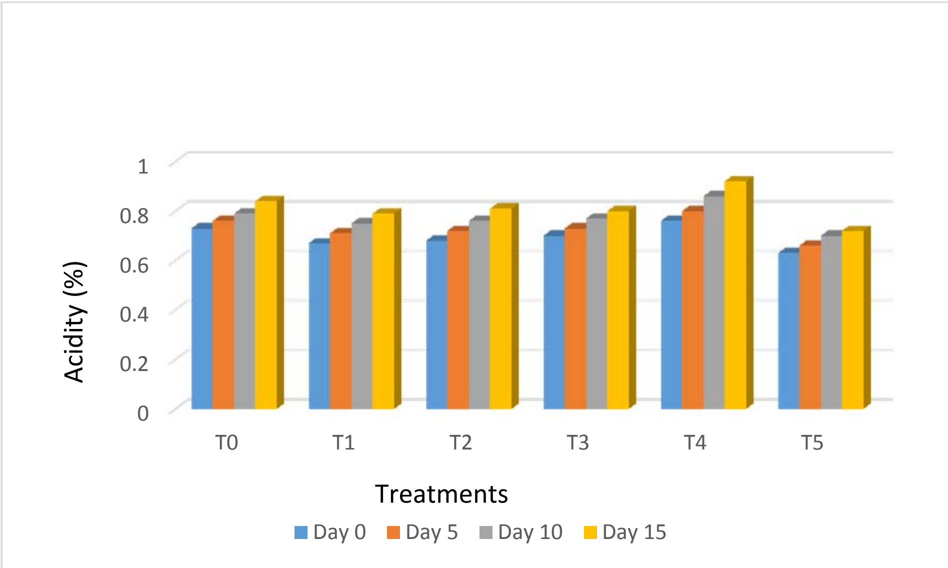

Fig. 47. Effect of storage on acidity of functional ingredient FS incorporated yoghurts

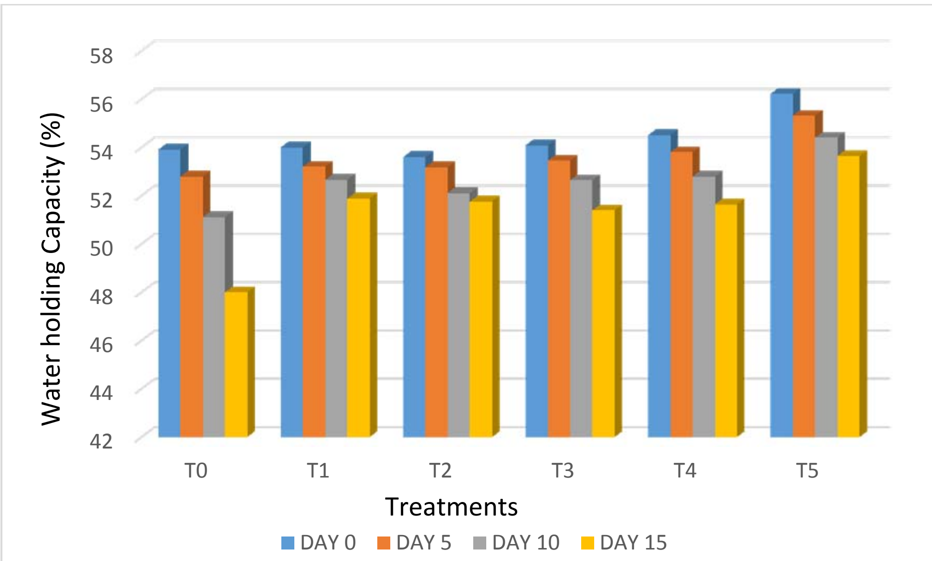

Fig. 48. Effect of storage on water holding capacity of functional ingredient FS incorporated yoghurts

ingredient (FS) incorporated fruit pulp incorporated yoghurts (SPBY, GPBY, JFPBY and BPBY).

Table 66. Effect of storage on acidity (%) of functional ingredient FS incorporated yoghurts

Treatments	Acidity (%)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (98% M + 2 % FS)	0.73^d	0.76^c	0.79^b	0.84^a	0.063
T_1 (88% M + 10% SP + 2 % FS)	0.67^d	0.71^c	0.75^b	0.79^a	0.066
T_2 (88% M + 10% GP + 2% FS)	0.68^d	0.72^c	0.76^b	0.81^a	0.064
T_3 (88% M + 10% JFP + 2%FS)	0.70^d	0.73^c	0.77^b	0.80^a	0.064
T_4 (88% M + 10% BPP + 2 % FS)	0.76^d	0.80^c	0.86^b	0.92^a	0.060
T_5 (88% M + 10% PP + 2 % FS)	0.63^{NS}	0.66^{NS}	0.70^{NS}	0.72^{NS}	-

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

5.4.2.2.4. Water holding capacity

The water holding capacity of selected functional ingredient (FS) incorporated FPBY with control was tabulated and is presented in Table 67.

Initial water holding capacity of control yoghurt was 53.91 which decreased during storage. On 15th day it was about 48.00 per cent. For, FS incorporated PPBY, the highest value of WHC was 56.22 to 53.64 per cent, during storage. A decrease in trend of WHC was observed in all yoghurt samples. A significant difference in water holding capacity at five days interval was observed in plain yoghurt and GPBY. No significant difference in water holding capacity were observed in JFPBY, BPBY and PPBY.

Table 67. Effect of storage on water holding capacity (%) of functional ingredient FS incorporated yoghurts

Treatments	WHC (%)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (98%M+2%FS)	53.91^{a}	52.80^{a}	51.11^{b}	48.00^{c}	1.883*
T_1 (88%M+10% SP+2%FS)	54.00^{NS}	53.20^{NS}	52.66^{NS}	51.88^{NS}	-
T_2 (88%M+10%GP+2%FS)	53.60^{a}	53.18^{ab}	52.11^{bc}	51.76^{c}	1.948*
T_3 (88%M+10%JFP+2%FS)	54.09^{NS}	53.45^{NS}	52.64^{NS}	51.39^{NS}	-
T_4 (88%M+10%BP+2%FS)	54.51^{NS}	53.80^{NS}	52.79^{NS}	51.65^{NS}	-
T_5 (88%M+10%PP+2% FS)	56.22^{NS}	55.31^{NS}	54.40^{NS}	53.64^{NS}	-

5% significant level; Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

5.4.2.2.5. Syneresis

The syneresis of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 68.

An increasing trend in syneresis was observed in all treatments. In plain yoghurt, syneresis increased from 1.20 per cent to 3.00 per cent. For FS incorporated SPBY it was about 0.85 to 2.20, for GCS incorporated GPBY (0.75 to 1.90 per cent), FS incorporated JFPBY (1.10 to 1.40 per cent), FS incorporated BPBY (1.10 to 2.80 per cent) and for FS incorporated PPBY (1.10 to 2.30 per cent).

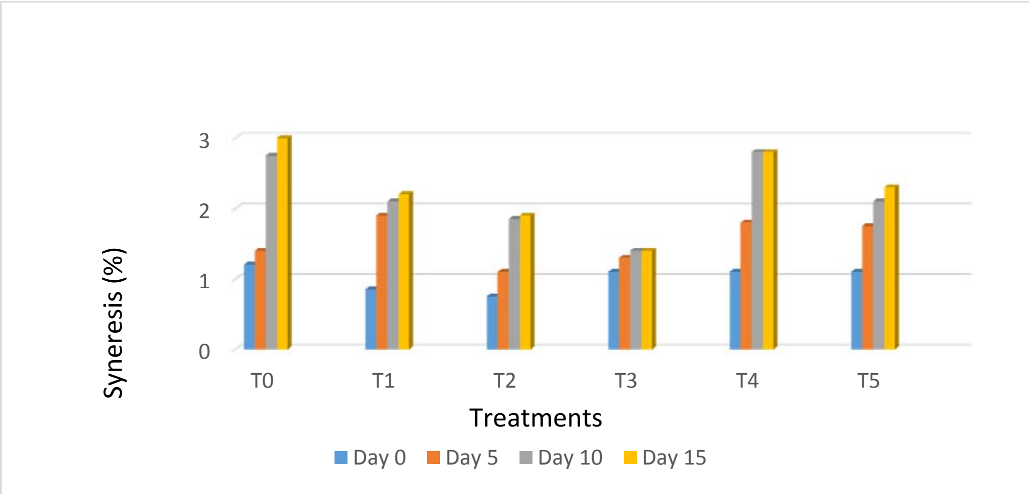

Fig. 49. Effect of storage on syneresis of functional ingredient FS incorporated yoghurts

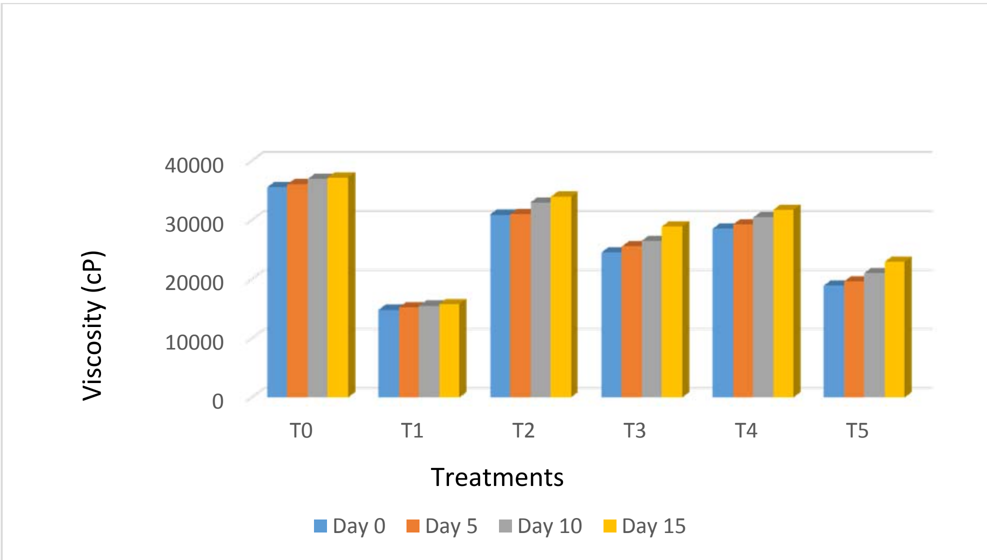

Fig. 50. Effect of storage on viscosity of functional ingredient FS incorporated yoghurts

Table 68. Effect of storage on syneresis (%) of functional ingredient FS incorporated yoghurts

Treatments	Syneresis (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98%M+2%FS)	1.20^{NS} (5.73)	1.40^{NS} (7.72)	2.75^{NS} (9.16)	3.00^{NS} (9.16)
T_1 (88%M+10%SP+2%FS)	0.85^{NS} (5.73)	1.90^{NS} (7.72)	2.10^{NS} (9.16)	2.20^{NS} (9.16)
T_2 (88%M+10%GP+2%FS)	0.75^{NS} (4.43)	1.10^{NS} (5.79)	1.85^{NS} (7.25)	1.90^{NS} (7.25)
T_3 (88%M+10%JFP+2%FS)	1.10^{NS} (4.34)	1.30^{NS} (4.65)	1.40^{NS} (4.65)	1.40^{NS} (4.65)
T_4 (88%M+10%BP+2%FS)	1.10^{NS} (5.12)	1.80^{NS} (6.72)	2.80^{NS} (7.94)	2.80^{NS} (8.74)
T_5 (88% M+10%PP+2%FS)	1.10^{NS} (5.43)	1.75^{NS} (6.99)	2.10^{NS} (8.37)	2.30^{NS} (8.37)

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

5.4.2.2.6. Viscosity

The viscosity of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 69.

The viscosity of plain yoghurt had 35500 cP initially and an increase in viscosity was noticed in every 5 days of interval and it reached up to 37200 cP followed by T_2 initially it was 30900 cP reached to 33900 cP. The lowest measure of viscosity was noticed in T_1, initially it was 14800 cP and during 15th day of storage the level of viscosity was increased up to 15800 cP. A significant difference in viscosity was observed during storage.

Table 69. Effect of storage on viscosity (cP) of functional ingredient (FS) incorporated yoghurts

Treatments	Viscosity (cP)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (98% M + 2 % FS)	35500^d	36000^c	36900^b	37200^a	0.001
T_1 (88% M + 10% SP + 2 % FS)	14800	15200^b	15500^b	15800^a	0.004
T_2 (88% M + 10% GP + 2% FS)	30900^d	31000^c	32950^b	33900^a	0.002
T_3 (88% M + 10% JFP + 2%FS)	24500^d	25500^c	26500^b	28900^a	0.001
T_4 (88% M + 10% BPP + 2 % FS)	28500^d	29200^c	30400^b	31700^a	0.002
T_5 (88% M + 10% PP + 2 % FS)	18900^d	19600^c	21000^b	22900^a	0.034

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

5.4.2.2.7. Curd tension

The curd tension of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 70.

Curd tension of yoghurts increased with days of storage. The initial curd tension of plain yoghurt T_0 was 55.50 g which increased to 62.10 g at the end of 15th day of storage. A significant increase in curd tension was observed at an interval of 5 days in plain yoghurt.

In FS incorporated sapota pulp based yoghurt (T_1), the curd tension varied from 40.00 g to 46.00 g from freshly prepared to 15th day of storage. In FS incorporated guava pulp based yoghurt (T_2) it varied from 39.00 to 46.66g. In FS incorporated jackfruit pulp based yoghurt (T_3), FS incorporated Banana pulp based yoghurt (T_4) and FS incorporated papaya pulp based yoghurt (T_5) it varied from 37.00 to 41.45g, 38.66 to 43.45g and 38.00 to 41.90g respectively.

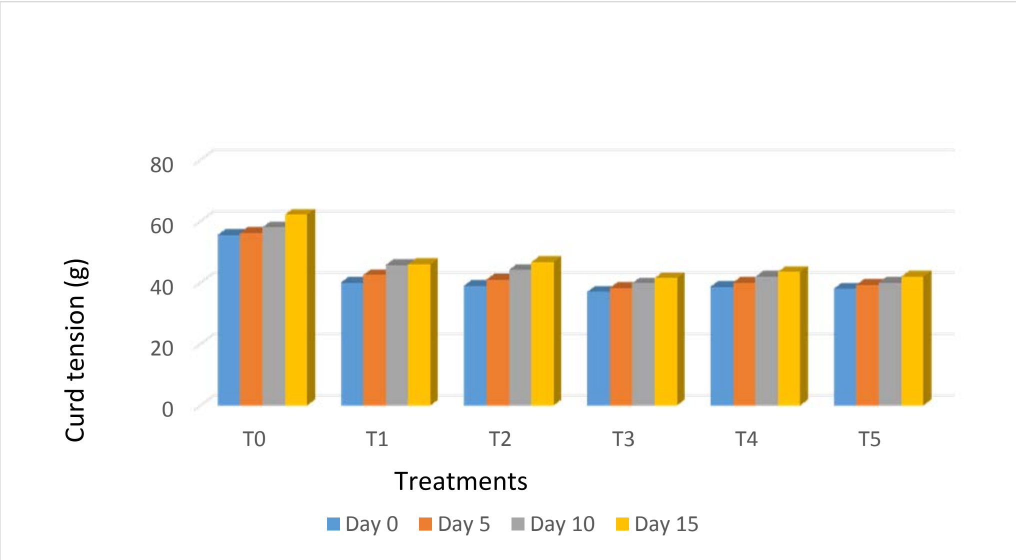

Fig. 51. Effect of storage on curd tension of functional ingredient FS incorporated yoghurts

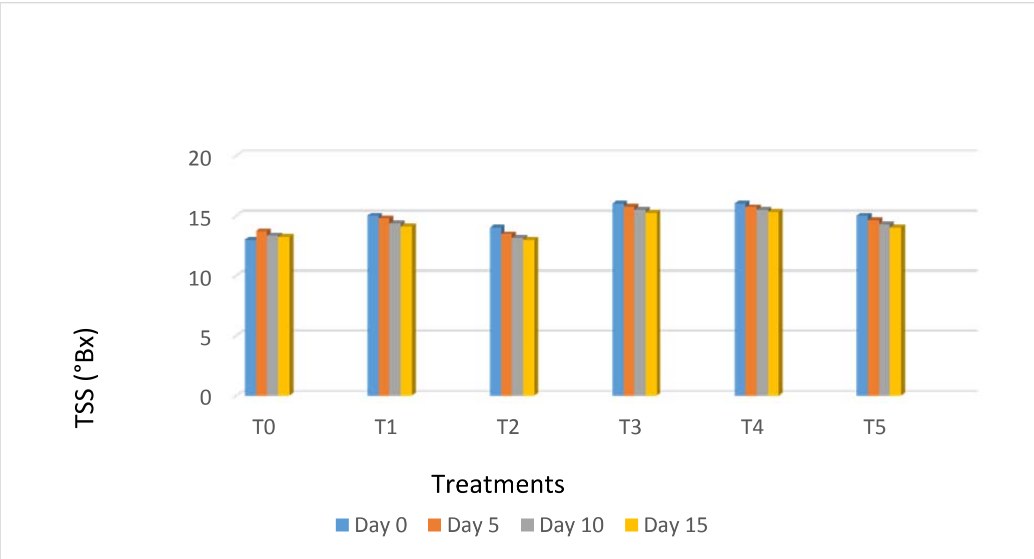

Fig. 52. Effect of storage on TSS content of functional ingredient FS incorporated yoghurts

Table 70. Effect of storage on curd tension (g) of functional ingredient FS incorporated yoghurts

Treatments	Curd tension (g)				CD (0.5)
	Day of storage				
	0	5	10	15	
T_0 (98% M + 2 % FS)	55.50^{c}	56.20^{c}	58.00^{b}	62.10^{a}	1.883
T_1 (88% M + 10% SP + 2 % FS)	40.00^{c}	42.44^{b}	45.70^{b}	46.00^{a}	1.882
T_2 (88% M + 10% GP + 2% FS)	39.00^{c}	41.00^{b}	44.11^{b}	46.66^{a}	1.882
T_3 (88% M + 10% JFP + 2%FS)	37.00^{b}	38.25^{b}	39.80^{b}	41.45^{a}	1.884
T_4 (88% M + 10% BP+2 % FS)	38.66^{c}	40.00^{bc}	41.90^{ab}	43.45^{a}	1.885
T_5 (88% M + 10% PP + 2 % FS)	38.00^{c}	39.25^{bc}	40.00^{b}	41.90^{a}	1.884

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.2. Nutritional properties

4.4.2.3.1. TSS

The TSS of selected functional ingredient (FS) incorporated FPBY with control was tabulated and presented in Table 71.

