DEVELOPMENT OF TECHNOLOGY FOR PREPARATION OF SOFT CHEESE (PANEER) FROM JACKFRUIT SEED MILK

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DEVELOPMENT OF TECHNOLOGY FOR PREPARATION OF SOFT CHEESE (PANEER) FROM JACKFRUIT SEED MILK

by

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THESIS

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2023

DECLARATION

I hereby declare that this thesis entitled "**Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk**" is a Bonafide record of research work done by me during the course of research in the department in chair and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk**" is a Bonafide record of research work done by **Ms. FATHIMA SANAM (2020-16-007)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship, associateship to her

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TABLES OF CONTENT

LIST OF TABLES

11	Sensory parameter of milk with Lemon juice	
12	Sensory parameter of milk with 10% Citric acid	
13	Yield ratio of different combination of milk	
14	Sensory evaluation of combination of milk for formulation of panner	
15	Sensory evaluation of paneer	
16	Total solid content	
17	Nutrient composition of jackfruit seed milk soy paneer	
18	Total bacterial count of paneer	
19	Total fungal count of panner	
20	Total coliform count of paneer	
21	Cost of production	

LISTS OF FIGURES

LIST OF GRAPHS

12	Sensory evaluation of paneer	
13	Carbohydrate content of paneer	
14	Fat content of paneer	
15	Protein content of paneer	
16	Crude fiber content of paneer	
17	Moisture content of paneer	
18	Calcium content of paneer	

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVATION AND SYMBOLS USED

cv	Cultivars
LDPEP	Low density polyethylene pouches
g	gram
mg	milligram
^{0}C	Degree Celsius
%	percentage
Fig	Figure
et al	And co-workers
CFU	Colony forming unit
TCC	Total coliform count
TLTC	Too low to count
viz	In other words,

INTRODUCTION

1.INTRODUCTION

The food sector is increasingly turning toward sustainability issues. A sustainable food system should provide sufficient, nutritious food for all within limited natural resources. Plant-based food and proteins are a recent, growing trend setting out to contribute to this challenge. Dairy analogues are one of the sustainable food alternatives that is cost effective and offer good nutritional value. Nowadays, people are demanding plant-based milk instead of animal milk due to many illness reasons like lactose intolerance promoting sustainable food system, high level of cholesterol in animal milk and hypersensitivity towards milk protein.

Plant based analogues of milk are produced from legumes, cereals, seeds etc. There are many orthodox varieties of milk analogues are present in market like Sikhye (cooked rice), Boza (fermented drink from wheat, rye, maize etc.), soy milk (Cruz *et al.,* 2007).

Among the physiological factors that affect the amount of lactose digested and its tolerance are gastrointestinal transit, intestinal lactase activity, visceral sensitivity, and the Prescence of functional bowel disorders, and possibly the composition of the colonic microflora. In addition, factors related to the sensory and central nervous systems modify symptom perception. Considering these complex factors and their interactions, it is not surprising that marked inter- and intraindividual differences exist in the symptoms of lactose intolerance (Papa *et al.,* 2021).

Malnutrition is one of the major problems in India due to inadequate protein intake. Jackfruit seeds could be used as an economic alternative protein source to tackle the malnutrition (Roy *et al.,* 2012). The demand for jackfruit seeds has been increased due to increased consumer awareness regarding the diet-disease relationship. It is believed to be a potent functional food ingredient since it imparts additional physiological benefits in addition to basic nutrition.

The jackfruit (*Artocarpus heterophyllus* Lam.) is one of the important tropical fruits grown in the world and is believed to be native to India. Jackfruit belongs to the family Moraceae and to the genus Artocarpus which includes evergreen or deciduous trees. In India, the major area under jackfruit is in Kerala state and it was regarded as heavenly fruit in the ancient periods. Jack fruit is also known as poor man's food which is easily available throughout the season (Ekanayake *et al.,* 2017).

According to Suprapti *et al.*, 2004, jackfruit seed contains 4.2 g of protein, 0.1 g of fat, 36.7 g of carbohydrate, 33 mg of calcium, as well as other vitamins and minerals. Even though jackfruit seed contains a high value of starch, it is categorized as a low glycemic index (GI) food due to the role of dietary fiber and un-gelatinized starch granules. Therefore, it is good to be consumed as it does not strongly increase the glucose blood level (Hettiaratchi *et al.,* 2011). It is an energy-rich fruit suitable for the treatment of physical or mental fatigue, stress, and muscle weakness and also for athletes. It has been found to exhibit antimicrobial, anti-diabetic, anti-inflammatory, antioxidant, and anti-helminthic properties. Due to these properties' jackfruit seed is very convenient for making plant-based alternatives (Shanmugapriya *et al.*, 2011).

Vegan soft cheese is a type of plant-based paneer that is made from non-animal-based products, usually non-dairy milk, such as soy milk, coconut milk, almond milk, cashew milk, etc. Nowadays, plant-based, or non-dairy milks are rising and fast growing as a trend in food development (Kirby *et al.*, 2010).

Cow's milk allergy and lactose intolerance are some of the reasons for the consumers to choose vegan diet as an alternative (Sethi *et al.*, 2016). The demand for plant-based cheeses, also known as plant cheese analogues, has increased drastically over the years because of the rising dietary shifts to plant-based foods in general populations in views of environmental, health, and animal-welfare considerations. Current commercial plant cheeses often fall short in terms of their nutritional content when compared to conventional dairy cheeses.

In addition, jackfruit seed-based paneer can be consumed by those people suffering from lactose intolerance and it also contains dietary fiber for health bowel function by preventing constipation and lowering the risk of colorectal cancer. Hence this study was conducted with the objective of processing the technology to prepare soft cheese (Paneer) from jackfruit seed milk, to meet the dietary needs of people who cannot consume dairy products. The paneer analogue made from jackfruit seed milk will be an innovative way of consuming dairy free products that is acceptable for people with lactose intolerance, thus makingit an option of healthy consumption. The jackfruit seed being cheap and available throughout the season makes it even more acceptable according to the expense of processing. And by this research it could be validated that even the usually milk-based products can also be veganized for healthy consumption of people.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature reviewed which is pertinent to the study entitled **"Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk"** is presented under the following subheadings.

2.1. Dairy analogue

2.2. Formation of dairy analogue

2.3. Benefits of dairy Analogue

2.4. Types of dairy analogue

2.5. Restructured dairy analogues

2.6. Dairy analogue market

2.7. Jackfruit seed and its benefits

2.1 DAIRY ANALOGUE

Migration towards a much more efficient plant-based diet is needed to sustain the world's rising population simultaneously minimizing ecological footprint. Animal agriculture accounts for almost 26% of total emissions and is responsible for many world greenhouse gas emissions (Aini *et al*., 2020). Plant based milk is a best alternative for people who suffer from lactose intolerance and milk allergy. Lactose intolerance is linked to a lack of lactase or β -galactosidase enzyme in the intestine.