The initial TSS of control yoghurt was 13.00 ° Bx which decreased in every five days of interval, it declined to 13.22 on 15 days of storage. T_1 hada TSS content of 15.00 ° Bx and it declined to 14.10, for T_2 it varied from 14.00 to 13.00, for T_3 it ranged from 16.00 to 15.25 ° Bx, for T_4 it varied from 16.00 to 15.30 ° Bx and for T_5 it was about 15.00 to 14.00 ° Bx. A significant decrease in TSS content was observed throughout the storage period. Based on DMRT there was no significant difference in all yoghurt during storage.

Table 71. Effect of storage on TSS content of functional ingredient FS incorporated yoghurts

Treatments	TSS ° (Bx)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	13.00^{NS} (21.96)	12.70^{N} (21.77)	12.35^{NS} (21.47)	12.22^{NS} (21.33)
T_1 (88% M + 10% SP + 2 % FS)	15.00^{NS} (23.57)	14.76^{NS} (23.30)	14.34^{NS} (23.05)	14.10^{NS} (22.78)
T_2 (88% M + 10% GP + 2% FS)	14.00^{NS} (22.77)	13.45^{NS} (22.67)	13.15^{NS} (22.25)	13.00^{NS} (22.06)
T_3 (88% M + 10% JFP + 2%FS)	16.00^{NS} (24.34)	15.75^{NS} (24.76)	15.50^{NS} (23.75)	15.25^{NS} (23.39)
T_4 (88% M + 10% BPP + 2 % FS)	16.00^{NS} (24.34)	15.70^{NS} (24.19)	15.50^{NS} (23.87)	15.30^{NS} (23.61)
T_5 (88% M + 10% PP + 2 % FS)	15.00^{NS} (22.77)	14.60^{NS} (22.49)	14.30^{NS} (22.13)	14.00^{NS} (21.81)

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.2. Total sugar

The total sugar content of selected functional ingredient (FS) incorporated FPBY with control was tabulated and presented in Table 72.

The control yoghurt had 10.96 per cent of total sugar (initial) and it decreased to 10.00 per cent on 15th day of storage. Among all the treatments, the initial total sugar content was high in FS incorporated JFPBY with 16.34 per cent followed by FS incorporated BPBY with 15.16 per cent, followed by FS incorporated SPBY 13.30 per cent, followed by FS incorporated GPBY 12.90 per cent, followed by and the lowest content of total sugar was observed in FS incorporated PPBY, it was 11.05 per cent. As per DMRT, there was no significant variation between control and functional ingredient incorporated FPBY noticed throughout the storage period.

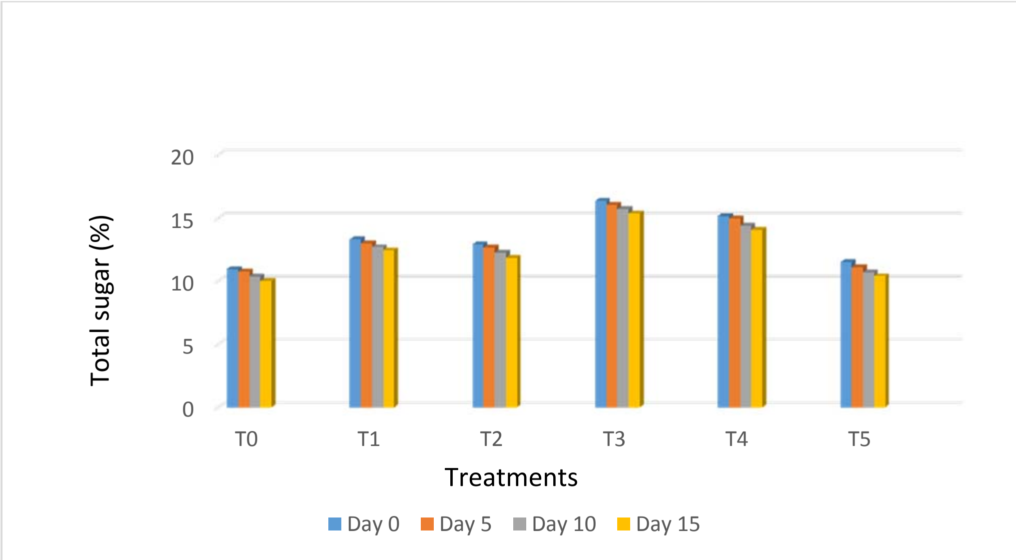

Fig. 53. Effect of storage on total sugar content of functional ingredient FS incorporated yoghurts

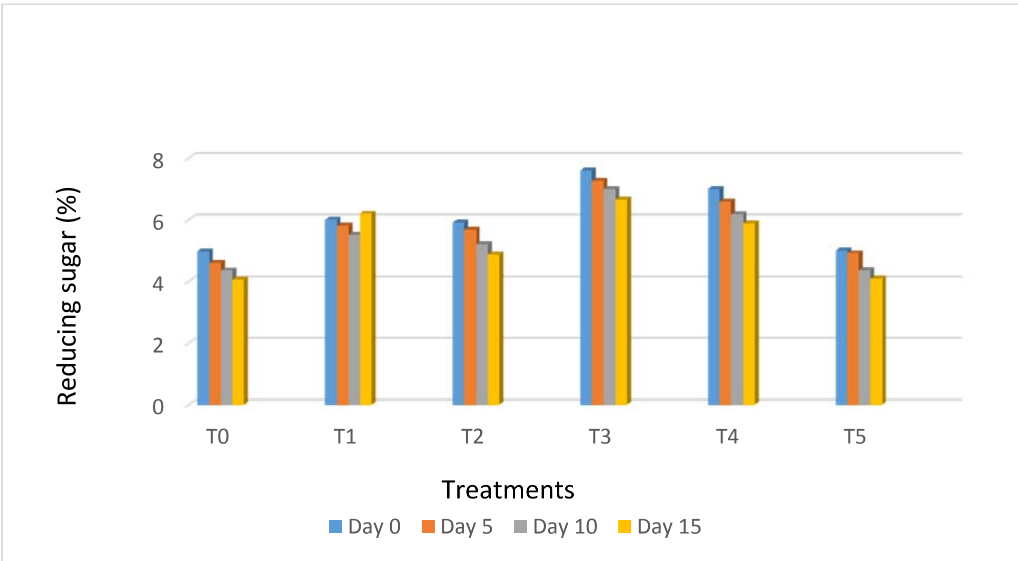

Fig. 54. Effect of storage on reducing sugar content functional ingredient of FS incorporated yoghurts

Table 72. Effect of storage on total sugar content (%) of functional ingredient FS incorporated FPBY

Treatments	Total sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	10.96^{NS} (19.28)	10.74^{NS} (18.72)	10.36^{NS} (18.34)	10.00^{NS} (17.99)
T_1 (88% M + 10% SP + 2 % FS)	13.30^{NS} (21.30)	13.00^{NS} (20.99)	12.70^{NS} (20.64)	12.45^{NS} (20.25)
T_2 (88% M + 10% GP + 2% FS)	12.90^{NS} (20.53)	12.65^{NS} (20.18)	12.25^{NS} (20.02)	11.85^{NS} (19.12)
T_3 (88% M + 10% JFP + 2%FS)	16.34^{NS} (23.61)	16.05^{NS} (23.33)	15.70^{NS} (22.93)	15.35^{NS} (22.53)
T_4 (88% M + 10% BPP + 2 % FS)	15.16^{NS} (22.86)	14.96^{NS} (22.66)	14.38^{NS} (22.31)	14.06^{NS} (22.01)
T_5 (88% M + 10% PP + 2 % FS)	11.50^{NS} (19.50)	11.10^{NS} (19.18)	10.70^{NS} (18.71)	10.40^{NS} (18.42)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.3. Reducing sugar

The reducing sugar of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 73.

Among all treatments reducing sugar content was found to be highest in FS incorporated JFPBY (7.60 per cent) followed by BPBY (7.00 per cent), SPBY (6.00 per cent), GPBY (5.91 per cent), PPBY (5.00) and the lowest reducing sugar content were observed in control yoghurt (4.98 per cent) and it declined to 4.06 per cent. During 15th day of storage reducing sugar content decreased as 6.65 per cent in functional ingredient incorporated JFPBY, 5.88 per cent for BPBY, 6.20 per cent for SPBY, 4.87 per cent for GPBY, 4.09 per cent for PPBY. There was no significant difference between functional ingredients (FS) incorporated FPBY and control yoghurt throughout the storage period.

Table 73. Effect of storage on reducing sugar content (%) of functional ingredient (FS) incorporated yoghurts

Treatments	Reducing sugar (%)			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	4.98^{NS} (12.87)	4.60^{NS} (13.72)	4.35^{NS} (12.02)	4.06^{NS} (11.55)
T_1 (88% M + 10% SP + 2 % FS)	6.00^{NS} (14.36)	5.80^{NS} (14.14)	5.50^{NS} (14.10)	5.20^{NS} (13.85)
T_2 (88% M + 10% GP + 2% FS)	5.91^{NS} (14.14)	5.68^{NS} (13.84)	5.20^{NS} (13.15)	4.87^{NS} (12.47)
T_3 (88% M + 10% JFP + 2%FS)	7.60^{NS} (16.30)	7.26^{NS} (15.76)	6.99^{NS} (15.3)	6.65^{NS} (14.99)
T_4 (88% M + 10% BPP + 2 % FS)	7.00^{NS} (15.44)	6.60^{NS} (14.91)	6.17^{NS} (14.38)	5.88^{NS} (13.91)
T_5 (88% M + 10% PP + 2 % FS)	5.00^{NS} (13.15)	4.92^{NS} (12.81)	4.36^{NS} (11.98)	4.09^{NS} (11.62)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.4. Energy

Energy of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 74.

Initially, control yoghurt had the energy value of 97.92 to 89.72 Kcal during 15th day of storage. High energy was noticed in T_1 (85.74 to 77.32 kcal) whereas in T_3 had a low energy value of 63.24 to 57.91 Kcal during storage. A gradual decline in energy value was noticed in each 5 days of storage. Statistically T_0, T_1, T_2 and T_3 are on par with each other during storage.

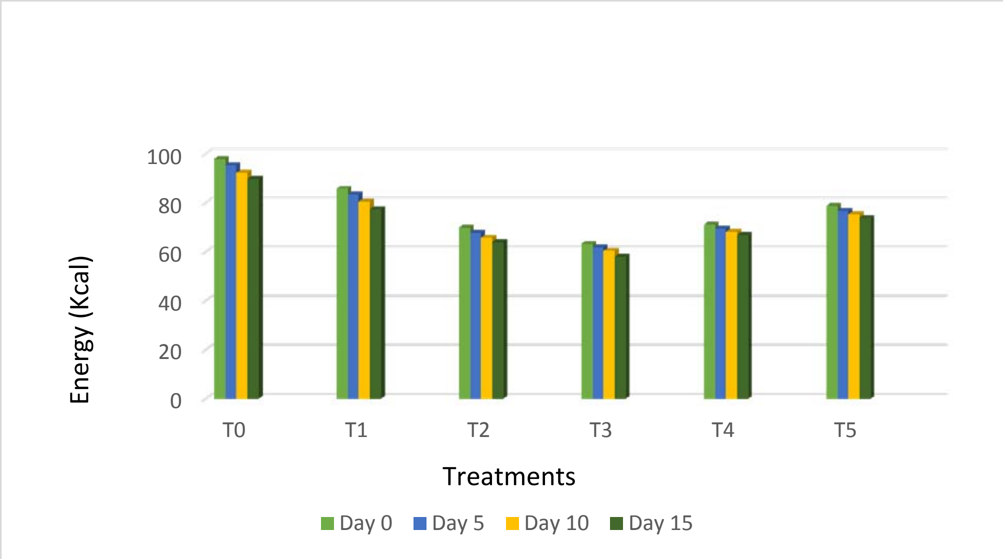

Fig. 55. Effect of storage on energy content of functional ingredient FS incorporated yoghurts

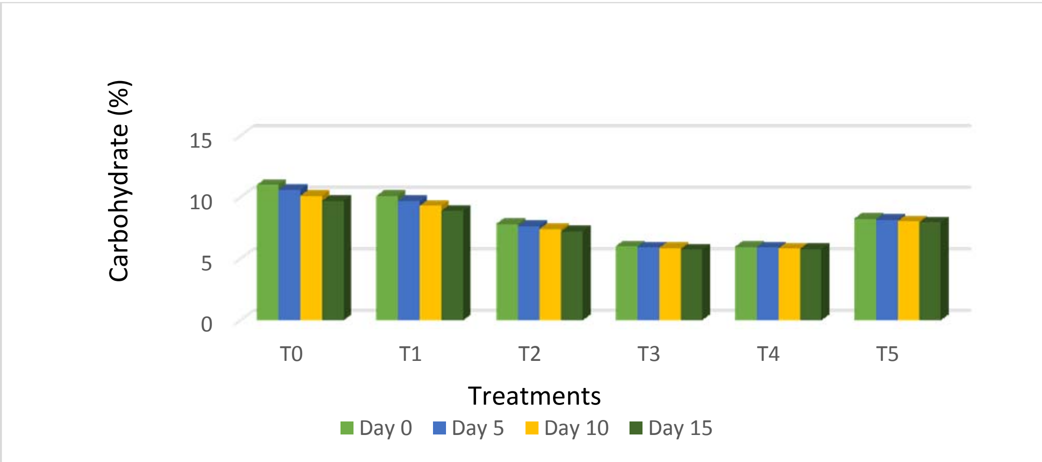

Fig. 56. Effect of carbohydrate content of functional ingredient FS incorporated yoghurts

Table 74. Effect of storage on energy (Kcal) of functional ingredient FS incorporated yoghurts

Treatments	Energy (Kcal)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (98%M+2%FS)	97.92^a	95.39^b	92.20^c	89.72^d	1.342
T_1 (88%M+10%SP+2%FS)	85.74^a	83.31^{ab}	80.46^{bc}	77.32^c	1.883
T_2 (88%M+10%GP+2%FS)	69.85^a	67.88^b	65.79^c	64.04^d	1.883
T_3 (88%M+10%JFP+2%FS)	63.24^a	61.80^{ab}	60.37^{bc}	57.91^c	1.883
T_4 (88% M+10%BP+2%FS)	71.02^{NS}	69.52^{NS}	68.13^{NS}	66.77^{NS}	-
T_5 (88%M+10%PP+2%FS)	78.63^{NS}	76.79^{NS}	75.27^{NS}	73.86^{NS}	-

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.5. Carbohydrate

The carbohydrate content of selected functional ingredient incorporated (FS) yoghurts with control was tabulated and presented in Table 75.