Milk allergy occurs when the immune system wrongly assumes that specific proteins in milk to be harmful (Ali *etal.,* 2020) Furthermore, bovine milk might contain residues of antibiotics and pesticides used during the animal's life (Bruno *et al.*, 2019) Soybean, coconut, almond, oat, and rice are used as a dairy substitute. These substances are easy to consume with a pack of nutrients and do not induce abdominal bloating. It also endows multifunctional and health-promoting nutritious foods. For instance, soy milk is high in phytic acid and isoflavones which aid in the prevention of cancer, cardiovascular disease and improve bone health (Atallah *et al*., 2017). Almond milk has free radical scavenging properties due to arabinose and αtocopherol (Batista *et al.,* 2019). Rice milk contains plant sterols which have anti-inflammatory and anti-diabetic characteristics. The current state there are several forms of dairy analogues such as imitation milk, cheese analogues, non-dairy fat, frozen dessert, and probiotic products.

2.2. FORMATION OF DAIRY ANALOGUE

2.2.1. Process

Plant based milk substitutes are colloidal suspensions or emulsions consisting of dissolved and disintegrated plant constituents. They are prepared traditionally by grinding the raw material into slurry and straining it to remove coarse particles. The general outline of a modern industrial scale process is essentially the same for different plant materials as it is soaked and wet milled to extract the milk constituents, or alternatively the raw material is dry milled and soluble material is extracted in aqueous media. The insoluble material is separated by filtering or decanting followed by addition of desired ingredients for acceptable product formulation. Most used ingredients include sweetener, flavourings, stabilizers, colouring agents etc. Since, plant based dairy analogue forms suspension type solution, hence, to improve suspension and microbial stability; homogenization and pasteurization/UHT treatment are necessary. These extracts can also be spray dried to produce more stable powder, which can be further reconstituted to get a desired product. (Diarra *et al*., (2005)

2.2.2. Pre-treatments

Raw material pre-treatments include dehulling, soaking and blanching (Debruyne *et al*., 2006). Blanching is required to inactivate trypsin inhibitors and lipoxygenase that would produce off-flavours in soy milk and peanut milk. Roasting of the raw material enhances the aroma and flavour of the final product, but heating decreases the protein solubility and extraction yield (Giri *et al.*, 2012).

2.2.3. Extraction

The extraction step has a profound effect on the composition of the resulting product. To increase the yield of the process, the efficiency of this step may be improved by increasing the pH with bicarbonate or NaOH, elevated temperatures or the use of enzymes. Alkaline pH during extraction increases the protein extractability. A higher extraction temperature increases the extractability of fat, but the denaturation of proteins decreases their solubility and yield. However, the extraction of protein can be enhanced by hydrolysing the protein using plant, animal, or microbial based enzymes (Chauahn *et al.*, 2003).

Observed increase in protein content of peanut and soy milk after hydrolysing with papain and crude enzyme extract of the milk. In addition to proteolytic enzymes, a mixture of amyloglucosidase and a cellulase cocktail has been shown to increase the carbohydrate recovery of peanut milk. Eriksen used a variety of enzymes in soymilk extraction and found that the highest protein and total solids yield was attained using a neutral or alkaline proteinases at their optimum pH (Eriksen *etal.*, 1983). In addition to increasing the extraction yield, proteolytic enzymes improve the suspension stability. Treatment with cellulase after homogenization has been reported to decrease the particle size and yield a more stable suspension.

2.2.4. Separation

After extraction, coarse particles are removed from the slurry by filtration, decanting or centrifugation. When using raw materials high in fat, such as peanuts, the excess fat can be removed using a separator as in dairy processing. The separated cream like product can be heat treated to obtain oil or can be used as such in ice-cream formulations and bakery industry. Thus, the process can be economized. Removal of excess oil/fat from the extract also facilitates to formulate a more stable beverage (Rawson *etal.*, 2021).

2.2.5. Product formulation

Other ingredients can be added to the product base after the removal of insoluble coarse material. These include vitamins, minerals sweeteners, flavourings, salt, oils, and stabilizers. Suspension stability of plant-based milk substitutes is a major concern, which can be overcome by using hydrocolloids/ emulsifiers. Mono- and diglycerides, glyceryl monostearate, guar gum and carrageenan can be effectively used for stabilizing peanut and soymilk. Though the plant-based milk analogues resemble in appearance and consistency to the animal milk but, they significantly differ in nutritional quality as well as bioavailability of nutrients. Hence fortification of these types of products is necessary to ensure the nutritional quality. The nutrients used must be bioavailable and sufficiently stable, and not cause excessive changes in product quality. The challenge in mineral enrichment is the reactivity of metal ions with other food components, and the use of sequestrates such as citric acid may thus be necessary (Zhang *et al.*, 2007). Some mineral sources used in plant-based milk substitutes include ferric ammonium citrate and ferric pyrophosphate as iron sources and tricalcium phosphate and calcium carbonate as calcium sources.

2.2.6. Stability

Plant based milk substitutes contain insoluble particles, such as protein, starch, fibre, and other cellular materials. Due to density difference, these particles get settled down, making the product unstable. The suspension stability can be increased by decreasing the particle size or by using hydrocolloids and emulsifiers (Durand *et al.,* 2003). Many plant-based milk substitutes coagulate during thermal treatment due to unfolding of proteins. Unfolding results in exposure of non-polar amino acids to water, which enhances protein-protein interactions and results in aggregation and sedimentation or gelling (Phillips *et al.,* 1994). The heat stability of proteins depends on the pH, ionic strength, and the presence of other compounds such as minerals and carbohydrates. Homogenization in the conventional dairy processing pressure range (20MPa) improves the stability of plant-based milk substitutes by disrupting aggregates and lipid droplets and thus decreasing the particle size distribution. Ultra-high-pressure homogenization (UHPH) of soy milk at 200-300MPa reduces (Arvind *etal*., 2017). A higher homogenization temperature has been reported to increase the stability of peanut milk (Hinds *et al.,* 1997). In soy milk, heat denaturation of proteins is required for suspension stability.

2.2.7. Shelf life

Commercial plant-based milk substitutes are pasteurized or UHT treated to extend the shelf life. Pasteurization is generally carried out at below 100 °C, which destroys pathogenic microorganisms. (Rustom *etal.,* 1996). Treated peanut beverage for 4 and 20 s at 137 °C and observed that the longer treatment time decreases suspension stability and enhances taste and acceptability. Pulsed electric fields have also been suggested to extend the microbial shelf life at commercial scale (Cortés *et al.,* 2005). Other non-thermal processes such as ultraviolet sterilization, high pressure throttling, high pressure processing and ultra-high-pressure homogenization (UHPH) have been explored as methods of soymilk preservation by various researchers.

2.2.8. Fermented products

Fermentation with lactic acid bacteria improves the sensory, nutritional properties and shelf life. Plant based milk substitutes can be fermented to produce dairy free yoghurt type products while rendering the raw material into a more palatable form (Bansal *et al.,* 2016). The levels of hexanal responsible for the undesired nutty flavour in peanut milk can be efficiently reduced with fermentation (Yadav *et al*., 2010). Fermentation of soy milk reduced the amount of flatulence inducing oligosaccharides (Yadav *et al*., 2008). Additives such as carboxymethyl cellulose, coagulants (calcium citrate), milk powder and gelatine have been used to enhance the texture and reduce syneresis in the final product (Cheng *et al*., 2006).

2.2.9. Nutritional quality

Plant based milk substitutes are often perceived as healthy. The nutritional properties vary greatly, as they depend strongly on the raw material, processing, fortification, and the presence of other ingredients such as sweeteners and oil. Milks produced using legumes other than soy, such as peanut and cowpea can have protein content as high as 4% (Tano *et al*., 2005). Plant milk substitutes are low in saturated fats and most products have calorific value comparable to skim milk. Plant proteins are generally of a lower nutritional quality compared to animal derived proteins due to limiting amino acids (lysine in cereals, methionine in legumes) and poor digestibility. The nutritional value of proteins depends mainly on the amino acid composition, physiological utilization, and absorption. Population groups with low animal milk intakes often have deficiency of dietary calcium, iodine, vitamin B12 and riboflavin. To combat these shortcomings, plant-based milk substitutes can be fortified with calcium and vitamins, mainly B12, B2, D and E. However, consumer awareness is important as many of the existing plant-based milk substitutes are not fortified (Tano *et al*., 2005).

2.2.10. Acceptability

The demand for plant milk substitutes is increasing; however, the unwillingness of the mainstream consumer to try unfamiliar foods that are perceived as unappealing may be a limiting factor. Many modern-day soy and peanut milks and related products may have an improved sensory quality, but the product group carries a stigma because of early fewer appealing products on the market. Legume milks tend to possess "beany" and "painty" off-flavours originating from lipoxygenase activity (Chauahn *et al.*, 2003). The presence and intensity of the "beany" flavour depends on processing and storage conditions of soy milks and varieties (Yadav *et al.,* 2003). Another problem is chalky mouthfeel due to large insoluble particles. The acceptance of peanut milk has been shown to depend on the colour, mouthfeel, nutty flavour, and similarity to cow's milk. Taste is the most important purchase criteria of foods, and the information about a good and/or familiar taste increase the willingness to try an unfamiliar food. Possible health benefits are also an important criteria and health information may increase both the willingness to try and the perceived liking of a food.

2.2.11. Cost effectiveness of dairy analogue

There is evidence to suggest that dairy analogues can be cost effective, particularly when compared to traditional products such as milk and cheese. A few studies have looked at the cost effectiveness of these products and the results are mixed but generally show a level of cost-effectiveness in comparison with traditional dairy products. For example, one study found that imitation lactose-free cheese was three times more expensive than regular shredded cheddar cheese (Burgess et al., 2010).

However, another study concluded that vegan alternatives for butter were less expensive than their non-vegan counterparts (Vega Romero *et al.,* 2015) which suggests potential savings when switching from dairy to plant-based options.

2.3. BENEFITS OF DAIRY ANALOGUE

2.3.1. Nutritional Difference between Lactose-Free Dairy and Normal Dairy

Lactose-free dairy may confer benefits to lactose intolerant people, allowing them to enjoy the taste of dairy without the uncomfortable intestinal symptoms from the ingestion of lactose. In addition, lactose-free dairy also has a growing health appeal to lactose tolerant people. In lactose-free dairy, the lactose is pre-digested into glucose and galactose. Consequently, the lactose content may be very low, but the glucose and galactose content of lactose-free milk will be approx. 25 g/L. As mentioned above, the glucose and galactose in lactose-free dairy are sweeter than lactose, enabling a reduction of the added sugar in dairy products by up to 10–15 g/kg, thereby reducing calorie addition (McCain *et al.*, 2018). Besides the advantages of reduced lactose intake for lactose intolerant people, lactose-free dairy is not likely to have different nutritional effects on the human body as compared to normal dairy. When pre-digested lactose is consumed, the glucose and galactose will also be absorbed in the small intestine like will be the case for the digestion products glucose and galactose when intact lactose is consumed by lactose tolerant dairy consumers. No difference in gastric emptying was found in rats when comparing lactose versus glucose and galactose (Gutzwiller *et al.*, 2000). A study in calves found no difference in the glycemic responses between milk and lactose-free milk. The absence of differences in glycemic response between milk and lactose-free milk was confirmed by a study on healthy subjects (internal unpublished data). Also, no difference was observed in the glycemic response of diabetes patients when consuming lactose compared to the lactose digestion products glucose and galactose (Burgess *et al.*, 2010).

2.3.1. Potential Health and Economic Impact of Lactose-Free Dairy vs. Dairy Avoidance

The National Institute of Health (NIH) concluded that most lactose mal-absorbers will tolerate up to 12 g of lactose per serving and that smaller amounts of lactose will generally not cause major problems (Suchy *et al.*, 2010). Still, most subjects with self-diagnosed or physician-diagnosed lactose intolerance will try to avoid all lactose-containing products. However, in its Updated Consensus Statement, the National

Medical Association reports that lactose free dairy products are the most ideal substitute for regular dairy products among individuals with lactose intolerance. In addition, evidence indicates that children prefer lactose-free cow's milk over soy beverages.

Alternatives that do not exclude cow's milk include lactose-free milk products, yogurt containing lactic acid bacteria and cow's milk combined with an intake of lactase supplements. Lactose-free dairy products and lactase supplements may have an advantage over excluding dairy products from the diet in that they do not reduce dietary intake and its essential nutrients. There is, however, still controversy surrounding the role of lactose in enhancing calcium and divalent mineral bioavailability. Lactose has been recognized as an enhancer of calcium absorption in mammals; in animal studies, lactose was found to enhance calcium absorption, but in humans, this effect is still debated (Kwak *et al.,* 2012).