The initial carbohydrate content of control yoghurt was 11.00 per cent which decreased in every five days of interval throughout the storage period, it declined to 9.7 per cent on 15 days of storage. Among the functional ingredient (FS) incorporated FPBY the highest carbohydrate content was observed in T_1, it ranged from 10.1 to 8.9 per cent on 15th day of storage followed by T_5 it varied from 8.25 to 7.94 per cent, for T_2 it was about 7.81 to 7.22 per cent respectively. The treatment T_3 had a carbohydrate content of 6.00 to 5.75 percent and the lowest value of carbohydrate content was found to be in T_4 (5.96 to 5.78 per cent). The carbohydrate content decreased in all samples with advancement of storage. Based on DMRT there was no significant difference in all yoghurt during storage.

Table 75. Effect of storage on carbohydrate content of functional ingredient FS incorporated yoghurts

Treatments	Carbohydrate (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98 % M + 2 % FS)	11.00^{NS} (19.35)	10.6^{NS} (18.98)	10.1^{NS} (18.51)	9.7^{NS} (18.13)
T_1 (88 % M + 10% SP + 2 % FS)	10.1^{NS} (18.51)	9.7^{NS} (18.13)	9.3^{NS} (17.74)	8.9^{NS} (18.32)
T_2 (88% M + 10% GP + 2 % FS)	7.81^{NS} (16.20)	7.64^{NS} (16.02)	7.41^{NS} (15.77)	7.22^{NS} (15.56)
T_3 (88 % M + 10% JFP + 2 % FS)	6.00^{NS} (14.14)	5.93^{NS} (14.06)	5.86^{NS} (13.97)	5.75^{NS} (13.84)
T_4 (88% M + 10% BP + 2 % FS)	5.96^{NS} (14.09)	5.90^{NS} (14.02)	5.83^{NS} (13.93)	5.78^{NS} (13.87)
T_5 (88% M + 10% PP + 2 % FS)	8.25^{NS} (16.67)	8.16^{NS} (16.57)	8.05^{NS} (16.46)	7.94^{NS} (16.34)

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.6. Lactose

The lactose content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 76.

The lactose content of control yoghurt was ranged between 2.90 to 2.60 per cent during storage. Among functional ingredient (FS) incorporated FPBY the highest amount of lactose was present in $T_{1,}$ initially it was 2.69 per cent and it declined in to 2.47 per cent, followed by T_3 it was about 1.60 to 1.25 per cent on 15^{th} day of storage. For T_4 it varied from 1.58 to 1.30 per cent during storage, followed by T_5 which was 1.45 to 1.20 per cent respectively and the lowest lactose content was found to be in T_2 that is 1.40 on fresh sample and it reduced in to 1.22 per cent on 15^{th} day of storage. As per DMRT, the lactose content was found to be non-significant during storage.

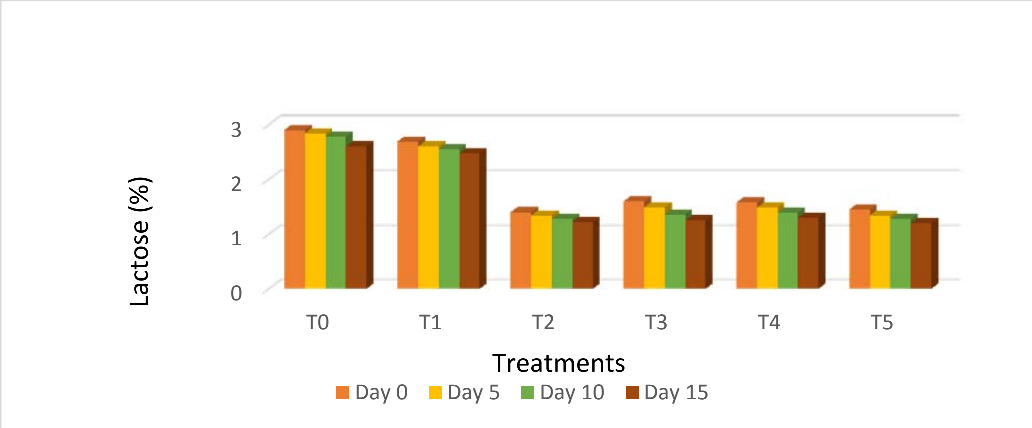

Fig. 57. Effect of storage on lactose content of functional ingredient FS incorporated yoghurts

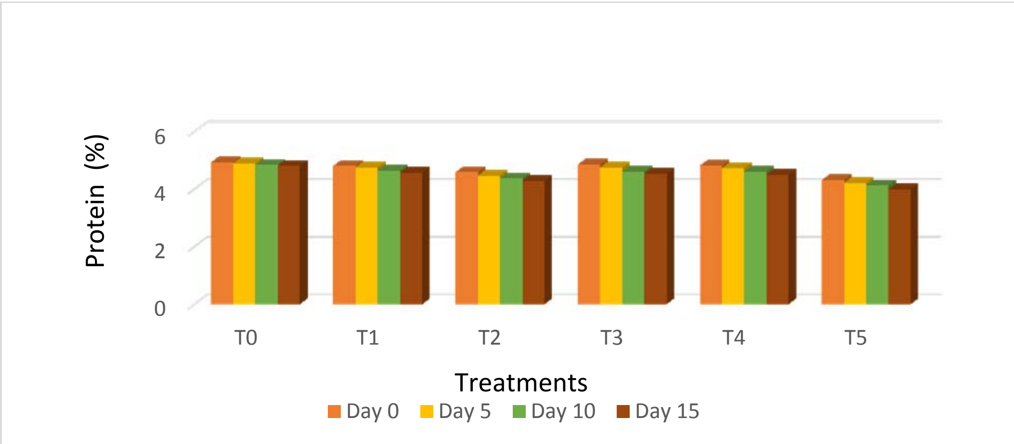

Fig. 58. Effect of storage on protein content of functional ingredient FS incorporated yoghurts

Table 76. Effect of storage on lactose content (%) of functional ingredient FS incorporated yoghurts

Treatments	Lactose (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	2.90^{NS} (9.70)	2.84^{NS} (9.60)	2.78^{NS} (9.49)	2.60^{NS} (9.16)
T_1 (88% M + 10% SP + 2 % FS)	2.69^{NS} (9.32)	2.60^{NS} (9.16)	2.55^{NS} (9.06)	2.47^{NS} (8.91)
T_2 (88% M + 10% GP + 2% FS)	1.40^{NS} (6.44)	1.34^{NS} (6.26)	1.27^{NS} (6.03)	1.22^{NS} (5.86)
T_3 (88% M + 10% JFP + 2%FS)	1.60^{NS} (6.99)	1.49^{NS} (6.70)	1.36^{NS} (6.32)	1.25^{NS} (5.97)
T_4 (88% M+10%BP+2%FS)	1.58^{NS} (6.60)	1.48^{NS} (6.36)	1.39^{NS} (5.79)	1.30^{NS} (5.15)
T_5 (88% M + 10% PP + 2 % FS)	1.45^{NS} (6.58)	1.34^{NS} (6.26)	1.28^{NS} (5.25)	1.20^{NS} (5.09)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.7. Protein

The protein content of selected functional ingredient incorporated (FS) yoghurts with control was tabulated and presented in Table 77.

Protein content of yoghurts decreased with days of storage. The initial protein content of plain yoghurt (T_0) was 4.93 per cent which decreased to 4.81 per cent at the end of 15th day of storage. No significant difference in protein content of all samples were observed in every five days of intervals.

In T_1, the protein content varied from 4.81 to 4.58 per cent from day zero to 15th day of storage. In T_2 varied from 4.59 to 4.29 per cent. In T_3, T_4 and T_5 it varied from 4.86 to 4.54per cent, 4.82to 4.50per cent and 4.32to 4.00per cent respectively. On statistical interpretation there was no significant difference observed in all treatments from initial to the end of storage.

Table 77. Effect of storage on protein content of functional ingredient FS incorporated yoghurts

Treatments	Protein (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	4.93 ^{NS} (12.78)	4.90 ^{NS} (12.74)	4.85 ^{NS} (12.67)	4.81 ^{NS} (12.62)
T_1 (88% M + 10% SP + 2 % FS)	4.81 ^{NS} (12.62)	4.76 ^{NS} (12.55)	4.65 ^{NS} (12.40)	4.58 ^{NS} (12.30)
T_2 (88% M + 10% GP + 2% FS)	4.59 ^{NS} (12.32)	4.47 ^{NS} (12.15)	4.38 ^{NS} (12.02)	4.29 ^{NS} (12.00)
T_3 (88% M + 10% JFP + 2%FS)	4.86 ^{NS} (12.69)	4.75 ^{NS} (12.54)	4.62 ^{NS} (12.36)	4.54 ^{NS} (12.21)
T_4 (88% M + 10% BPP + 2 % FS)	4.82 ^{NS} (12.63)	4.73 ^{NS} (12.51)	4.61 ^{NS} (12.35)	4.50 ^{NS} (12.19)
T_5 (88% M + 10% PP + 2 % FS)	4.32 ^{NS} (11.94)	4.22 ^{NS} (11.80)	4.13 ^{NS} (11.66)	4.00 ^{NS} (11.47)

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.8. Fat

The fat content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 78.

Fat content of yoghurts decreased with days of storage. The initial fat content of plain yoghurt T_0 was 3.80 which decreased to 3.52 per cent. A significant decrease in fat content was observed for each 5 days of interval during storage. The same decreasing trend was observed in flax seed incorporated FPBY.

In T_1, the fat content varied from 2.90 to 2.60 from freshly prepared to 15th day of storage. In T_2 it varied from 2.25 to 2.00 per cent. In T_3, T_4 and T_5 it varied from 2.20 to 1.99, 3.10 to 2.85 and 3.15 to 2.90 per cent respectively. There was no significant difference observed during storage.

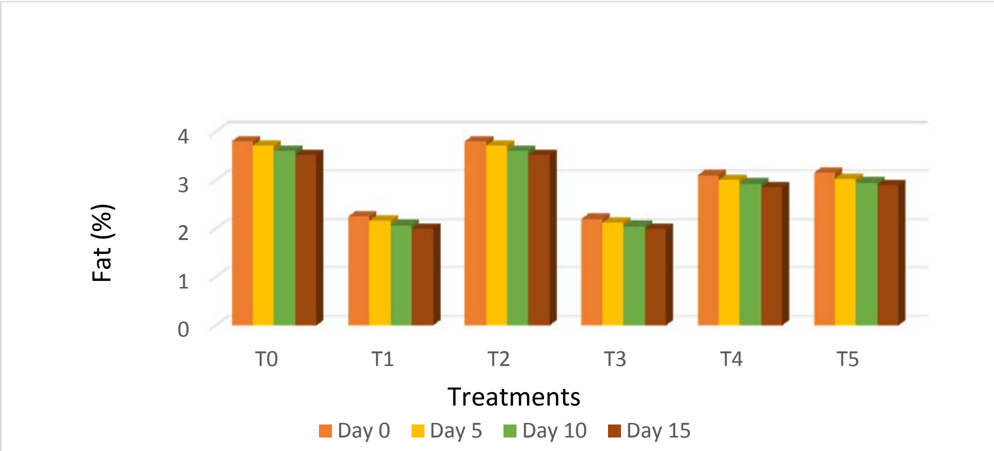

Fig. 59. Effect of storage on fat content of functional ingredient FS incorporated yoghurts

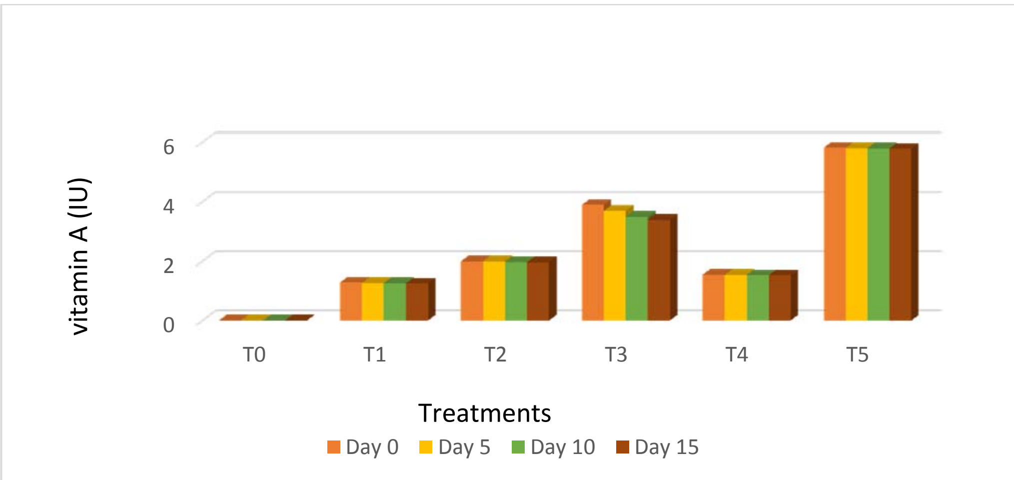

Fig. 60. Effect of storage on vitamin A content of functional ingredient FS incorporated yoghurts

Table 78. Effect of storage on fat content (%) of functional ingredient FS incorporated yoghurts

Treatments	Fat			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	3.80^{NS} (11.17)	3.71^{NS} (11.03)	3.60^{NS} (10.86)	3.52^{NS} (10.74)
T_1 (88 % M + 10% SP + 2 % FS)	2.90^{NS} (8.47)	2.83^{NS} (8.29)	2.74^{NS} (8.10)	2.60^{NS} (7.94)
T_2 (88% M + 10% GP + 2 % FS)	2.25^{NS} (11.17)	2.16^{NS} (11.03)	2.07^{NS} (10.86)	2.00^{NS} (10.74)
T_3 (88% M + 10% JFP + 2 % FS)	2.20^{NS} (8.37)	2.12^{NS} (8.20)	2.05^{NS} (9.66)	1.99^{NS} (7.92)
T_4 (88%M+10%BP+2%FS)	3.10^{NS} (10.05)	3.00^{NS} (9.88)	2.93^{NS} (9.75)	2.85^{NS} (9.61)
T_5 (88% M + 10% PP + 2 % FS)	3.15^{NS} (10.13)	3.03^{NS} (9.93)	2.95^{NS} (9.79)	2.90^{NS} (9.70)

Value in parenthesis arc transformed value; 5% level of significance; Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.9. Vitamin A

The vitamin A content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 79.

Vitamin A was not detected in control yoghurt throughout the storage period. The highest amount of vitamin A was present in T_5 (5.82 IU) and it decreased to (5.79 IU), followed by T_3 (3.9 to 3.4 IU), for T_2 (2.00 to 1.96 IU) and for T_4 (1.55 to 1.52 IU). The lowest amount of vitamin A was found to be in T_1 (1.28 to 1.25 IU). There was no significant difference observed during storage.

Table 79. Effect of storage on vitamin A (IU) of functional ingredient FS incorporated yoghurts

Treatments	Vitamin A (IU)			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	ND	ND	ND	ND
T_1 (88% M + 10% SP + 2 % FS)	1.28^{NS} (6.03)	1.27^{NS} (6.02)	1.26^{NS} (6.01)	1.25^{NS} (6.00)
T_2 (88% M + 10% GP + 2% FS)	2.00^{NS} (8.33)	2.00^{NS} (8.33)	1.97^{NS} (8.08)	1.96^{NS} (8.07)
T_3 (88% M + 10% JFP + 2%FS)	3.9^{NS} (10.73)	3.7^{NS} (10.71)	3.5^{NS} (10.69)	3.4^{NS} (10.68)
T_4 (88% M + 10% BPP + 2 % FS)	1.55^{NS} (4.87)	1.54^{NS} (4.84)	1.53^{NS} (7.81)	1.52^{NS} (7.78)
T_5 (88% M + 10% PP + 2 % FS)	5.82^{NS} (13.94)	5.81^{NS} (13.40)	5.80^{NS} (13.38)	5.79^{NS} (13.35)

ND – Not detected

Value in parenthesis arc transformed value; 5% level of significance**;** Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.10. Vitamin C

The Vitamin C content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 80.

A significant decrease in vitamin C was observed during storage period. Highest content of vitamin C of 0.87 mg/ 100g was noticed in T_5 and it decreased in to 0.82mg/ 100g during storage followed by T_2 0.79 mg/100g (initial) to 0.72 mg/100g (15th day), for T_1 it is about 0.71 mg/100g (initial) to 0.65 mg/100g (15th day), for T_3 (0.62 to 0.59 mg/100g) and the lowest per cent of vitamin C was found to be in T_4 (0.48 mg/100g to 0.45 mg/100g) on 15th day of storage. There was no significant difference observed in control yoghurt.