2.4. TYPES OF DAIRY ANALOGUES

2.4.1. Liquid milk analogues / Imitation milk

Plant-based milk analogues have gained tremendous attention due to the existence of functional compounds, free from lactose and convenient to prepare from extracts of cereals, legumes, nuts, and seeds that mimic the appearance of bovine milk. To prolong the shelf life and meet nutritional requirements of non-dairy fluid milk, a lot of processing factors are used such as pre-treatments, extraction, and fortification. Traditionally, these are manufactured by soaking it for a certain amount of time, then grinding into a slurry and filtered to separate milk and coarse particles followed by the addition of ingredients to enhance the final product's palatability. Milk substitutes were stabilized by the addition of mono- and diglycerides, glycerol monostearate, guar gum, and carrageenan. To compensate minerals requirements through the addition of ferric ammonium citrate and ferric pyrophosphate as the iron sources and calcium carbonate and tricalcium phosphate as calcium sources (N B *et al.,*2017). There are many types of vegetable milk. For example, soymilk is considered as multifunctional refreshing milk that contains a rich amount of protein, vitamins, minerals (majorly calcium, iron, and zinc), and isoflavones particularly genistein and daidzein. As compared to unfermented soybeans, fermented soybeans suppress the progression of Type 2 diabetes and have a beneficial impact on reducing the risk of cardiovascular disease (Bisla *et al.*, 2016).

Soybean water absorption during soaking is directly proportional to the flavour of soymilk. The amount of water absorbed by soybeans during soaking is directly proportionate to the flavour of soymilk. While using a soaking temperature of 25°C and a pH of 9, the absorption rate and liberation of 7S globulin protein increased (Bruno *et al*.,2019). A blend of 60% almond milk and 40% soy milk had a better sensory profile than bovine milk, but calcium and protein content were lower (Chandan *et al.,* 2011) Almond nuts are high in monounsaturated fatty acids (MUFA), which drastically decrease the levels of low –density lipoproteins in the bloodstream. Furthermore, almond allergies caused by amandine, legumin (11S), and prunin which are all recognized as almonds allergens (Rodríguez *et al*., 2010). Coconut milk and similar products may help to raise high-density lipoprotein (HDL) levels (Demir *et al*., 2021) Polyphenolic compounds are prevalent in oats. The function of β-Glucan in oats has been described by Food and Drug Administration (FDA) to lessen the risk of heart disease (Tangyu *et al.,* 2019) Non-dairy fluid milk from different sources and their potential.

2.4.2. Dairy fat Analogues/ Alternatives

Market demand for this sector is anticipated to grow by 2.6% annually from 2018-21. Mayonnaise is an oil-in-water emulsion with a fat content ranging from 70-80%. Mayonnaise is formed by vigorously beating oil, egg, vinegar, salt, and few more ingredients to improve acceptability the fat phase is crucial in terms of textural qualities and sensory profile. The egg is a base ingredient and egg yolk serves as an emulsifier in mayonnaise. Modified starch such as oats, arrowroot, and maize were utilized as a fat replacer. For vegetarians, Arabic gum is used as an egg substitute. It functioned as an antioxidant, antibacterial, and emulsifier (Giha *et al*., 2021).

Low-fat mayonnaise was sonicated at 20 kHz, 750 W for 5 minutes. This research showed that decline in microorganisms especially yeasts, moulds, and acid tolerant bacteria (Tangyu *et al*., 2019) In mayonnaise 0.5% of peppermint essential oil and Malva sylvestris exhibits antioxidant and antimicrobial activity (Romero *etal.,* 2011) The stability of low-fat mayonnaise was increased by the addition of 6% watermelon rind flour. It acts as a stabilizer with no deviation in moisture content, pH, and sensory profile when compared with the control sample (Guo *et al*., 1997). Various combinations of egg white, egg yolk, and soy protein are being used to form non-dairy cream mimics. With the addition of egg yolk, the level of polyunsaturated fatty acids (oleic and linoleic acids) increased.

The optimal dissolving temperature for cream analogue powder is 55-75°C Soybean oil and soybean protein isolate were combined to develop non-dairy whipped cream (Moradi *et al*., 2021).
Vegan cream was formulated by admixing chickpea aquafaba, salt, xanthan gum, and sucrose to produce a stiff foamy structure Avocados are enriched with monounsaturated fatty acids and phytosterols. Avocado puree was used to replace dairy fat in ice cream (Fibrianto *et al*., 2021).

2.4.3. Cheese Analogues

Cheese analogues resemble bovine milk cheese and are designated as partial dairy or non-dairy depending on the ingredient used in the cheese formulation. Casein is used as a protein source; it plays a major role in cheese analogues. Acid casein has a higher potential for water binding than rennet casein. In a mozzarella cheese analogue, rennet casein confers a high degree of stretchability and firmness (Oyeyinka *etal.*, 2019). Sodium caseinates are preferred over rennet casein in the fabrication of cheese spread analogue. Peanut, cottonseed, and soy protein isolate are used alone or in combination with casein as vegetable source proteins. It produces a product with hardness, sticky body, and lack of elasticity if the addition level exceeds 20%, (Paul *et al*., 2020). Typical Fat sources are palm oil, soy oil, rapeseed oil, and coconut oil. In analogues, emulsifying salts are used such as citrate, lactate, phosphate, and tartrate with ammonium, potassium, or sodium and food-grade citric or lactic acids used at a rate of 0.2-1% and 0.1% preservatives (potassium sorbate, nisin, natamycin and calcium/ sodium propionate) are used.

Flavour enhancers can also be used. This group of compounds includes glutamates and yeast autolysates. Colours are elective components that are usually added at a rate of

0.04%. Minerals and vitamins (magnesium, zinc, iron, vitamin A, B1, B2, B9) are used as a dietary supplement at a concentration of 0.05% to meet nutritional equivocation to natural cheese, it may contain a nutritional value in addition to natural cheese (Poore *et al*., 2018) Functional cheese prepared from peanut milk, fermented by Lactobacillus rhamnoses NCDC18 strain. The product showed the best solid recovery (51.7%), protein recovery (69.21%), and water retention properties (67.39%). The vegan cheese was made by replacing part of cow milk with 10% lentil milk and 3.5% inulin as a fat replacer had higher acceptance (McClements *et al*., 2019) Moringa oleifera seed, tamarind seed, lime juice, and alum are used as coagulants in the preparation of soy cheese (tofu). Moringa extract showed potent richer vitamin B, higher solid recovery, and no coliform detection in tofu. To reduce the danger of malnutrition, vegan cheese was fabricated using 40% cashew milk and 60% soy milk combination. Naturally, it is a rich source of essential fatty acids (Ogundipe *et al*., 2021). Pizza pie with mozzarella cheese as a topping is a popular fast food. Manufacturers are looking towards plant-based mozzarella cheese due to the high cost of bovine milk cheese. For mozzarella cheese analogue, an aqueous phase containing 20% rice bran oil, 16% sodium caseinate, and 7.75% modified sodium caseinate yielded cheese analogues with improved stretchability and melting properties (Garg *et al*., 2016) In cheese spread analogues, butterfat is replaced with peanut cream fat at a ratio of 1:1 or 0:1. The resulting spread has been less cohesiveness and hardness than butterfat cheese formulate cheese analogue by combining coconut milk, soya milk (50:50) along with the addition of 0.1% rennet, 1.5% salt, 0.5% stabilizer, 1% preservative. The resultant product shelf life has been extended to 7 Days (Sanjukta *et al.,* 2016) Virgin coconut oil (VCO) was exploited as a milk fat substitute in low-fat cheese analogues. It lowers LDL cholesterol, triglycerides, and phospholipids Levels. The results showed that 25 % VCO and 1% Tween-80 had a yield of 59.93%, moisture content of 54.62 %, and a fat content of 19.96% (Sethi *etal.,* 2016).