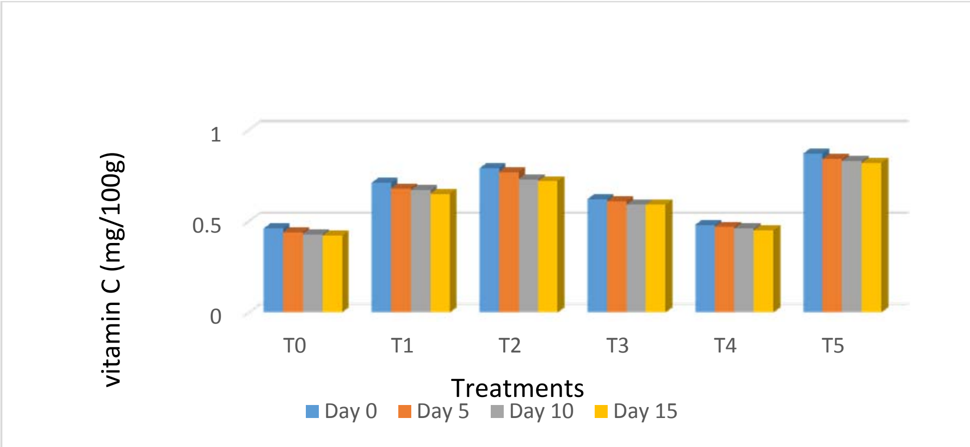

Fig. 61. Effect of storage on vitamin C content of functional ingredient FS incorporated yoghurts

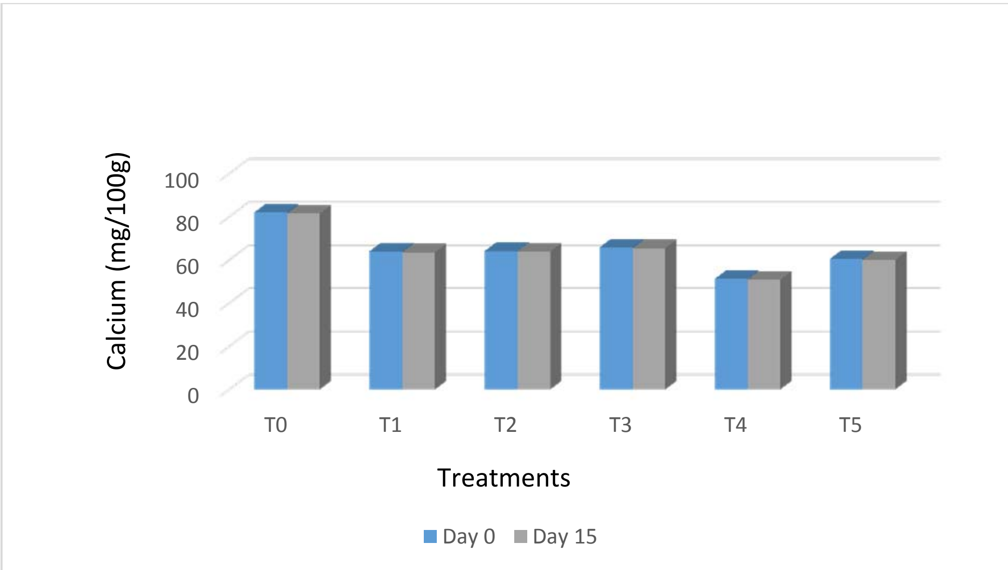

Fig. 62. Effect of storage on calcium content of functional ingredient FS incorporated yoghurts

Table 80. Effect of storage on vitamin C content (mg/100 g) of functional ingredient FS incorporated yoghurts

Treatments	Vitamin C (mg/100 g)				CD (0.5)
	Day of storage				
	Day 0	Day 5	Day 10	Day 15	
T_0 (98% M + 2 % FS)	0.46^{a} (3.88)	0.44^{b} (3.80)	0.43^{bc} (3.76)	0.42^{c} (3.71)	0.082
T_1 (88% M + 10% SP + 2 % FS)	0.71^{a} (4.83)	0.68^{b} (4.73)	0.67^{b} (4.69)	0.65^{c} (4.62)	0.066
T_2 (88% M + 10% GP + 2% FS)	0.79^{a} (5.09)	0.77^{b} (5.03)	0.73^{c} (4.90)	0.72^{c} (4.86)	0.062
T_3 (88% M + 10% JFP + 2%FS)	0.62^{a} (4.51)	0.61^{a} (4.47)	0.59^{b} (4.40)	0.59^{b} (4.40)	0.070
T_4 (88% M + 10% BPP+2%FS)	0.48^{a} (3.97)	0.47^{ab} (3.93)	0.46^{bc} (3.88)	0.45^{c} (3.84)	0.079
T_5 (88% M + 10% PP + 2 % FS)	0.87^{a} (5.35)	0.84^{b} (5.25)	0.83^{bc} (5.22)	0.82^{c} (5.19)	0.059

Value in parenthesis arc transformed value; 5% level of significance; Values having different superscripts differ significantly in DMRT

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.11. Calcium

The calcium content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 81.

The initial calcium content of control yoghurt varied from 82 mg/100g to 81.5 mg/100g during 15th day of storage. A decreasing trend in calcium content with days of storage was observed among all the treatments. The initial calcium content of T_1, T_2, T_3, T_4 and T_5 were 64.00, 64.11, 65.89, 51.22 and 60.44, respectively. At the end of storage it decreased to 63.6, 64.00, 65.5, 50.95 and 60.1 mg/100g for T_1, T_2, T_3, T_4 and T_5 respectively. There was no significant difference observed during storage.

Table 81. Effect of storage on calcium content (mg/100g) of functional ingredient FS incorporated yoghurts

Treatments	Calcium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (98% M + 2 % FS)	82^{NS}	81.5^{NS}
T_1 (88% M + 10% SP + 2 % FS)	64^{NS}	63.6^{NS}
T_2 (88% M + 10% GP + 2% FS)	64.11^{NS}	64^{NS}
T_3 (88% M + 10% JFP + 2%FS)	65.89^{NS}	65.5^{NS}
T_4 (88% M + 10% BPP+2%FS)	51.22^{NS}	50.95^{NS}
T_5 (88% M + 10% PP + 2 % FS)	60.44^{NS}	60.1^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.12. Iron

The iron content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 82.

The iron content of control yoghurt varied from 0.52 mg/100g (initially) and 0.48 mg/100g at the end of the storage period under the study. The treatment, T_5 had highest value of iron content (1.45 mg/100g to 1.40 mg/100g) followed by T_1 (1.10 to 1.00 mg/100g) T_3 (0.65 to 0.60 mg/100g), and T_2 (0.58 to 0.55 mg/100g). The lowest value of iron content was found to be in T_4 that is about 0.48 to 0.44 mg/100g.

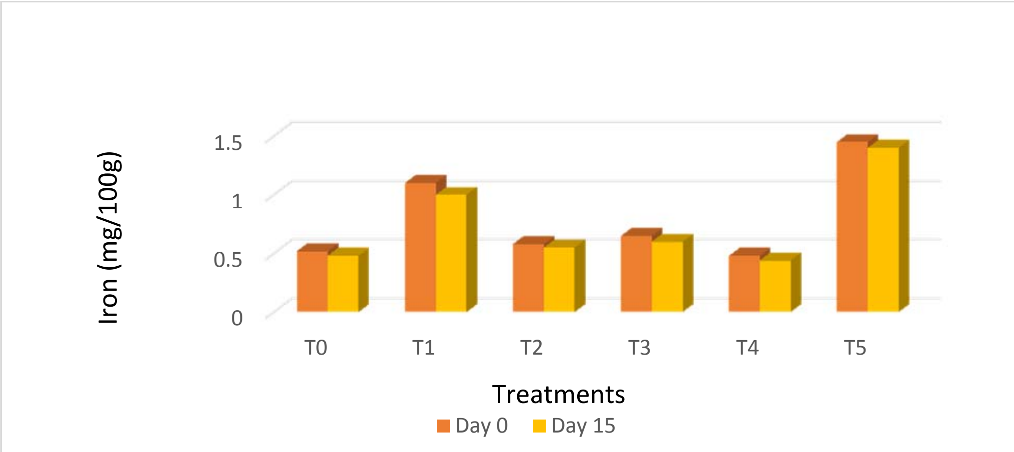

Fig. 63. Effect of storage of iron content of functional ingredient FS incorporated yoghurts

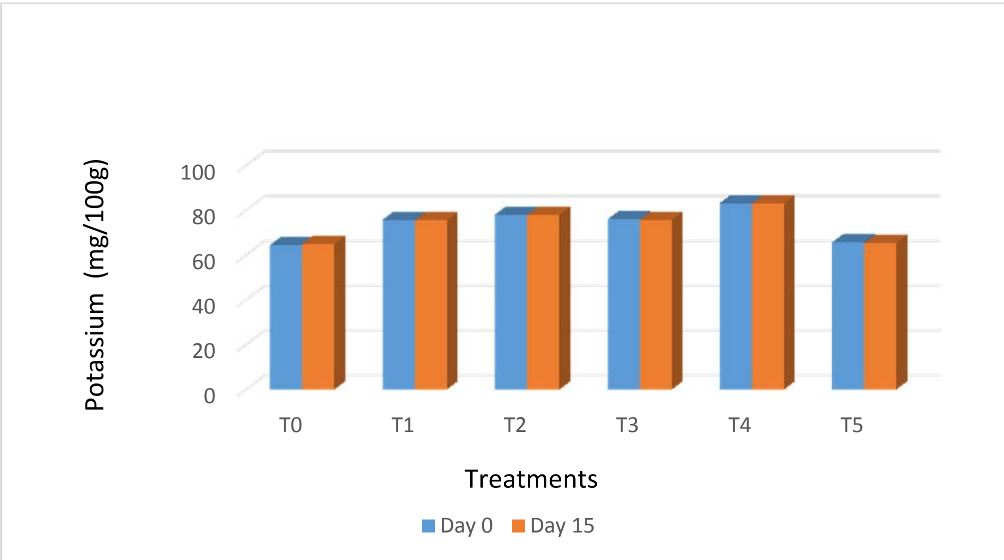

Fig. 64. Effect of storage on potassium of selected functional ingredient FS incorporated yoghurts

Table 82. Effect of storage on iron content (mg/100g) of functional ingredient FS incorporated yoghurts

Treatments	Iron (mg/100g)		CD (0.5)
	Day of storage		
	Day 0	Day 15	
T_0 (98% M + 2 % FS)	0.52^{a} (4.13)	0.48^{b} (4.01)	0.092
T_1 (88% M + 10% SP + 2 % FS)	1.10^{NS} (6.06)	1.00^{NS} (5.73)	-
T_2 (88% M + 10% GP + 2% FS)	0.58^{a} (4.36)	0.55^{b} (4.43)	0.087
T_3 (88% M + 10% JFP + 2%FS)	0.65^{a} (4.62)	0.60^{b} (4.42)	0.082
T_4 (88% M + 10% BPP + 2 % FS)	0.48^{a} (3.97)	0.44^{b} (3.80)	0.096
T_5 (88% M + 10% PP + 2 % FS)	1.45^{NS} (7.45)	1.40^{NS} (7.40)	-

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.13. Potassium

The potassium content of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 83.

Among all the treatments, potassium content was highest in T_4 (83.25 mg 100 g^{-1}) in freshly prepared yoghurt with a variation in potassium content level of 83.05 mg 100 g^{-1} found in 15th day of storage. This was followed by $T_2$with a potassium content of 78.12 mg 100 g^{-1} (initial) to 78.00 mg 100 g^{-1} (15th day). Compared to FPBY control yoghurt had the lowest content of potassium (64.50 to 64.00 mg 100 g^{-1}) on storage. There was a reduction in potassium content observed during storage period. Based on DMRT, there was no significant difference observed in treatments during storage.

Table 83. Effect of storage on potassium content (mg/100g) of functional ingredient FS incorporated yoghurts

Treatments	Potassium (mg/100g)	
	Day of storage	
	Day 0	Day 15
T_0 (98% M + 2 % FS)	64.5^{NS}	64.00^{NS}
T_1 (88% M + 10% SP + 2 % FS)	75.8^{NS}	75.5^{NS}
T_2 (88% M + 10% GP + 2% FS)	78.12^{NS}	78.00^{NS}
T_3 (88% M + 10% JFP + 2%FS)	76.00^{NS}	75.75^{NS}
T_4 (88% M + 10% BPP + 2 % FS)	83.25^{NS}	83.05^{NS}
T_5 (88% M + 10% PP + 2 % FS)	65.68^{NS}	65.33^{NS}

5% significant level; Values having different superscripts differ significantly in DMRT
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.3.14. Total ash

The total ash of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and is presented in Table 84.

A decreasing trend in ash content was observed in all treatments. The control yoghurt had total ash content of 1.60 to 0.95 per cent during storage. The treatment T_5 had the highest content of total ash of 1.61 to 1.20 per cent and the lowest content was observed in T_1. It ranged from 1.15 to 0.74 per cent. No significant difference was observed during storage of yoghurts.

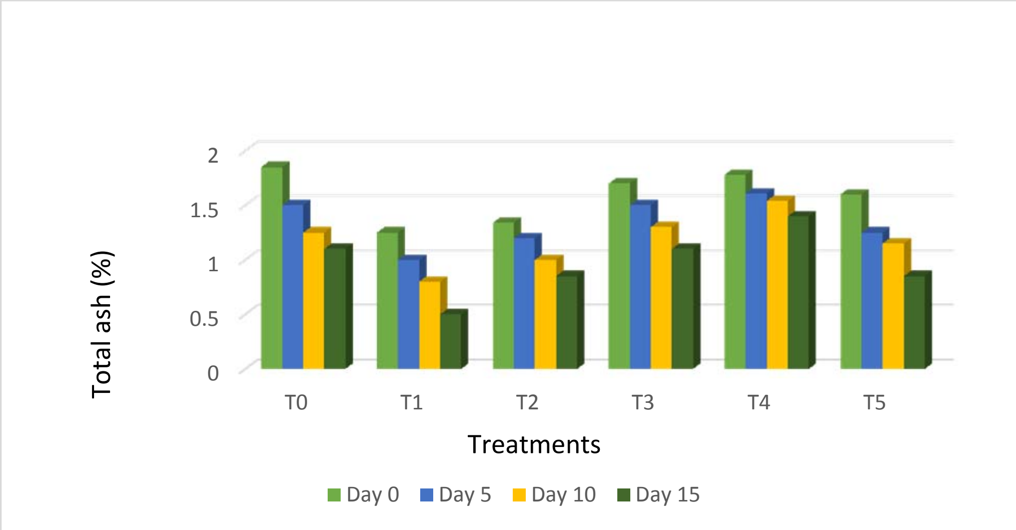

Fig. 65. Effect of storage on total ash content of functional ingredient FS incorporated yoghurts

Table 84. Effect of storage on total ash (%) of functional ingredient FS incorporated yoghurts

Treatments	Total ash (%)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	1.60 ^{NS} (6.99)	1.45 ^{NS} (6.58)	1.27 ^{NS} (6.03)	0.95 ^{NS} (5.59)
T_1 (88% M + 10% SP + 2 % FS)	1.15 ^{NS} (6.15)	0.96 ^{NS} (5.65)	0.82 ^{NS} (5.19)	0.74 ^{NS} (4.93)
T_2 (88% M + 10% GP + 2% FS)	1.25 ^{NS} (5.97)	1.10 ^{NS} (5.38)	0.86 ^{NS} (5.32)	0.77 ^{NS} (5.03)
T_3 (88% M + 10% JFP + 2%FS)	1.52 ^{NS} (6.78)	1.39 ^{NS} (6.41)	1.15 ^{NS} (5.60)	0.82 ^{NS} (5.19)
T_4 (88% M + 10% BPP + 2 % FS)	1.61 ^{NS} (7.02)	1.50 ^{NS} (6.72)	1.39 ^{NS} (6.41)	1.20 ^{NS} (5.79)
T_5 (88% M + 10% PP + 2 % FS)	1.43 ^{NS} (6.53)	1.25 ^{NS} (5.97)	1.02 ^{NS} (4.92)	0.86 ^{NS} (5.32)

5% significant level; Values having different superscripts differ significantly in DMRT
Figure in parenthesis indicates arc transformation value
T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.4. Microbial qualities

4.4.2.4.1. *E coli*

The *E coli* count of FS incorporated yoghurts with control is presented in Table 85.

E coli count was not detected in any of samples during storage.

Table 85. Effect of storage on *E coli* count (10^1cfu/g) of yoghurts

Treatments	*E coli* count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	ND	ND	ND	ND
T_1 (88% M + 10% SP + 2 % FS)	ND	ND	ND	ND
T_2 (88% M + 10% GP + 2% FS)	ND	ND	ND	ND
T_3 (88% M + 10% JFP + 2%FS)	ND	ND	ND	ND
T_4 (88% M + 10% BPP + 2 % FS)	ND	ND	ND	ND
T_5 (88% M + 10% PP + 2 % FS)	ND	ND	ND	ND

ND – Not detected

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.4.2. *Coliform* bacteria

The Coliform bacteria count of FS incorporated FPBY along with control and is presented in Table 86.

Coliform bacterial count was not detected.