2.4.4. Non- Dairy Probiotic Products

A probiotic product is an appealing choice for better gut health. Plant-based milk substitutes are fermented through the favourable fermentation process. Lactobacillus spp and Bifidobacterium spp are the most often used probiotic bacteria in the food industry since they have been approved as "Generally Recognized As Safe", while Saccharomyces cerevisiae and S.Boulardii are probiotics that could be exploited in probiotic products (Zinati *et al*., 2018) . At least 106 colony forming units (CFU) per gram or ml of viable cells should be present in a probiotic product to be capable of providing 108-109 of viable cells in daily intake (da silva *etal.,* 2018) Antioxidants were found to be increased in buckwheat, wheat germ, barley and rye after fermenting with L.rhamnosus and S.cerevisiae Soybean fermentation with B.subtilis led to significant levels of Glu, Asp and other amino acids, all of which have multifaceted effects on increasing antioxidant effects and suppress blood pressure (Rawson *et al*., 2021). L.rhamnosus and L.johnsonii La-1 along with yogurt cultures (L.bulgaricus & S.thermophilus) have been added to soy milk. Peanut-soy milk has been fermented with the six distinct lactic acid bacteria. In certain cases, collective cultures proved to be superior over single strain (Sumarmono *et al*., 2021).

The UV-C-T (coil tube type assisted thermal) technology has been used to prepare set yogurt from oat milk. E. coli K-12 was permanently inactivated and the syneresis value was minimal (Ervina *et al.,* 2018) The inclusion of raisins puree into coconut milk yogurt stimulates probiotic action while also increasing prebiotic level (Tavakoli *et al*., 2021). Non-dairy yogurt formulated by using potato protein isolate and canola oil afterward homogenized at 200 MPa to form stable emulsions (Teh *etal.,* 2005). Soymilk cultured with 5% kefir grains exhibited a probiotic count of 7 Log10 CFU/ml after 28 days of storage (Tuntragul *et al.,* 2010). The curd was fabricated from sesame milk fortified with 5% lactose, 1% electrolyte salt mix, and 1% sucrose with 5% inoculum. The resultant curd has 6.70% protein, 6.91% fat and 0.925 ash (Welch *etal.,* 2005) Cashew nut milk was scrutinized as a substrate for providing non-dairy probiotic drink (B. animalis, L. acidophilus, and L. plantarum). Throughout the storage time, B. animalis counts remained above 107 CFU/ml. Kombucha is also an example or non-dairy probiotics. (Yadav *et al.,* 2017).

2.4.5. Non-dairy frozen dessert

The formulation of delicious treats from lowbush blueberries, soy protein, and coconut milk was formulated. It has a multitude of positive health impacts. Softy ice cream was prepared by partially replacing skim milk with soy milk with the addition of cocoa to mask beany flavour (Yadav *et al.,* 2020). Unfermented and fermented yam dough is used to make low-fat ice cream. The Leuconostoc lactic CCMA 0415 remained after three months of storage. Taro is a kind of root vegetable that is underused and inexpensive. Frozen treat prepared by using taro milk as an alternative for bovine milk as well as soy protein and pea protein (Yu *et al*., 2016) Protein and minerals particularly iron are widely present in soybean and watermelon. Frozen dessert was designed by combining 50% soy milk and watermelon seed milk with guava pulp was proven to be extremely nutritious and a rich source of ascorbic acid.

2.5. RESTRUCTURED DAIRY ANALOGUES

The consumption of dairy products has been on the rise for decades, but as more consumers are turning towards plant-based diets, the demand for dairy analogues has grown. Dairy analogues are plant-based products that mimic the taste, texture, and nutritional profile of dairy products. Restructured dairy analogues are a type of dairy analogue that has been processed to give them a texture that is like the real thing. This article will explore the world of restructured dairy analogues, their benefits, and how they are made (Atra *et al.,* 2005).

Restructured dairy analogues are made from a variety of plant-based ingredients such as soy, rice, oats, almonds, and cashews. The process of making these analogues involves blending and processing the plant-based ingredients with water, stabilizers, and emulsifiers to create a product with a texture like that of dairy products. The process can be complex, and manufacturers often use a combination of processing techniques such as extrusion, texturization, and micro fluidization to create the desired texture (Walstra *et al.,* 2006).

One of the main benefits of restructured dairy analogues is that they offer a dairy-free alternative for consumers who are lactose intolerant or have a dairy allergy. Additionally, restructured dairy analogues are often lower in saturated fat, calories, and cholesterol than traditional dairy products. They are also rich in vitamins, minerals, and other nutrients that are essential for a healthy diet (Gardiner *et al.*, 2000).

A study published in the Journal of Dairy Science in 2020 compared the nutritional content of various restructured dairy analogues with that of whole milk. The study found that some restructured dairy analogues had a higher protein content than whole milk, while others had a higher calcium content. The study concluded that restructured dairy analogues could be a nutritious alternative to traditional dairy products (Kearney *et al.*, 2009).

Another study published in the Journal of Food Science and Technology in 2021 evaluated the sensory attributes of restructured dairy analogues made from a blend of soy protein isolate and rice flour. The study found that the analogues had a texture and flavour like that of dairy products and were well-accepted by consumers (Radaeva *et al.* 1982).

The market for restructured dairy analogues is growing rapidly, with more and more manufacturers entering the space. In 2020, Nestlé launched its Garden Gourmet Incredible Burger, a plant-based burger made from soy and wheat protein that has a texture and flavour like that of beef. Other companies such as Beyond Meat and Impossible Foods have also launched plant-based burgers that are designed to look, taste, and cook like real beef (Fox *et al.*, 2004).

2.6. DAIRY ANALOGUE MARKET

The global dairy analogue market has been on the rise in recent years due to increasing consumer demand for plant-based alternatives to traditional dairy products. Dairy analogues are plant-based products that mimic the taste, texture, and nutritional profile of dairy products. In this article, we will explore the current state of the dairy analogue market, its growth drivers, and the challenges it faces (Ahmed *et al.*, 1995).