Table 86. Effect of storage on *coliform* bacterial count (10^1cfu/g) of FS incorporated FPBY

Treatments	Coliform bacterial count (10^1cfu/g)			
	Day of storage			
	Day 0	Day 5	Day 10	Day 15
T_0 (98% M + 2 % FS)	ND	ND	ND	ND
T_1 (88% M + 10% SP + 2 % FS)	ND	ND	ND	ND
T_2 (88% M + 10% GP + 2% FS)	ND	ND	ND	ND
T_3 (88% M + 10% JFP + 2%FS)	ND	ND	ND	ND
T_4 (88% M + 10% BPP + 2 % FS)	ND	ND	ND	ND
T_5 (88% M + 10% PP + 2 % FS)	ND	ND	ND	ND

ND – Not detected

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.4.2. Yeast

Yeast count of selected functional ingredient (FS) incorporated yoghurts with control was tabulated and presented in Table 87.

The initial and up to 10^{th} day of storage yeast count was not detected in the selected yoghurts. Presence of yeast was observed at 15^{th} day of storage.

Table 87. Effect of storage on yeast count (10^3cfu/g) of selected functional ingredient (FS) incorporated yoghurts

Treatments	Yeast (10^3cfu/g)			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	ND	ND	ND	2.00
T_1 (88% M + 10% SP + 2 % FS)	ND	ND	ND	1.5
T_2 (88% M + 10% GP + 2% FS)	ND	ND	ND	1.2
T_3 (88% M + 10% JFP + 2%FS)	ND	ND	ND	1.00
T_4 (88% M + 10% BPP + 2 % FS)	ND	ND	ND	0.6
T_5 (88% M + 10% PP + 2 % FS)	ND	ND	ND	1.00

ND – Not detected

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.2.4.3. Fungi

Fungi count of selected functional ingredient (FS) incorporated yoghurts along with control was tabulated and presented in Table 88.

The fungi count was assessed at five days interval for a period of 15 days. The fungi count was detected in all selected treatments only on 15th day of storage. The highest fungi count was detected in control yoghurt which was 1.80 cfu/g. The lowest count was observed in $T_5$and it was 0.05 cfu/g.

Table 88. Effect of storage on fungal count (10^3cfu/g) of selected functional ingredient (FS) incorporated yoghurts

Treatments	Fungi (10^3cfu/g)			
	Day of storage			
	0	5	10	15
T_0 (98% M + 2 % FS)	ND	ND	ND	1.80
T_1 (88% M + 10% SP + 2 % FS)	ND	ND	ND	1.10
T_2 (88% M + 10% GP + 2% FS)	ND	ND	ND	1.11
T_3 (88% M + 10% JFP + 2%FS)	ND	ND	ND	1.00
T_4 (88% M + 10% BP + 2 % FS)	ND	ND	ND	0.07
T_5 (88% M + 10% PP + 2 % FS)	ND	ND	ND	0.05

ND – Not detected

T_0 – 98% Milk + 2 % Flax seed, T_1– 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

Table 89. Mean scores for organoleptic evaluation of selected functional ingredient FS incorporated yoghurts on storage

Treatments	Appearance				Colour				Flavour			
	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15
T_0 (98 % M + 2 % FS)	6.65	6.55	6.40	6.34	6.51	6.43	6.40	6.35	6.77	6.44	6.34	6.22
T_1 (88 % M + 2 % FS + 10% JFPBY)	6.24	6.20	6.13	6.02	6.40	6.35	6.30	6.20	6.55	6.46	6.30	6.20
T_2 (88% M + 2 % FS + 10% PPBY)	6.40	6.30	6.20	6.08	6.50	6.43	7.35	6.30	6.20	6.10	6.06	6.00
T_3 (88% M + 2 % FS + 10% BPBY)	6.31	6.28	6.16	6.05	6.30	6.20	6.15	6.10	6.30	6.20	6.15	6.06
T_4 (88 % M + 2 % FS + 10% GPBY)	6.33	6.29	6.21	6.06	6.22	6.16	6.10	6.03	6.40	6.30	6.24	6.18
T_5 (88 % M + 2 % FS + 10% SPBY)	6.35	6.30	6.22	6.07	6.30	6.21	6.17	6.11	6.25	6.20	6.16	6.00

Treatments	Overall acceptability				Taste				Texture			
	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15	Day 0	Day 5	Day 10	Day 15
T_0 (98 % M + 2 % FS)	6.80	6.57	6.06	6.00	6.97	6.60	6.50	6.41	6.66	6.51	6.45	6.30
T_1 (88 % M + 2 % FS + 10% JFPBY)	6.39	6.30	6.22	6.01	6.40	6.35	6.25	6.10	6.40	6.31	6.22	6.15
T_2 (88% M + 2 % FS + 10% PPBY)	6.20	6.17	6.10	6.00	6.30	6.24	6.14	6.00	6.22	6.20	6.10	6.05
T_3 (88% M + 2 % FS + 10% BPBY)	6.35	6.20	6.10	6.00	6.60	6.45	6.30	6.15	6.30	6.28	6.28	6.08
T_4 (88 % M + 2 % FS + 10% GPBY)	6.50	6.46	6.30	6.15	6.75	6.70	6.50	6.25	6.46	6.37	6.24	6.18
T_5 (88 % M + 2 % FS + 10% SPBY)	6.61	6.50	6.40	6.18	6.80	6.72	7.35	6.30	6.55	6.49	6.37	6.21

T_0 – 98% Milk + 2 % Flax seed, T_1 – 88% Milk + 10% Sapota pulp + 2 % Flax seed, T_2 - 88 % Milk + 10% Guava pulp + 2 % Flax seed, T_3 – 88 % Milk + 10% Jack fruit pulp + 2 % Flax seed, T_4 – 88% Milk + 10% Banana pulp + 2 % Flax seed, T_5 – 88% Milk + 10% Papaya pulp + 2% Flax seed

4.4.3. Organoleptic evaluation of selected functional ingredient FS incorporated FPBY on storage

The mean scores for the appearance of T_1 to T_5 was varied from 6.24 to 6.35 which gradually decreased during storage and it reached up to 6.02 to 6.07. The control (T_0) had an initial score of 6.65 which decreased to 6.34 at the end of storage. The colour of the FPBY varied from 6.40 (T_1) to 6.30 (T_5) initially and during storage it decreased to 6.20 to 6.11.

The highest mean scores for the flavour of FPBY was 6.55 to 6.20 in FS incorporated JFPBY and lowest in FS incorporated PPBY of 6.20 to 6.00. The taste and texture of FPBY (T_1 to T_5) was varied from 6.40 to 6.80 and 6.40 to 6.55 (initially) and 6.10 to 6.30 and 6.15 to 6.21 (15^{th} day) respectively. The taste and texture of control yoghurt, shows the mean score of 6.97 to 6.41 and 6.66 to 6.30 during storage.

The overall acceptability was high in treatment $T_5$6.61 to 6.18 during storage and lowest in T_2 6.20 to 6.00 during storage. The control (T_0) was highest in all the sensory parameters compared to FS incorporated FPBY.

5.5. Cost of production of selected FPBY and functional ingredient incorporated FPBY

Table 90. Cost of production of 100 ml plain yoghurts

Sl. No.	Item	Quantity	Amount (Rs./100ml)
1	Raw materials		
	Cow's milk	100ml	4.4
	Sugar	8g	0.36
	Skim milk powder	1g	0.25
	Yoghurt culture	2ml	2
	Packaging materials	1 cup	2
2	Other items		
	Electricity charge	0.75 units/h	0.50
	Fuel charge	10 minutes	2.00
			13.50

Table 91. Cost of production of 100 ml fruit yoghurts

Sl. No.	Item	Quantity	Amount (Rs./100ml)
1	Raw materials		
	Cow's milk	100ml	4.4
	Fruit pulp	10g	2 to 5
	Sugar	8g	0.36
	Skim milk powder	1g	0.25
	Yoghurt culture	2ml	2
	Packaging materials	1 cup	2
2	Other items		
	Electricity charge	0.75 units/h	0.50
	Fuel charge	10 minutes	2.00
			17 to 20

Table 92. Cost of production of 100 ml fruit yoghurt incorporated with garden cress seed

Sl. No.	Item	Quantity	Amount (Rs/100ml)
1	Raw materials		
	Cow's milk	100ml	4.4
	Fruit pulp	10g	2 to 5
	Sugar	8g	0.36
	Skim milk powder	1g	0.25
	Yoghurt culture	2ml	2
	Garden cress seed	0.5g	0.15
	Packaging materials	1 cup	2
2	Other items		
	Electricity charge	0.75 units/h	0.50
	Fuel charge	10 minutes	2.00
			17.16 to 21

Table 93. Cost of production of 100 ml fruit yoghurt incorporated with flax seed

Sl. No.	Item	Quantity	Amount (Rs/100ml)
1	Raw materials		
	Cow's milk	100ml	4.4
	Fruit pulp	10g	2 to 5
	Sugar	8g	0.36
	Skim milk powder	1g	0.25
	Yoghurt culture	2ml	2
	Flax seed	2g	1
	Packaging materials	1 cup	2
2	Other items		
	Electricity charge	0.75 units/h	0.50
	Fuel charge	10 minutes	2.00
			18 to 21

The cost of production of control (plain) yoghurt 13.50 Rs/100 ml and the fruit pulp based yoghurt ranged from 17 to 20 Rs/100 ml. The cost of selected

FPBY incorporated with garden cress seed varied from 17.16 to 21.00 Rs/100 ml and flax seed incorporated FPBY ranging from 18 to 21.00 Rs/100 ml. Among the different yoghurts, control yoghurt was found to have the lowest price whereas in flax seed incorporated FPBY was observed to be the highest price.

Discussion

5. Discussion

Results of the study entitled **"Process optimisation and quality evaluation of fruit pulp based yoghurts"** are discussed under the following headings.

5.1. Organoleptic qualities of fruit pulp based yoghurts (FPBY) and selection of the most acceptable product.

5.2. Quality evaluation of selected FPBY

5.2.1. Physicochemical qualities

5.2.2. Nutritional qualities

5.2.3. Microbial enumeration

5.2.4. Organoleptic evaluation of selected FPBY on storage

5.3. Organoleptic qualities of functional ingredient incorporated FPBY and selection of most acceptable product

5.4. Quality evaluation of selected functional ingredient incorporated FPBY

5.4.1. Physicochemical qualities

5.4.2. Nutritional qualities

5.4.3. Microbial enumeration

5.5. Cost of production of selected FPBY and functional ingredient incorporated FPBY

5.1. Organoleptic qualities of fruit pulp based yoghurts (FPBY) and selection of the most acceptable products.

Fruit pulp based yoghurts were prepared by replacing milk with fruit pulps at different levels. Underexploited and locally available fruits such as sapota, guava, Banana *(Palayankodan)*, papaya and jackfruit were used for the preparation of yoghurt. Twenty-six treatments were evaluated for different organoleptic attributes like appearance, colour, flavour, taste, texture and overall acceptability compared with control (T_0).

Among sapota pulp based yoghurts the treatments T_1 (90 % milk + 10 % sapota pulp) secured maximum mean score for all quality attributes like appearance (8.66), colour (8.57), flavour (8.46), taste (8.66), texture (8.35) and overall acceptability (8.53) when compared to other treatments.

Control (T_0) prepared out of 100 per cent milk obtained higher mean scores for all organoleptic attributes than T_1. The total score attained for control was 52.57 and for T_1 it was 51.23. Aruna and Satapathy (2012) observed the highest sensory score for sapota pulp yoghurt compared to other fruits and vegetables incorporated yoghurts. Nanzi and Komathi (2014) prepared yoghurt by using buffalo milk enriched with sapota and grape pulp. Incorporation of 24 per cent sapota pulp yoghurt had high acceptability value than grape pulp added yoghurts. According to Meenashi *et al.* (2018) probiotic yoghurt with 10 per cent sapota pulp had secured highest overall acceptability of 8.60 than 5 per cent (8.10) and 15 per cent (8.20), incorporation of sapota pulp.

Among different treatments tried for the preparation of guava pulp based yoghurts the highest mean scores and mean rank scores were observed for the treatment T_1 which was prepared using 90 % milk and 10 % guava pulp. The lowest mean score was noticed in treatment T_5 (70 % milk + 30 % guava pulp The treatment T_1 got the total score of 50.34 and T_5 attained a score of 36.5.

Yoghurt prepared out of 100% milk had highest mean score for all sensory attributes than other treatments, except taste. A slightly higher mean score value for taste was observed in T_1 (8.91) and for T_0 it was (8.71). Salwa *et al.* (2014) prepared plain yoghurt and carrot yoghurt from cow's milk. Carrot yoghurt was prepared by blending milk with 5, 10, 15 and 20 per cent carrot juice. Sensory quality were investigated during refrigerated storage at 4° C for 3 weeks. Sensory score was obtained yoghurt with 15 % carrot juice.

Jayasinghe *et al.* (2010) prepared yoghurt with pasturised dragon fruit juice at varying proportions 5, 7.5, 10 and 12.5 per cent respectively. The highest sensory score were observed in the product which consisted of 10 per cent dragon fruit juice. In the present study maximum organoleptic scores was attained for the treatment T_1 (90 % milk + 10 % guava pulp) than other treatments.

Banana *(Palayankodan)* pulp based yoghurts were prepared with varying proportions of Banana *(Palayankodan)* pulp and compared with control (100 % milk). Treatment T_1 (90 % milk + 10 % pulp) was highly acceptable after control (T_0).

The results of sensory evaluation a highest mean score for BPBYin treatment T_1 obtained a score of 8.97. 8.13, 8.80, 8.06, 8.97 and 8.06 for appearance, colour, flavor, taste, texture and overall acceptability. Amna *et al.* (2008) observed addition of 9 % banana pulp secured highest score of 8.25 with respect to overall acceptability. Mahmood *et al.* (2008) prepared banana, apple and plain yoghurt with buffalo milk and the highest sensory score was attained for the stirred yoghurt with 8 % apple and 8 % banana pulp. Youset *et al.* (2013) opined that incorporation of 7 % and 10 % banana pulp is suitable for yoghurt preparation. Amany *et al.* (2014) prepared yoghurt with adding different proportions of banana puree. Addition of 15 per cent banana puree received the highest score followed by 10 per cent compared to control. Menakshi *et al.* (2018) found that probiotic yoghurt with 10 % addition of banana pulp had secured highest value for sensory score. The results of the above studies are similar to the findings of the present study.

Papaya pulp based yoghurt were prepared along with control. The control yoghurt had a slight higher mean score than T_1.

Among PPBY treatment T_1 had the highest mean score all sensory attributes like appearance, colour, flavor, texture and taste. Roy *et al.* (2015) prepared yoghurt with three different fruit pulps such as banana, papaya and watermelon. All fruits were found nutritionally and organoleptically superior than control. Papaya yoghurt was preferred over banana and watermelon yoghurts. Amal *et al.* (2016) reported that yoghurt containing 15 per cent papaya pulp had the highest overall acceptability as compared to cactus pear yoghurt. Addition of mango and papaya juice to yoghurt in optimum level improved sensory attributes and physico chemical properties of yoghurt (Teshome *et al.,* 2017).

Among different treatments tried for the preparation of jackfruit *(Koozha type)* pulp based yoghurts, control yoghurt got the highest mean score for all sensory parameters. The total score attained for control was 52.00. In JFPBY the treatment T_1 (90 % milk + 10 % pulp) had highest mean score for all sensory attributes like appearance (8.84), colour (7.68), flavor (7.7), taste (8.17), texture (8.64), overall acceptability (8.80) and the total score was 49.90. According to Rahman *et al.* (2001) yoghurt can be prepared by adding 5, 10 and 15 per cent level of jackfruit with milk. The mean score of yoghurt improved with the addition of jackfruit. Yoghurt containing 5 per cent jackfruit juice showed better organoleptic qualities. Dey *et al.* (2014) observed that 5 to 10 per cent addition of jackfruit juice had better appearance, colour, flavor, texture and overall acceptability compared to 15 per cent jackfruit juice incorporated yoghurt.

5.4. Quality evaluation of selected FPBY

5.4.1. Physicochemical qualities

The initial moisture ranged from 78.05 per cent to 80.16 per cent among various yoghurts prepared in this study. A decrease in moisture content, as 70.00 per cent to 73.04 per cent was observed at 15th day of storage. A decreasing trend in moisture content as 70.00 per cent to 73.04 per cent was observed for all treatments. According to Tammine and Robinson (1999) a typical full fat yoghurt and fruit yoghurt should contain 81.9 and 77.00 per cent moisture respectively. This is similar to the result of the present study.

Nazni and Komathi (2014) noticed 80.97% moisture content in control yoghurt and 83.92, 82.49 per cent in banana pulp and papaya pulp added yoghurts respectively. Warakaulle *et al.* (2014) noticed 79.37 per cent moisture content in plain cow's milk yoghurt and 79.35 per cent moisture content in water melon enriched yoghurt. Amal *et al.* (2016) observed 87.64 per cent moisture content in papaya yoghurt and 84.79 per cent in cactus pear added yoghurts.

Tammine and Robinson, (1985) reported that pH should be 4.6 for production of good quality yoghurts. In this study the initial pH of plain yoghurt was 4.52 and for FPBY it varied from 4.49 (PPBY) to 4.68 (SPBY). A gradual decrease in pH was observed among all treatments during storage. When, the sugar sources exhausts, microorganisms begin to consume proteins and the metabolites formed by microbial activity could increase the pH of the product (Frazcer and Westhoff, 1995). Celik *et al.* (2006) also observed continued decrease in pH of the plain yoghurt and fruit flavoured yoghurts during storage. The decrease in pH can be attributed to the fermentation of sugar and the production of lactic acid producing organisms.

The pH is inversely proportional to the acidity of products. The pH of yoghurts with storage, leads to an increase in acidity. Lactic acid produced during fermentation can increase the acidity or decrease the pH. In this study also the acid content increased with storage and similar reports were observed by Shalini, (2006) and Amal *et al.* (2016).

The initial acidity of control yoghurt was 0.68 which increased with every five days of interval, it reaches up to 0.76 on 15 days of storage. Initial acidity of treatment T_1 to T_5 ranged from 0.61 to 0.57 and it reached up to 0.65 to 0.64 at the end of the storage period. The acidity of different treatments increases during storage. Shalini (2006) reported acidity of yoghurt samples increased during storage. Sarabhai (2012) also reported that acidity was increased throughout the storage period. Morvarid *et al.* (2013) prepared yoghurt with different fruit pulp including apple, banana and strawberry. The fruit pulp were added at the rate of 7 and 10 per cent level. They found a significant increase in acidity during storage as compared to first day of storage. Sengupta *et al.* (2014) studied the fruit yoghurt prepared by adding watermelon juice with milk. They found that fruit yoghurt had higher acidity than control yoghurt. Amal *et al.* (2016) reported increased acidity during storage period in papaya and cactus pear pulp added yoghurt.

The water holding capacity in yoghurt indicates the microstructure of the protein network. If the water binding is not sufficient whey will be expelled on the surface of the product during storage (Moetensen *et al.,* 2010). In the present study the initial water holding capacity of plain yoghurt was 53.66 which decreased 15th day of storage to 47.00 per cent. The highest value of WHC was found in PPBY. Initially it was about 56.34 and at the end of the storage it declined up to 53.00 per cent. An increase in trend of water holding capacity was observed in all yoghurt samples.

Lower WHC or whey separation is referring to a weakness of gel network (Singh and Muthukun, 2008). Isanga and Zhang (2009) noticed peanut milk based yoghurt had higher WHC capacity (46.60) than cow's milk yoghurt (42.25). The WHC of yoghurt sample increased with increase in soy milk content than plain yoghurt (Kpodo *et al.,* 2014). Amal *et al.* (2016) also observed an increase in WHC throughout the storage period. The WHC of cactus pear yoghurt was found to be higher than that of papaya yoghurt.

Syneresis is the major visible defect that occur during yoghurt storage and can affect the final product acceptance (Fisczman *et al.,* 2004). Syneresis occurs due to the loss of yoghurt gel capacity to entrap serum phase through the weakening of the gel network resulting on whey separation (Lucey, 2004).

In control yoghurt the syneresis was ranged from 1.0 to 2.6 per cent on storage period. Compared to FPBY control yoghurt had slight higher value of synersis in storage. The results are in conformation with the research of previous workers (Fox *et al.,* 2000), wherein they stated the rate of syneresis is directly related to the pH. An increase in syneresis of yoghurts with storage was observed by (Panes and Shindi, 2012). The addition of fruit pulp caused a decrease in synersis. It may due to the capacity to absorb water by solids present in fruits. Joon *et al.* (2017) found that yoghurts from goat milk revealed the higher syneresis (9.92 ± 0.02) whereas, yoghurt from cow milk was found to be the lowest (9.65± 0.03). Compared to these values a lower per cent of 0.6 to 2.6 per cent syneresis was only observed in this study.

Wide variations in viscosity was observed in control and FPBY. The viscosity of control and FPBY increased with duration of storage. Abu-Jdayil and Mohameed (2002) reported an increase in the viscosity of concentrated yoghurt during storage and its reason was reported as the development of gel structure during storage. Celik *et al.* (2006) reported that the viscosity of the cornelian cherry fruit-flavored yoghurt increase rapidly up to 7^{th} day and continued to increase slowly up to 14^{th} day of storage and afterward decreased slowly.This increase in viscosity during storage may due to the change in three dimensional protein network of yoghurt (Sahan *et al.,* 2008). The similar increasing trend of viscosity was observed in stirred soy yoghurt. A viscosity of 31,200 cP, 34,500 cP, 33,000 cP and 32,500 cP were observed in plain yoghurt at an interval of 7 days by Izadi *et al.,* (2015). They also observed a decrease in viscosity in phytosterol enriched yoghurts.

Curd tension determines the character of clot and the factors determining the toughness of curd are the constituents of milk namely casein, calcium ions and rennet. All others modify the clot superficially (Kugelmaes, 2019). In the present study the maximum curd tension was noticed in plain yoghurt which varied from 54.00 (initial) to 60.00g (15^{th} day) than other treatments. Among the treatments T_1 to T_5maximum curd tension of 37.68 was noticed in treatment T_2 (GPBY) initially and minimum of 36.00 was found in T_5 (PPBY). The value of curd tension was increased in every five days of storage and finally the values reached between the range of 45.66 (GPBY) to 40.41(JFPY). Increased trend of curd tension was observed in all the yoghurt samples including control.

An increase of curd tension with advancement in days of storage was observed by Salwa (2004) and Malarkannan*et al.* (2012) in coconut water yoghurts. Boraey *et al.* (2015) reported the curd tension of cow's milk as 35.41 g in freshly prepared yoghurts and 36.15 g after 7 days of storage. A high curd tension of 70.87 was observed in yoghurt prepared with buffalo milk.

Chandhari *et al.* (2007), reported that the average curd tension in dahi prepared from buffalo milk was higher (43.44 g) than that prepared from cow milk (34.94 g). Increase in curd tension, helps to overcome wheying off of dahi, with improvement in viscosity and consistency.

5.4.2. Nutritional properties

The control yoghurt had a TSS content of 14° Bx (initial) to 13.24° Bx (15th day). The TSS content of treatments T_1 and T_5 was found to be higher than plain yoghurt. The initial TSS content of treatments T_1 to T_5 were 16.00 to 15.00° Bx respectively, and the gradual decrease was noticed throughout the storage period. The TSS content of treatments T_1 and T_5 reduced to 15.10 and 13.42 respectively at the end of storage. Desai *et al.* (1994) described that the TSS content of fruit yoghurts was significantly higher than that of plain yoghurt, which is in line with the findings of the present study. These reduction of TSS content may be due to the action of yoghurt starter culture reported by Wang *et al.* (2000). Supavititpatana *et al.* (2010) also reported a decrease in TSS content from 7.33 to 6.83% in corn milk based yoghurt and in plain yoghurt as 15.33 to 14.93°Bx. Ariaii *et al.* (2011) observed a decrease in TSS content of banana flour incorporated yoghurt at 6th day of storage.

The changes in total sugar content during storage period of selected FPBY were compared with control. The total sugar content in control yoghurt varied from 3.88 to 3.71 per cent. The highest total sugar content was noticed in JFPBY which was 17.29 per cent and it reduced in to 17.00 per cent during 15th day of storage and the lowest content of PPBY varied from 12.42 to 12.00 per cent. According to Illiaskutty (2004) the total sugar content of coconut water yoghurt was 12.44 per cent and in soy milk based yoghurt was 13.22 per cent. Kale *et al.* (2008) also observed similar total sugar content of 13.5% in pomegranate incorporated yoghurt. These results are similar to the present study.

In the present study significant reduction in reducing sugar and total sugar content were observed during storage. Compared to control fruit yoghurts, fruit pulp based yoghurts had higher reducing and total sugar content. Kale *et al.* (2008) prepared pomegranate yoghurt they observed reducing sugar content of 5.67 per cent. Guava pulp incorporated yoghurt was found to have 5% reducing sugar and 7.9% non - reducing sugar (Patil *et al.,* 2009).

In the present study, calorific value of control yoghurt varied from 82.68 to 55.20 Kcal during 15 days of storage. The lowest calorie value was found to be in JFPBY and it ranged to 52.88 to 32.33 Kcal. According to Nazni and Komathi, (2014) observed energy value of different yoghurts as 63.3 Kcal (control) 77.00 Kcal (papaya yoghurts) and 76.00 Kcal (banana yoghurt).

In the present study the carbohydrate content of control yoghurt ranged between 11.50 to 10.00 per cent during storage. The treatment T_1 and T_2 obtained a carbohydrate content of 10.6 to 9.40 and 8.0 to 6.00 per cent during storage. Acharya (1999) noticed 18.8 per cent of carbohydrate in yoghurt. According to Roy *et al.* (2015) addition of fruit pulp did not affect the carbohydrate content.

Lactose content of yoghurt is comparatively low than of milk. Fruit yoghurts showed significant decrease in lactose content. In control (plain yoghurt) the lactose content ranged between 2.94 to 2.82 per cent. The lowest amount of lactose was found in GPBY. Zanjad (2001) noticed that full fat yoghurt had 5.20 per cent of lactose while low fat yoghurt contain 5.03 per cent. Hassan and Amjad(2010) reported that average lactose value of *L. bulgaricus* yoghurt was 5.21per cent while that of *L. acidophilus* yoghurt was 4.61 per cent.

Kaup (2011) stated that yoghurt is recommended for lactose intolerance individuals because of the reduced lactose content. Besides this, lactic acid also helps in the absorption of calcium and phosphorous in the intestine.

In the present study, the initial protein content of selected FPBY ranged from 3.91 to 3.23 and the highest protein content was observed in BPBY whereas the lowest content of protein was observed in GPBY. Compared to control the lowest protein content observed in FPBY. Initially 4.59 per cent of protein was found to be in control and it reduced to 3.35 at 15^{th} day of storage. Protein content decreased significantly in all samples during storage. As per FSSAI (2011) regulations milk yoghurt should contain 3.2 per cent milk proteins and for fruit yoghurts it is 2.6%. The present study observed a protein content of 4.59 to 3.35 per cent in control yoghurt during end of storage. Similar protein content was noticed in rice based yoghurt enriched with strawberry (3.05) developed by Wonkkhalaung and Boonyaratanakornkit (2000). Mahmood (2008) prepared mango flavoured yoghurt and has also reported a decrease in protein content during storage. Yoghurt enriched with 5% juice of strawberry and orange had a protein content ranged from 3.30 to 3.6% (Hossain *et al.* 2012). The fat content of FPBY was compared with control yoghurt.

The fat content in all treatments was above 1.2 g in freshly prepared yoghurts and decreasing trend of fat was observed in every 5 days of interval. Sharf *et al.* (2003) reported that a decrease in fat content during storage is due to the lipolytic activity of enzymes lipase and lipoxidase produced by microorganisms. Shalini (2006) also observed, unsignificant reduction of fat content in plain yoghurt during storage. In different fruit yoghurts a progressive decrease in fat content was noticed in fat content of mango flavoured yoghurt during storage. Dipti (2015) reported. A lower fat content of 1.85 % in multigrain yoghurt.

In the present study vitamin A content was not detected in control sample throughout the storage period but in FPBY presence of vitamin A was noticed. PPBY had higher content of vitamin A. It may be contributed by the ß carotene content of fruit pulps. During storage a gradual reduction in vitamin A content was observed in the present study. According to Balakannan *et al.* (2012) yoghurt prepared by incorporating mango pulp in different proportions had increased vitamin A content. Hossain *et al.* (2012) reported increased in vitamin A content in bush mango enriched yoghurt than control yoghurt.

Vitamin C content of FPBY were found to be higher than plain yoghurt. Addition of fruit pulp increased the vitamin C content. The highest amount of vitamin C was found in PPBY (1.00 mg/100 g). Similar vitamin C content (0.75 mg/100 g) was observed in rice based yoghurt enriched with pineapple bits (Sarabhai, 2012). The addition of water melon juice in to the yoghurt resulted an increased in vitamin C content (Warakaulle *et al.,* 2014). Nazni and Komathi (2016) reported 0.7 mg/100g of vitamin C content in plain yoghurt and 1.47 mg/100g in papaya pulp based yoghurt.

In the present study calcium content of FPBY were low when compared to control yoghurt. A significant decrease in calcium content was observed in both control and FPBY treatments during storage. In FPBY treatments JFPBY had the highest amount of calcium content. Balasubramanyam and Kulkarani (1991) noticed that yoghurt is a valuable source of calcium. Wongkhalaung and Boonyaratankornkit (2000) reported lower calcium content in rice based yoghurt enriched with strawberry compared to control. Illiaskutty (2004), reported coconut water yoghurt had a high amount of calcium content (525 mg/100 g). Sarabai (2012) also observed lowest calcium content in flavoured yoghurts compared to control yoghurt.

In the present study the lowest value of iron was found in control yoghurt. FPBY had a slightly higher value for iron content compared to control yoghurt. Milk is a poor source of iron and this may be the reason for lower iron content in yoghurt. Similar iron content was observed in coconut water yoghurt and soy milk yoghurt (Illiaskutty, 2004). Swati (2012) reported a highest iron content in rice based yoghurt enriched with mango and pineapple bits and also found reduction in iron content while storage.

In present study, the control yoghurt had a potassium content which ranged 60.01 to 59.50 mg/100g during storage. FPBY treatments had highest content of potassium when compared control yoghurt. This is because of the presence of the increased potassium content of the fruits. Seggara *et al.* (2000) analysed notably high content of potassium in wild strawberry and pineapple fruit flavoured yoghurts. However, lowest concentration of potassium were noticed in peach flavoured yoghurt. Illiaskutty (2004), noticed high potassium content in coconut water based yoghurt (410 mg/100 g) than soy milk added yoghurt (387 mg/100 g).

In the present study a decreasing trend in ash content was observed in all treatments. The highest value of ash content was observed in control yoghurt than FPBY. Kadam (2006) reported the total ash content of fortified yoghurt sample as 1.53%. This yoghurt was fortified with 30 per cent soy milk and 20 per cent mango pulp. Ndife *et al.* (2014) observed that the total ash content of coconut cake incorporated yoghurt ranged from 0.53 to 1.01 per cent. Nain (2016) also reported that control yoghurt had highest value of ash content than pineapple flavored yoghurts. Compared to control yoghurt agar gum added samples got highest value for ash (Syed, 2016).

5.4.3. Microbial enumeration

In the present study, E coli were absent in all treatments during storage and coliform bacterial count was detected only in SPBY. Yoghurt shelf life is based on whether the products display any of the physical, chemical, microbial or sensory characteristics that are undesirable for consumption. Studies of changes in these quality characteristics during storage would be instrumental in predicting the shelf life of the product (Salvador and Fiszman, 2004). Presence of contaminating bacteria in fermented products was reported by Aziz *et al.* (2002). Salwa *et al.* (2004) reported the increase in yeast, mould and coliform counts during 21 days storage of carrot yoghurt. Ariaii *et al.* (2011) reported increase in contaminating bacteria count during storage. Swati (2012) found that mould and yeast were not detected in rice based yoghurt and in control throughout the storage period, but in case of fruit enriched yoghurt mould and yeast growth were observed on 14^{th} day of storage. At the end of 17 days of storage the yoghurts were found not acceptable as per the microbiological standards (Sivakumar, 2014).

5.2.4. Organoleptic evaluation of selected FPBY on storage

The mean score for different organoleptic qualities of FPBY decreased gradually during 15 days of storage. All the treatments maintained a mean score within the acceptable levels during storage. Gazzer and Hafez (1992) reported microbial hydrolysis of yoghurt component during storage is the key deteriorating factor of taste, colour, flavor, texture and overall acceptability of the products. According to Tarakci and Kucukoner (2003) noticed a decrease in flavor and texture of fruit yoghurt during storage. Praseeda (2005) reported a decrease in organoleptic qualities in curd under refrigerated condition in 21 days of storage. Darkening of colour and development of alcoholic flavor due to increased acidity in banana flavored yoghurt during storage (Ariaii *et al.,* 2011).

5.4. Quality evaluation of selected functional ingredient (GCS) incorporated FPBY

5.4.1. Organoleptic qualities

The selected FPBY, one from each fruit based yoghurts was incorporated with the functional ingredient (GCS) at 2 and 4 per cent levels. All treatments attained an organoleptic score of less than five for all attributes. Hence, they were experimented by incorporating at 0.5 per cent and 1 per cent levels. Twenty six treatments were evaluated for different organoleptic attributes like appearance, colour, flavor, taste, texture and overall acceptability compared with control (T_0).