According to a report by Market Research Future, the global dairy analogue market is expected to grow at a CAGR of 7.6% during the forecast period from 2020 to 2027. The report attributes this growth to several factors, including increasing consumer demand for plant-based products, rising health consciousness, and the availability of innovative and diverse product offerings (Green *et al.,* 2006).

One of the main drivers of growth in the dairy analogue market is the increasing popularity of plant-based diets. According to a survey conducted by the Plant Based Foods Association, sales of plant-based products in the US increased by 27% in 2020, with plant-based milk being the fastest-growing category. This trend is not limited to the US, as the global plant-based milk market is projected to reach $21.52 billion by 2024, according to a report by Markets and Markets (Kyriakopoulou *et al.,* 2019).

In addition to the growing popularity of plant-based diets, the dairy analogue market is also being driven by technological advancements in the food industry. Manufacturers are using a variety of plant-based ingredients and processing techniques to create dairy analogues that closely mimic the taste, texture, and nutritional profile of traditional dairy products. For example, some dairy analogues are made using soy, almond, or coconut milk, while others use a combination of plant-based proteins and fats to create a product that is like dairy products (Sha *et al.,* 2020).

Despite the growth in the dairy analogue market, it also faces several challenges. One of the main challenges is the competition from traditional dairy products. While the demand for plant-based products is growing, traditional dairy products still dominate the market. Additionally, the cost of producing dairy analogues can be higher than traditional dairy products, which can make them less accessible to some consumers (Sun *et al.,* 2021).

Another challenge is the perception that dairy analogues are less nutritious than traditional dairy products. However, several studies have shown that dairy analogues can be just as nutritious as traditional dairy products, and in some cases, even more so.

For example, a study published in the Journal of Dairy Science found that some dairy analogues had a higher protein content than traditional dairy products (Zhang *et al.,* 2021).

The dairy analogue market is expected to continue to grow in the coming years, driven by increasing consumer demand for plant-based products, technological advancements, and the availability of diverse product offerings. However, the market also faces several challenges, including competition from traditional dairy products and the perception that dairy analogues are less nutritious. As the market continues to evolve, it will be interesting to see how manufacturers and consumers respond to these challenges and opportunities (Piazza *et al.,* 2015).

2.6.1. Dairy analogues in India

Dairy analogues, also referred to as dairy alternatives, are a form of milk-like product made from plant proteins and other ingredients that have become increasingly popular in India. This trend is due to several factors, including the following:

Increasing vegan/vegetarian population – As more Indians turn towards vegetarianism and veganism, they are looking for plant-based products with similar nutritional value compared to cow milk. Plant derived milks offer many health benefits over their traditional counterparts such as being lower in fat and cholesterol levels while providing essential nutrients like calcium, iron vitamins A & D (Shailja *et al.,* 2014).

Rising awareness about food sensitivities - Dairy analogues contain no animal derived lactose or casein which can trigger allergies for people who suffer from these types of intolerances (Madsen *et al.,* 2018). This factor has been increasing demand for soy milk where it offers hypoallergenic properties making it suitable alternative to regular milk consumption thus driving its sales rise in recent years.

Lower cost than traditional dairy products- Being typically cheaper than their conventional equivalent, this type of substitutes provide higher margins per unit sold acting further driver for manufacturers so seek out better investment’s opportunities abroad market wise (Solís *et al.,* 2020).

2.7. JACK FRUIT SEED POWDER AND ITS BENEFITS

Jackfruit is a tropical fruit that is widely consumed in Southeast Asia, South Asia, and parts of Africa. While the fruit is popularly used for its sweet and juicy flesh, its seeds are often discarded or used for other purposes. However, recent innovations in the food industry have led to the development of jackfruit seed powder, a nutritious and versatile ingredient that can be used in a variety of food products. In this article, we will explore the benefits of jackfruit seed powder and the scientific research behind it (Chandrasekharan *et al.,* 2014).

Jackfruit seed powder is made by drying and grinding jackfruit seeds into a fine powder. The powder is a rich source of nutrients, including protein, fiber, and healthy fats. According to a study published in the Journal of Food Science and Technology, jackfruit seed powder is a good source of antioxidants and has anti-inflammatory properties. Additionally, the powder contains high levels of starch, which makes it an ideal ingredient for various food products, including bakery goods, beverages, and meat analogues (Arpit *et al.,* 2015).

One of the main advantages of using jackfruit seed powder in food products is its ability to improve their nutritional profile. In a study published in the Journal of Food Processing and Preservation, researchers used jackfruit seed powder to replace wheat flour in bread and found that the bread had higher levels of protein, fiber, and minerals compared to the bread made with wheat flour alone. Additionally, the use of jackfruit seed powder in food products can help reduce food waste, as it is made from a part of the jackfruit that is typically discarded (Pratama *et al.,* 2020).

Jackfruit seed powder also has functional properties that make it an ideal ingredient for food products. The powder contains high levels of amylose, a type of starch that has a lower gelatinization temperature compared to other types of starch. This means that the starch can be cooked at a lower temperature, resulting in a smoother and creamier texture in food products (Banergee *et al.,* 2015).

In addition to its nutritional and functional benefits, jackfruit seed powder has also been well-received by consumers. According to a report by Grand View Research, the global plant-based protein market is expected to reach USD 16.55 billion by 2027, driven by increasing consumer demand for plant-based and vegan alternatives to traditional meat products (Butool *et al.*, 2015).

Jackfruit seed powder is a nutritious and versatile ingredient that can be used in a variety of food products. Its unique nutritional profile and functional properties make it an ideal ingredient for improving the nutritional profile and texture of food products. Its potential to support sustainable agriculture practices and its popularity among consumers make it an ingredient to watch in the future of the food industry (Chandrasekharan *et al.*, 2014).

2.7.1. Ice cream prepared from jackfruit seed

Jackfruit, known for its large size and distinct tropical flavour, has long been enjoyed as a delicious fruit. However, what many people may not realize is that the seeds of the jackfruit also hold great potential. In recent years, an innovative and sustainable approach to utilizing jackfruit seeds has emerged – the creation of ice cream from jackfruit seed milk (Chowdhury *et al.*, 2012).

The process begins with the collection of jackfruit seeds, which are often discarded as waste. These seeds are carefully extracted, dried, and ground into a fine powder. The powder is then mixed with water to create a creamy and flavourful milk alternative. Unlike traditional dairy milk, jackfruit seed milk is vegan-friendly and lactose-free, making it a suitable choice for individuals with dietary restrictions or preferences (Kaur *et al.*, 2005).

The use of jackfruit seed milk in ice cream production offers several benefits. First and foremost, it provides a unique and exotic flavour profile. The jackfruit seed milk imparts a subtle nutty undertone to the ice cream, enhancing the overall taste experience. Additionally, it adds a smooth and creamy texture, similar to that of traditional dairy-based ice cream (Naik *et al.*, 2017).

Jackfruit seeds are a rich source of nutrients, including protein, fiber, and healthy fats. According to a study published in the Journal of Food Science and Technology, jackfruit seeds are a good source of antioxidants and have anti-inflammatory properties. Additionally, the seeds contain high levels of starch, which makes them an ideal ingredient for ice cream production (De *et al.,* 2011).

Furthermore, the production of jackfruit seed milk ice cream promotes sustainability by reducing food waste. By utilizing jackfruit seeds that would otherwise be discarded, this innovative approach helps minimize environmental impact and maximize resource efficiency (Cortés *et al.,* 2005).

While the concept of ice cream made from jackfruit seed milk may still be relatively new, it is gaining attention and appreciation among food enthusiasts and environmentally conscious individuals. With its tantalizing flavour, creamy texture, and eco-friendly attributes, jackfruit seed milk ice cream is a promising addition to the diverse world of frozen treats (Murtaza *et al.,* 2004).

MATERIALS AND METHODES

3.MATERIALS AND METHODS

The study entitled "Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk" was aimed at standardization of the procedure for extraction of jackfruit seed milk and developing a Dairy Analogue of Paneer from Jackfruit seed milk. The development of paneer was standardised from seeds of two varieties of Jackfruit *Varikka cv* and *Koozha cv.* The developed Jackfruit seed paneer was studied for their sensory and shelf-life qualities. In depth analysis of their chemical properties and nutritional profiles were also undertaken. The methodology of the study is presented in the following heads:

3.1. Standardization of Extraction of Jackfruit Seed Milk

3.2. Pre-processing techniques

3.3. Extraction of Jackfruit seed milk

3.4. Screening of best treatment

3.5. Development of jackfruit seed milk soft cheese (paneer)

3.6. Sensory acceptability

3.7. Quality analysis of paneer

3.8. Shelf-life stability of the jackfruit seed milk soft cheese (paneer)

3.9. Cost of production

3.10. Statistical Analysis of data

3.1. STANDARDISATION OF EXTRACTION OF JACKFRUIT SEED MILK

The standardization of jackfruit seed milk extraction is important to ensure the quality and consistency of the final product. According to a study published in the Journal of Food Science and Technology by Rathore *et al.,* 2020, the extraction process involved several steps, like selecting and preparing the raw material, soaking, grinding, straining, heating, standardization, packaging, and storage. Overall, the standardization of jackfruit seed milk extraction is crucial for producing a high-quality product that meets consumer's expectations and demand (Rathore *et al.,* 2020).

3.1.1. Selection of fruits for seed collection:

Selecting the right jackfruits for seed collection is essential to ensure high-quality seeds that yield nutritious and tasty milk. The two most commonly seen cultivars of jackfruit are *Varikka cv* and *Koozha cv*. For *Varikka cv* variety, it is suggested to select jackfruits that have a yellowish-green skin with a smooth surface and oval shape. The seeds should be extracted when the fruit is ripe and starts to crack. For *Koozha* variety, it is suggested to select jackfruits that have a brownish-green skin with a rough surface and round shape. The seeds should be extracted when the fruit is fully ripe and starts to rot (Nair *et al.,* 2020). Selecting the right variety and maturity stage of jackfruits for seed collection is crucial for producing high-quality jackfruit seed milk that meets consumers' expectations and demand.

Jack fruit cultivars *Koozha* and *Varikka* selected for the study were purchased from local markets.

v_1= Varikka

v_2= Koozha

3.1.2. Stage of fruit maturity

The stage of fruit maturity is an important factor to be considered when collecting jackfruit seeds for milk production. The maturity stage of jackfruit affects the quality and yield of the seeds. For jackfruit seed milk production, the fruit should be harvested when it is fully ripe, i.e., when it starts to rot. At this stage, the pulp of the fruit becomes soft and easily separable from the seed. Seeds from fully ripe and fully matured fruits of both the cultivars were selected for the study.

- m_1**-** Fully ripe
- m_2 - Fully matured

Overall, harvesting jackfruit when it is fully ripe is crucial for obtaining high-quality seeds and producing nutritious and tasty jackfruit seed milk. (Rathore *et al.,* 2020).

3.2. PRE-PROCESSING TECHNIQUES

The seeds from both varieties were cleaned manually under running under water to remove any dirt or debris and the white arils (seed coat) were peeled off manually using a stainless-steel knife before further processing. The brown inner skin coat was also removed manually after soaking the seed for 24 hours to obtain the pure white milk.

3.2.1. Soaking media

Seeds of both cultivars with the different maturity indices were treated with the distinct soaking media. Soaking time was standardized to identify the best medium for the optimum milk yield is further processing. The different soaking media used to treat the seeds before milk extraction were as follows:

- s_1= Water
- s_2= 2% Sodium bi carbonate
- s_3= 3% Sodium hydroxide
- s_4= 2% Salt water (NaCl)

Table 1: Soaking treatments

TREATMENTS	
$T_1 = v_1m_1s_1$	$T_9=v_1m_2s_1$
$T_2= v_2m_1s_1$	$T_{10}=v_2m_2s_1$
$T_3=v_1m_1s_2$	$T_{11}=v_1m_2s_2$
$T_4=v_2m_1s_2$	$T_{12}=v_2m_2s_2$
$T_5=v_1m_1s_3$	$T_{13}=v_1m_2s_3$
$T_6=v_2m_1s_3$	$T_{14}=v_2m_2s_3$
$T_7=v_1m_1s_4$	$T_{15}=v_1m_2s_4$
$T_8=v_2m_1s_4$	$T_{16}=v_2m_2s_4$

V_1=Varikka V_2=Koozha m_1=fully ripe m_2=fully matured s_1=water s_2= 2%sodium bi carbonate s_3= 3% sodium hydroxide s_4= 2% salt water

The different soaking treatments for jackfruit seed milk extraction has been reported.

The water soaking process helps to soften the seed coat, which is typically thick and hard, making it easier for the embryo inside to absorb water and nutrients. Additionally, soaking helps to remove any inhibitors or chemicals present on the seed surface helping in extraction of better jackfruit seed milk (Siripongvutikorn *et al.,* 2013).

Boiling and soaking jackfruit seeds are essential steps to prepare them for consumption. These methods soften the tough outer layer, remove impurities, and enhance the taste and texture of the jackfruit seed milk (Ramesh *et al.,* 2014).