Yoghurt incorporated with 0.5 per cent GCS attained high organoleptic scores compared to 1 per cent incorporation. Hence yoghurts with 0.5 per cent incorporation were selected for further studies. The total scores was found to be high in 0.5 per cent incorporated GPBY (48.45) followed by 0.5 per cent GCS incorporated SPBY (48.33). Patil *et al.* (2015) developed biscuits incorporated with garden cress seed in varying proportion of 10, 15 and 20 per cent. The parameters like flavour and texture was decresed in 15 per cent (6 and 7) and 20 per cent (7 and 7) incorporated garden cress seed powder than 10 per cent (9 and 9). The texture and overall acceptability of garden cress seed products was significantly affected by increased level of garden cress seed powder (Singh *et al.,* 2015). Yareshimi and Hiremath (2017) developed value added products like *laddu*, biscuits, papad and soup by incorporating five and ten per cent of roasted garden cress seeds. Among the developed by products prepared with five per cent incorporated seeds obtained higher scores for texture. (*laddu*- 7.95, biscuit- 7.75, *pappad*- 7.75 and soup 7.80) and flavour (*laddu*- 7.90, biscuit- 7.85, *pappad*- 8.25 and soup 7.95). Mohite *et al.* (2012) did organoleptic evaluation of health drink and observed that health drink prepared with three per cent (w/v) of processed garden cressseed powder scored highest (8.75) compared to other drinks using different concentration (1-5% w/v).

5.4.2. Physicochemical properties

In the present study, the highest moisture content was observed in GCS incorporated BPBY 81.78 to 78.00 per cent during storage and the lowest moisture content were observed in GCS incorporated SPBY it was 80.01 to 74.32 per cent. Mohite *et al.* (2012) observed moisture content of 84.10 per cent in garden cress seed incorporated milk based health drink.

In the present study the pH was highest in GCS incorporated SPBY (4.65 to 4.35) and the highest acidity was noticed in GCS incorporated BPBY which was 0.72 to 0.91 per cent. Yellow mustard extract incorporated yoghurt had a pH value of 4.53 in fresh mustard and 4.52 in dried mustard and the acidity ranged about 1.00 to 1.01 per cent (Geeta, 2000). The present study observed the highest syneresis value in GCS incorporated JFPBY, BPBY and PPBY, it was about 1.00 per cent. Geeta, (2000) observed the syneresis value of 15 ml in yellow mustard incorporated yoghurt.

In the present study the highest value of viscosity and curd tension was observed in GPBY incorporated with GCS it was about 30800 to 34600 cP and 38.68 g to 45.66 g during storage. Geeta, (2000) found that the viscosity value of 45000 and 37000 cP and curd tension 88.8 and 77.6 g in fresh and dried mustard incorporated yoghurt.

5.4.3. Nutritional properties

In the present study, the highest TSS content was observed in JFPBY and BPBY it was about 17.00°Bx. The highest total and reducing sugar content was observed in GCS incorporated JFPBY that is 16.05 to 14.70 and 7.90 to 6.72 per cent during storage. Geeta, (2000) observed the TSS, total and reducing sugar content of mustard added yoghurt. It was about 12° Bx for TSS, 8.92 per cent for total sugar and 6.01 per cent for reducing sugar content.

In the present study the highest energy value was observed in GCS incorporated SPBY, it was about 67.53 (initial) and at the end of storage it declined to 62.41. Singh *et al.* (2015) observed energy value of 65.53 in garden cress seed incorporated milk based health drink. This findings was similar to the present study.

The initial carbohydrate content of GCS incorporated yoghurt was 9.70 to 8.00 in control during storage. The initial carbohydrate content of GCS incorporated FPBY was highest in SPBY that is 8.90 to 7.96 during storage. The protein content of GCS incorporated FPBY was highest in BPBY (4.77 to 4.44 per cent). Highest content of lactose was found to be in GCS incorporated SPBY that is 2.72 to 2.62 per cent. Kaup (2011) stated that yoghurt is recommended for lactose intolerance individuals because of the reduced lactose content. Besides this, lactic acid also helps in the absorption of calcium and phosphorous in the intestine.

In the present study, the highest fat content was observed in GCS incorporated PPBY (2.17 to 1.89) during storage and the lowest content of fat was found to be in 1.85 to 1.60 per cent in SPBY (1.85 to 1.60 per cent). Singh *et al.* (2015) observed 1.22 per cent of fat in milk based health drink incorporated with garden cress seed. Patil *et al.* (2015) developed biscuit incorporated with garden cress seeds in varying proportions of 5, 10, 15 and 20 per cent. The protein content was increased by increasing the proportion of garden cress seeds to5.19, 5.98, 6.25, 6.60 and 6.90 g respectively. Kaur and Sharma (2016) developed traditional food products incorporated with garden cress seeds ranging from 8-20per cent. The incorporation of roasted garden cress seeds increased protein content that varied from 44.9 per cent to 76.29 per cent. Carbohydrate content of roasted garden cress seeds incorporated food preparations varied from 18.6 g to 83.2 g per 100gm.

In the present study, vitamin A from control yoghurt was not detected but fruit pulp incorporated yoghurts shows presence of vitamin A content. In GCS incorporated FPBY, the highest vitamin A content was observed in PPBY incorporated with garden cress seed, the amount of vitamin A is 5.83 to 5.80 IU this is due to the presence of β carotene content of fruit pulps. Garden cress seed in yoghurts did not affect the vitamin A content. Vitamin A content was not detected in garden cress seed (NIN, 2017).

In the present study the highest amount of vitamin C was observed in GCS incorporated PPBY it was 0.90 to 0.87 mg/100g during storage. Grover (2016) observed the vitamin C content of garden cress seed enriched *chapathi* as 0.90 mg/100g. This value is similar to the present study.

In the present study, the highest calcium content was observed in GCS incorporated JFPBY. The initial calcium content was 64.00 mg/100g and during storage it declined to 63.73.Elizabeth and Poojara (2014) developed garden cress seed incorporated snacks for adolescent girls they found that 91 mg/100g calcium in garden cress seed added Mini raisin muffin and 72 mg/100g in Carrot Halim cookies and 54 mg/100g in Corn flake Halim cookies.

The highest iron content was observed in GCS incorporated PPBY 1.75 to 1.69 mg/100g. Elizabeth and Poojara (2014) developed value added products incorporated with gardan cress seeds (10, 20 and 30 per cent) and found that the iron content was ranged from 12 to 18 per cent. Rani and Sucharita (2016) developed iron rich *laddu* by incorporating different combinations of garden cress seed (10 and 15 per cent) and the iron content was ranged from 11.14 mg and 16.01 mg. The highest per cent of potassium content was observed in GCS incorporated BPBY (81.55 to 81.47 mg/100g) and the lowest potassium content was observed in GCS incorporated PPBY which was about 64.33 to 64.25 mg/100g. Chaudhary and Gupta, (2017) reported garden cress seed contain highest amount of potassium.

The highest total ash content was observed in GCS incorporated BPBY that is 1.61 to 1.20 per cent. The ash content of garden cress seed supplemented biscuit was 1.37% and garden cress seed supplemented *ladoo* it was about 2.13% (Rana and Kapur, 2016).

5.4.4 Microbial qualities

In the present study, contaminating microorganisms was detected only in 15th day of storage. The garden cress seed incorporated nutri mixes were shelf stable up to 4 months of storage in laminated aluminium pouches (Reshma, 2017).

5.4.5 Organoleptic evaluation of selected GCS incorporated FPBY on storage

The mean score for different organoleptic qualities of GCS incorporated FPBY decreased gradually during 15 days of storage. All the treatments attained a mean score above 6 during storage. Garden cress seed incorporated biscuits were stored under ambient condition. Different sensory attributes like color, flavor, taste, texture and over all acceptability were performed significant difference in taste, flavor and color during 40 days of shelf life study (Patil *et al.*, 2015). Reshma (2017) reported four months of shelf life in millet based nutri mix incorporated with garden cress seed.

5.4.b. Organoleptic qualities of functional ingredient (FS) incorporated FPBY

The selected FPBY, one from each fruit based yoghurts was incorporated with the functional ingredient (FS) at 2 and 4 per cent level. Twenty six treatments were evaluated for different organoleptic attributes like appearance, colour, flavor, taste, texture and overall acceptability compared with control (T_0).

Yoghurt incorporated with 2 per cent FS attained high organoleptic scores compared to 4 per cent incorporation. Hence yoghurts with 2 per cent incorporation were selected for further studies. The total scores was found to be high in 2 per cent FS incorporated GPBY (40.15) followed by 2 per cent FS incorporated SPBY (40.14). Gaggat and Singh (2014) developed value added products incorporated with flax seed. Five per cent incorporated products was highly acceptable. Saxena and Vashishth (2016) developed value added products incorporated with flax seed powder at different levels of 10, 20, 30 and 40 per cent. The products like muffin and *khakra*incorporated with 10 per cent flax seed was obtained overall score of 4.4 and *thepla*and *mathri* incorporated with 40 per cent flax seed have a mean score of 4.8.

5.4.1.b. Physicochemical properties

In the present study, the highest moisture content was observed in FS incorporated JFPBY. It was about 79.11 to 70.10 per cent and the lowest per cent of moisture content was observed in FS incorporated BPBY it was about 77 to 70 per cent during storage. Warakaulle *et al.* (2014) noticed 79.37 per cent moisture content in cow's milk yoghurt. Amal *et al.* (2016) observed 84.79 to 87.64 per cent moisture content in fruit yoghurts.

In this study the initial pH of plain yoghurt was 4.47. It varied from 4.24 and in FPBY incorporated with 2% flax seed the highest pH was observed in SPBY 4.60 to 4.33. A gradual decrease in pH was observed among all treatments. Flax seed incorporated yoghurt had the pH value of 4.25 (Sivakumar, 2014). Oakenfull (2001) and Lim *et al.,* (2010) reported that the similar value of pH. The value of acidity was increased during storage in the present study. According to Sivakumar (2014) fruit yoghurt incorporated with flax seed had acidity value of 0.86 to 0.88 per cent. This is similar to the present study.

In the present study, the highest water holding capacity was found to be in

FS incorporated PPBY it was about 56.22 to 53.54per cent. During storage an increasing tendency of water holding capacity was observed in all yoghurt samples. Kpodo *et al.* (2014) observed increase in WHC in soy milk added yoghurt than control yoghurt. Amal *et al.* (2016) also observed an increase in WHC throughout the storage period.

In the present study, the highest value of viscosity was found to be in flax seed incorporated GPBY, 30900 to 33900 cP. Sivakumar (2014) also reported highest value of viscosity in flax seed powder incorporated yoghurt it is about 40000 cP.

In the present study, the control yoghurt had the syneresis value of 1.20 to 3.00 per cent during storage. In flax seed incorporated FPBY the highest value of syneresis was observed in JFPBY, BPBY and PPBY that is 1.10 per cent and the syneresis value was observed during storage. Sivakumar (2014) noticed 0.62 per cent of syneresis in 10g of flax seed incorporated yoghurt.

In the present study the value of curd tension increased during storage and the highest curd tension was observed in FS incorporated GPBY that is about 39.00 to 46.66g. An increase of curd tension with advancement in storage was observed by Salwa (2004) and Malarkannan*et al.* (2012).

5.4.2.b. Nutritional qualities

In the present study, the highest TSS content was observed in JFPBY and BPBY it was about 16.00°Bx. The highest total and reducing sugar content was observed in FS incorporated JFPBY that is 16.34 to 15.35 and 7.60 to 6.65 per cent during storage. Geeta, (2000) observed TSS, total sugar and reducing sugar content of mustard incorporated yoghurt.

In the present study the highest energy value was found to be in FS incorporated with SPBY that is 67.53 to 62.41Kcal during storage. Sivakumar (2014) observed the energy value of flax seed added yoghurt was 140.24 Kcal.

In the present study the highest content of carbohydrate was found to be in flax seed incorporated SPBY it was about 8.90 to 7.69 per cent. In all selected samples a gradual reduction was observed throughout the storage period.

(Sivakumar, 2014) observed carbohydrate content of flax seed incorporated yoghurt is 23 per cent. In the present study the highest lactose content was found to be in FS incorporated SPBY that is 2.69 to 2.47, respectively. Zanjad (2001) noticed that full fat yoghurt had 5.20% of lactose while low fat yoghurt contain 5.03 per cent.

In the present study, the protein content of control yoghurt had highest value than FPBY incorporated with 2% flax seed and the highest protein content was found to be in JFPY incorporated with flax seed it was about 4.86 to 4.24 during storage. The similar protein content was observed in fruit pulp incorporated with 2 and 1 per cent flax seed (3.42 to 3.53 per cent) (Sivakumar, 2014). Daun *et al.* (2003) and Kozlowska (1989) reported that flax seed contained high protein content.

In the present study, the fat content of control yoghurt varied from 3.80 to 3.52 per cent. In fruit pulp based yoghurts the highest fat content was observed in PPBY 3.15 to 2.90 per cent. Sivakumar (2014) observed fat content of 4.03 per cent in flax seed incorporated yoghurt. Flax seed have contributed the highest fat content in yoghurt. The fat content of flax seed powder incorporated nutri mix varied from 2.99 g 100^{-1} to 7.13 g 100^{-1}(Reshma, 2017).Gambus *et al.* (2004) who found that addition of 10-13 per cent flaxseed in bread will increase about 800-1000 time enhancement of linolenic acid content as compared to control bread. Mervat *et al.* (2014) reported that, 10 per cent incorporation of full fat flax seed powder in composite flour will increase the fatty acid composition than defatted flax seed powder.

In the present study, vitamin A from control yoghurt is not detected but fruit pulp incorporated yoghurts shows presence of vitamin A content. In FS incorporated FPBY, the highest vitamin A content was observed in PPBY incorporated with flax seed (5.82 to 5.79 IU). Balakannan *et al.* (2012) reported vitamin A content in mango pulp based yoghurt.

In the present study the highest vitamin C content was found to be in FS incorporated PPBY and the lowest content was noticed in BPBY (0.87 to 0.82 and 0.48 to 0.45 per cent during storage). Vitamin C content was not detected in flax seed (NIN, 2017).

Compared to FPBY, flax seed incorporated yoghurts have highest amount of mineral contents than control yoghurt. The highest calcium and iron content was observed in JFPBY incorporated with flax seed it was 65.89 to 65.50 mg/100g and 0.60 to 0.65 during storage and the potassium content was highest in FS incorporated BPBY which was about 83.25 to 83.05 mg/100g during storage. Sivakumar (2014) noticed a calcium content of 104.75 mg/100g and iron content 0.55 mg/100g in flax seed incorporated yoghurt.

5.4.3.b. Microbial enumeration

The contaminating microorganisms of the selected treatments was assessed 15th day of storage. At the end of 9 days of storage, the fungi and mould counts marginally increased in control yoghurt 60 cfu/g and flax seed incorporated yoghurt samples 55 cfu/g (Sivakumar, 2014). Yingying *et al*. (2006) reported that flaxseed flour (15% w/w) delayed mould growth in noodles.

4.4.4.b. Organoleptic evaluation of selected FS incorporated FPBY on storage

The mean score for flax seed incorporated FPBY was decreased during 15 days of storage in all the treatments. According to Ramneet (2011), Flax seed incorporated muffins stored under ambient conditions became unacceptable after 15 days of storage due to visible fungal growth. Under refrigeration conditions, muffins were acceptable for 1 month of storage period, but the scores decreased significantly due to loss of texture with time. Reshma (2017) reported four months of shelf life in millet based nutri mix incorporated with flax seed seed.

4.5. Cost of selected FPBY and functional ingredient incorporated FPBY

The cost of production of FPBY was varied from 17 to 20.00 and FPBY incorporated with garden cress seed and flax seed was varied from 17.16 to 21.00 and 18 to 21.00 respectively. The cost of production of plain yoghurt was 13.50.

The present study observed a lower price for FPBY and plain yoghurts than fruit and plain yoghurts available in market. Use of alternative raw materials in production of yoghurts can reduce the cost of production (Farinde *et al.,* 2008).

Summary

6. SUMMARY

The present study entitled "Process optimisation and quality evaluation of fruit pulp based yoghurts" was undertaken to standardise fruit pulp based yoghurts and to enrich the selected products with functional ingredients like garden cress seed and flax seed. The study also aimed to evaluate the organoleptic, physicochemical, nutritional and shelf life qualities of the selected products.

Fruit pulp based yoghurts (FPBY) were prepared by incorporating different proportions of various fruit pulps to yoghurt. Fruit pulps selected for incorporated were sapota (SP), guava (GP), Banana *(Palayankodan)* (PP), jackfruit *(Koozha)* and papaya. They were incorporated at 10, 15, 20, 25 and 30 per cent levels. With a view to find out the most appropriate combination for the preparation of FPBY, 24 treatments were evaluated for various organoleptic qualities like appearance, colour, flavour, odour, texture, taste and overall acceptability and compared with control yoghurt. In different treatments tried for the preparation of FPBY, the mean score for different quality attributes showed a decreasing trend with increasing the quantity of fruit pulps.

Compared to control, the mean score for different quality attributes of FPBY had a lower scores for different quality attributes. From five treatments (T_1 to T_5), of each fruit pulp one acceptable products from each fruit yoghurts were selected based on the mean score obtained for the organoleptic evaluation. Treatment T_1 (90% milk + 10% FP) had a better mean score for different quality attributes compared to other combinations. Hence, the treatment T_1 of all fruit pulps along with the control were selected for further studies. In fruit pulp based yoghurts, SPBY got highest total score of 51.23.

In the developed products, the moisture content of yoghurts varied from 78.05 to 81.18 per cent. The highest moisture content was present in PPBY and during storage it declined up to 70.00 to 73.04 per cent. The pH value of FPBY was varied from 4.49 to 4.68 and during storage the pH value declined up to 4.15 to 4.46. The acidity of selected yoghurts ranged from 0.57 to 0.69 per cent initially and during storage it increased up to 0.64 to 0.89 per cent. The highest water holding capacity was observed in PPBY it was about 54.76 to 52.88 per cent during storage. The lowest value of water holding capacity was observed in GPBY, it was about 52.80 to 50.34 per cent. Syneresis is one of the key quality parameter of yoghurt. An increasing trend in syneresis was observed in all the yoghurt samples. The highest syneresis range was observed in PPBY it was about 0.9 to 2.22 ml during storage. The viscosity was ranged between 14620 cP to 30800 cP initially and at the end of storage it was increased up to 15640 to 34600 cP. Curd tension of selected samples ranged from 36.00 to 38.66g and 40.41 to 45.66g during storage.

In the developed products, TSS content varied from 15 to 17°Bx initially and it declined up to 13.42 to 16.16°Bx. The total sugar content and reducing sugar content of FPBY was varied from 12.42 to 17.29 per cent initially and 5.55 to 8.06 per cent during storage. The highest total and reducing sugar content was observed in JFPBY.

The highest energy content was found to be in SPBY it was about 73.54 to 50.35 Kcal in freshly prepared and 15th day of storage respectively. The lowest content of energy was observed in JFPBY, which was 52.88 to 32.33 Kcal. The carbohydrate content in yoghurts ranged from 6.0 per cent to 10.6 per cent at initial day and a gradual decrease in carbohydrate content was noticed throughout the storage period and it decreased to 5.00 to 9.4 per cent. The highest lactose content was found to be in SPBY that is 2.72 to 2.62 per cent and the lowest content of lactose was found to be in PPBY it was 1.52 to 1.41 per cent initially and during storage. Protein content of freshly prepared FPBY varied from 3.23 to 4.42 per cent and during 15th day of storage it was about 2.34 to 2.71 per cent. The highest fat content was observed in BPBY and PPBY and it was 2.00 per cent.

In control yoghurt, vitamin A was not detected and in FPBY, vitamin A was detected in the form of ß carotene. The highest amount was observed in PPBY it was 5.83 to 5.80 IU and the lowest content was found to be in SPBY, it was 1.29 to 1.26 IU. The vitamin C content was also more in FPBY. The highest vitamin C content was found to be in PPBY 1.00 to 0.97 mg/100g and the lowest vitamin C content was observed in BPBY with 0.54 to 0.49 mg/100g.

The calcium content of FPBY ranged from 62.35 to 47.54 mg/100g and it declined to 62.26 to 47.25 mg/100g during storage. The highest calcium content was found to be in JFPBY and the highest amount of iron content was observed in SPBY. It was about 1.24 mg/100g initially and during storage it declined up to 1.21 mg/100g. In selected products the potassium content varied from 62.14 to 79.06 per cent and during storage it reduced to 61.62 to 78.70 mg/100g. The potassium content was highest in FPBY than control yoghurt. It may due to the presence of high potassium content in fruit pulps. The total ash content was highest in GPBY, it was about 1.71 to 0.80 during storage and it increased during storage in all treatments.

In FPBY and control yoghurt the contaminating microorganisms like yeast and fungi was not detected up to 10th day of storage and at 15th day of storage the presence of contaminating microorganisms were observed among all the selected yoghurt samples.

The selected five FPBY with control were enriched with functional ingredients garden cress seed and flax seed at 2 per cent and 4 per cent respectively. Since GCS incorporated yoghurts were not acceptable, they were incorporated at 0.5 and 1 per cent levels.

From 24 treatments, two highly acceptable products from GCS and FS incorporated FPBY along with control were selected for further studies based on the mean score of organoleptic evaluation. In functional ingredients incorporated FPBY, GCS (89.5% milk + 10% FP + 0.5% GCS) and (88% milk + 10% FP + 2% FS) had highest organoleptic score compared to other treatments. Hence, these treatments with two control one from GCS incorporated FPBY and another one from FS incorporated FPBY were selected for further studies.

Yoghurts prepared with functional ingredient GCS at 0.5% level had a moisture content of 80.01 to 81.78 and 74.21 to 70.00 per cent in freshly prepared and during storage respectively. The pH value of GCS incorporated FPBY varied from 4.50 to 4.65 during storage. The pH value declined up to 4.13 to 4.45 and the acidity of selected yoghurts ranged from 0.60 to 0.72 initially and during storage it increased up to 0.74 to 0.91 per cent. The highest water holding capacity was observed in PPBY incorporated with GCS it was about 54.80 to 52.98 per cent during storage. The lowest value of water holding capacity was observed in GCS incorporated GPBY, it was about 52.86 to 50.37 per cent. The highest syneresis was observed in GCS incorporated BPBY followed by GCS incorporated GPBY and GCS incorporated PPBY. The viscosity was ranged between 14630 cP to 30800 cP initially and at the end of storage it was increased up to 15640 to 34600 cP. Curd tension of selected samples were ranged from 36.50 to 38.68 g (initial) and 41.90 to 45.66 g during storage.

In the developed products, TSS content was varied from 15 to 17°Bx initially and it declined up to 13.82 to 16.06°Bx. Total sugar content and reducing sugar content of GCS incorporated FPBY varied from 16.05 to 14.70 per cent initially and 7.90 to 6.78 per cent during storage. The highest total and reducing sugar content was observed in GCS incorporated JFPBY.

The highest energy content was found to be in GCS incorporated SPBY, it was about 67.53 to 62.41 Kcal and the lowest content of energy was observed in GCS incorporated JFPBY, which was about 56.28 to 51.76 Kcal. The carbohydrate content was ranged from 5.15 per cent to 8.90 per cent in freshly prepared yoghurt and a gradual decrease in carbohydrate content was noticed throughout the storage period and it decreased to 4.90 to 7.96 per cent. The highest lactose content was found to be in GCS incorporated SPBY that is 2.40 to 2.17 and the lowest content of lactose was found to be in GCS incorporated PPBY, which was 1.31 to 1.11 during storage. Protein content of selected GCS incorporated FPBY varied from 3.81 to 4.77 per cent and during 15th day of storage it was about 3.58 to 4.44 per cent. The highest fat content was observed in GCS incorporated PPBY which was 2.17 to 1.89 per cent.

In control yoghurt vitamin A was not detected and in GCS incorporated FPBY the highest amount was observed in GCS incorporated PPBY, it was 5.80 to 5.83 per cent. In GCS incorporated FPBY, the highest vitamin C content was found to be in GCS incorporated PPBY 0.90 to 0.87 per cent and the lowest content was found to be in GCS incorporated BPBY (0.53 to 0.50 mg/100g).

The highest calcium content was found to be in GCS incorporated JFPBY it was about 64.00 to 63.73 mg/100g. The highest amount of iron content was observed inGCS incorporated PPBY which was about 1.74 mg/100g and during storage it declined up to 1.69 mg/100g. The highest potassium content was observed in GCS incorporated BPBY, which was 81.55 to 81.47 mg/100g. The total ash content was highest in GCS incorporated BPBY, it was about 1.61 to 1.20 per cent during storage.

In GCS incorporated FPBY and GCS incorporated control the contaminating microorganisms like *E coli* and coliform bacteria was not detected during storage whereas yeast and mold was not detected up to 10th day of storage and on the 15th day of storage the presence of contaminating microorganisms were observed among all the selected yoghurt samples.

In functional ingredient incorporated developed products the moisture content of FS incorporated yoghurts varied from 77.00 to 79.11 (initial) and 70.00 to 71.10 per cent during storage. The pH value of FS incorporated FPBY varied from 4.45 to 4.60 during storage. The pH value declined up to 4.11 to 4.43 and the acidity of selected yoghurts ranged from 0.63 to 0.76 per cent, initially and during storage it increased up to 0.79 to 0.92 per cent. The highest water holding capacity was observed in $T_{5,}$ it was about 54.09 to 53.64 per cent during storage. The lowest value of water holding capacity was observed in T_3 (54.09 to 51.39 per cent). The highest syneresis was observed in FS incorporated BPBY, GPBY and PPBY which was about 1.10 per cent. The highest viscosity was observed in T_2 that is 30900 to 33900 cP. Curd tension of selected samples were ranged from 37.00 to 40.00 g (initial) and 41.45 to 46.00 g during storage.

In the developed products, TSS content varied from 14 to 16°Bx initially and it declined up to 13.00 to 15.30°Bx. The total sugar content and reducing sugar content of FS incorporated FPBY was varied from 11.50 to 16.34 per cent and 10.40 to 15.35 per cent initially and 5.00 to 7.60 and 4.09 to 6.65 per cent during storage. The highest total and reducing sugar content was observed in FS incorporated JFPBY.

The highest energy content was found to be in FS incorporated SPBY it was about 85.74 to 77.32 Kcal. The carbohydrate content was ranged from 5.96 per cent to 10.1 per in freshly prepared yoghurts and a gradual decrease in carbohydrate content was noticed throughout the storage period and it decreased to 4.09 to 8.90 per cent. The highest lactose content was found to be in FS incorporated SPBY that is 2.69 to 2.47 per cent. The highest protein content was found to be in FS incorporated JFPBY (4.86 to 4.54 per cent) and the lowest protein content was observed in FS incorporated FS incorporated PPBY (4.32 to 4.00 per cent). The highest fat content was observed in FS incorporated PPBY it was 3.15 to 2.90 per cent during storage.

In control yoghurt vitamin A was not detected and in FS incorporated FPBY the highest amount was observed in PPBY, with a content of 5.82 to 5.79 IU and the vitamin C content was highest in FPBY the highest vitamin C content was found to be in FS incorporated PPBY 0.87 to 0.82 mg/100g and the lowest vitamin C content was observed in FS incorporated BPBY 0.48 to 0.45 per cent.

The highest calcium content was found to be in FS incorporated JFPBY it was about 65.89 to 65.50 mg/100g and the highest amount of iron content was observed in FS incorporated PPBY it was about 1.45 initially and during storage it declined up to 1.40 mg/100g. The highest potassium content was observed in FS incorporated BPBY it was 83.25 to 83.05 mg/100g. The total ash content was highest in FS incorporated BPBY it was about 1.61 to 1.20 during storage.

In FS incorporated FPBY and control yoghurt the contaminating microorganisms like E coli, coliform bacteria was not detected in all treatments. Yeast and fungi was not detected up to 10th day of storage and in 15th day of storage the presence of contaminating microorganisms were observed among all the selected yoghurt samples.

The cost of production for control yoghurt was Rs.13.50/100 ml and for fruit pulp based yoghurts it ranged from Rs.17.00 to 20.00/100 ml) The cost computed for production of functional ingredient incorporated yoghurts were Rs.17.16 to 21.00/100 ml in GCS incorporated FPBY and Rs.18.00 to 21.00/100 ml in FS incorporated FPBY. The cost computed for production of yoghurts was found to be lower than the price of similar products available in market.

From this study it is clear that acceptable yoghurts are possible by incorporating fruit pulps and functional ingredients in different combinations. Diversification in milk based products will be a boon to the dairy industry. Such value added products can fetch good markets and in the modern food industry.

Future line of work

1. Standardisation of fruit pulp based yoghurts using other fruits
2. Explore the potential of therapeutic benefits of yoghurts

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Appendices

APPENDIX – I

Score card for the organoleptic evaluation of fruit pulp based yoghurts

Name:

Date:

Signature

S.No	Parameter	Treatments					
		T_0	T_1	T_2	T_3	T_4	T_5
1	Appearance						
2	Colour						
3	Flavour						
4	Texture						
5	Taste						
6	Overall acceptability						

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

APPENDIX – II

Score card for the organoleptic evaluation of functional ingredients incorporated yoghurts

Name:
Date:
Signature:

Parameter	T_0				T_1			
	GCS .5	GCS 1	FS 2	FS 4	GCS .5	GCS 1	FS 2	FS 4
Appearance								
Colour								
Flavor								
Texture								
Taste								
Overall acceptability								

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

PROCESS OPTIMISATION AND QUALITY EVALUATION OF FRUIT PULP BASED YOGHURTS

By
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ABSTRACT OF THE THESIS
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ABSTRACT

Yoghurt is a coagulated milk product that results from the fermentation of lactose in milk by *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Yoghurt is known for its nutritional, therapeutic and functional properties. The present study was undertaken to standardise fruit pulp based yoghurts and to enrich the standardised products with functional ingredients like garden cress seed and flax seed. The study also envisaged to evaluate the organoleptic, physico chemical, nutritional and keeping qualities of the standardised products.

Fruit pulp based yoghurts (FPBY) were prepared using locally available fruits such as sapota, guava, jackfruit (*Koozha* type), banana (*Palayamkodan*) and papaya. Twenty six treatments were evaluated for various organoleptic qualities and was compared with 100 per cent milk yoghurt (control). In different treatments tried for the preparation of FPBY, the mean scores for different quality attributes showed a decreasing trend with increase in the quantity of fruit pulps. Yoghurts prepared by incorporating 10 per cent fruit pulp was selected as the most acceptable treatment from all FPBY.

Physicochemical properties like moisture and pH decreased during storage and a gradual increase in acidity, syneresis, curd tension and viscosity was observed in FPBY. In the selected products TSS, reducing sugar, total sugar, energy, carbohydrate, lactose, fat, vitamin C and iron content decreased during storage. Protein content of freshly prepared control yoghurt was 4.59 per cent and on 15th day of storage it decreased to 3.35 per cent. The protein content varied from 3.76 to 2.71 per cent in SPBY (Sapota pulp based yoghurt), 3.23 to 2.61 per cent in GPBY (Guava pulp based yoghurt), 3.91 to 3.08 per cent in BPBY (Banana pulp based yoghurt), 4.42 to 3.22 per cent in JPBY (Jackfruit pulp based yoghurt) and 3.23 to 3.24 per cent in PPBY (Papaya pulp based yoghurt) in initial and at the end of storage respectively.

Vitamin A and vitamin C content was found to be increased with incorporation of fruit pulp. The highest calcium content was found to be in control (78mg/100g) and a slight decrease in calcium content was observed among FPBY. A slight increase in iron and potassium content was observed in

FPBY compared to control. The highest potassium content was observed in BPBY with an initial content of 83.25 to 83.05 mg/100g at the end of storage.

The selected FPBY was incorporated with garden cress seeds (GCS) and flax seeds (FS) at 0.5 per cent and 2 per cent level, respectively. The highest total organoleptic scores were attained for control (51.67) which was incorporated with garden cress seeds. This was followed by GPBY (48.45), SPBY (48.33), JFPBY (47.81), BPBY (46.73) and PPBY (43.72). In flax seeds incorporated yoghurts the highest organoleptic score was attained for control (40.78) which was followed by GPBY (40.15), SPBY (40.14), BPBY (39.94), PPBY (39.82) and JFPBY (39.78). Incorporation of 0.5 per cent garden cress seeds and 2 per cent flax seeds increased the protein content from 4.59 per cent to 4.78 and 4.93 per cent respectively. Incorporation of functional ingredients increased the fat, iron, calcium and potassium content in all yoghurts.

During storage, *E coli* and coliform bacteria were not detected in all yoghurt samples. Yeast and fungi was not detected up to 10th day of storage and at 15th day of storage the presence of yeast and fungi were observed among all the selected yoghurt samples, indicating a shelf life of ten days.

The cost of production of plain yoghurt was Rs. 13.50/100 ml and for FPBY it varied from Rs. 17.00 to 20.00/100 ml. Incorporation of functional ingredients increased the cost of production from Rs. 17.16 to 21.00/100 ml.

The standardised products are suitable for commercialisation and diversification. Milk based functional food products will be a boon to the dairy food industry.