Fermentation soaking of jackfruit seeds is a traditional and efficient method employed to enhance their nutritional value and improve their palatability. The fermentation process leads to the production of organic acids and enzymes, which not only improve the overall taste but also aid in the digestion and absorption of nutrients. Furthermore, fermentation also helps to reduce antinutritional factors and increase the availability of vitamins, minerals, and antioxidants in the jackfruit seeds (Thamanna *et al.,* 2015).

It's important to note that the soaking conditions may vary depending on personal preferences and cultural practices. The extracted milk can be used in various culinary applications such as curries, desserts, smoothies, and vegan milk alternatives (Rai S *et al.,* 2021).

3.2.2. Heat treatments

Both V_1 and V_2 with the different maturity indices were subjected to the following heat treatments.

- h_1= Steaming
- h_2= Pressure cooking

The pre-treated seeds were cleaned under running water, and the skin was peeled off before further processing.

Table: 2 Heat Treatments- Cultivars x Maturity indices x Heating Techniques

Heat Treatments
$T_1= v_1m_1h_1$
$T_2=v_2m_1h_1$
$T_3=v_1m_2h_1$
$T_4=v_2m_2h_1$
$T_5=v_1m_1h_2$
$T_6=v_2m_1h_2$
$T_7=v_1m_2h_2$
$T_8=v_2m_2h_2$

V_1= Varikka V_2= Koozha

m_1= fully ripe m_2= fully matured h_1=steaming h_2= pressure cooking

To extract jackfruit seed milk, various heat treatments can be employed, each offering a unique approach and outcome. One common method is boiling the jackfruit seeds in water. In this process, the seeds are first removed from the fruit, washed, and then boiled in water until they become soft and tender. The softened seeds are then blended with water to create a creamy milk-like consistency (Lim *et al.,* 2012).

Another heat treatment option is roasting the seeds. After being extracted from the fruit, the seeds are roasted to enhance their flavour and aroma. Once roasted, the seeds are ground into a fine powder and mixed with water, resulting in a rich and nutty seed milk (Ghosh *et al.,* 2017). Alternatively, steaming can also be used as a heat treatment method. The seeds are steamed until they are easily mashed, and then they are processed similarly to the other methods. These heat treatments not only help to soften the seeds but also aid in breaking down the starches and proteins, making it easier to extract the desired milk-like consistency. The choice of heat treatment can be influenced by personal preference, desired flavours, and the intended use of the jackfruit seed milk in various culinary applications (Karuna *et al.,* 2009).

Plate 1. Different soaking media

Soaked in Water **soaked in 2% Sodium bi carbonate**

Soaked in 3% Sodium Hydroxide **soaked in 2% Salt Water (NaCl)**

Plate 2. Different Heat Treatments

Steamed and pressure-cooked jack fruit seeds

Plate 3. Curd setting of jackfruit seed milk in different soaking media

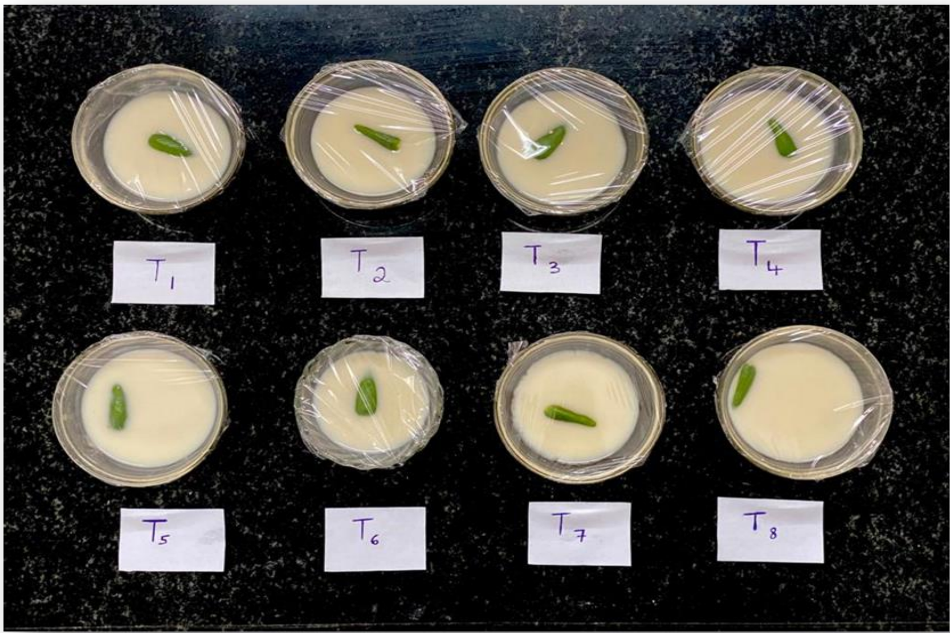
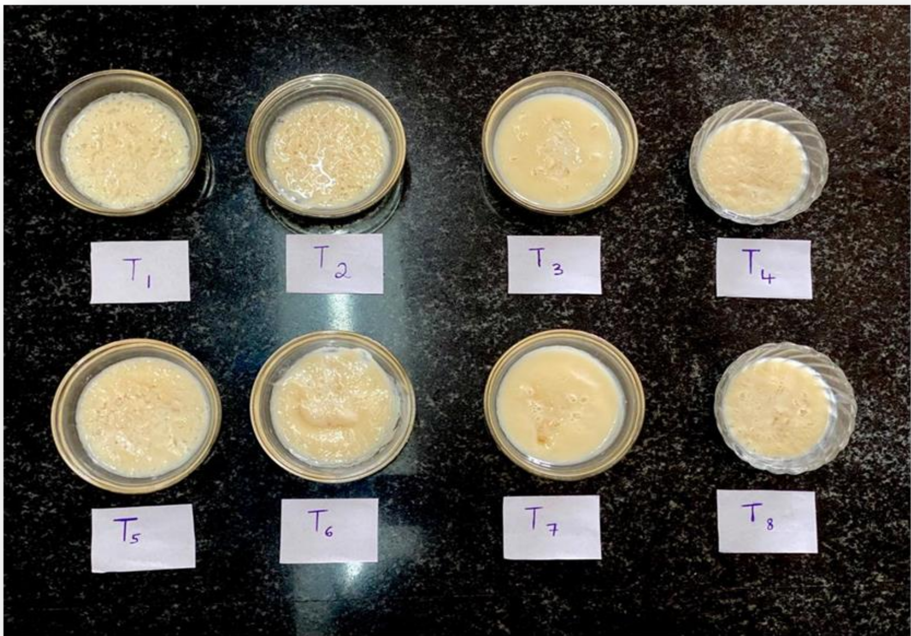
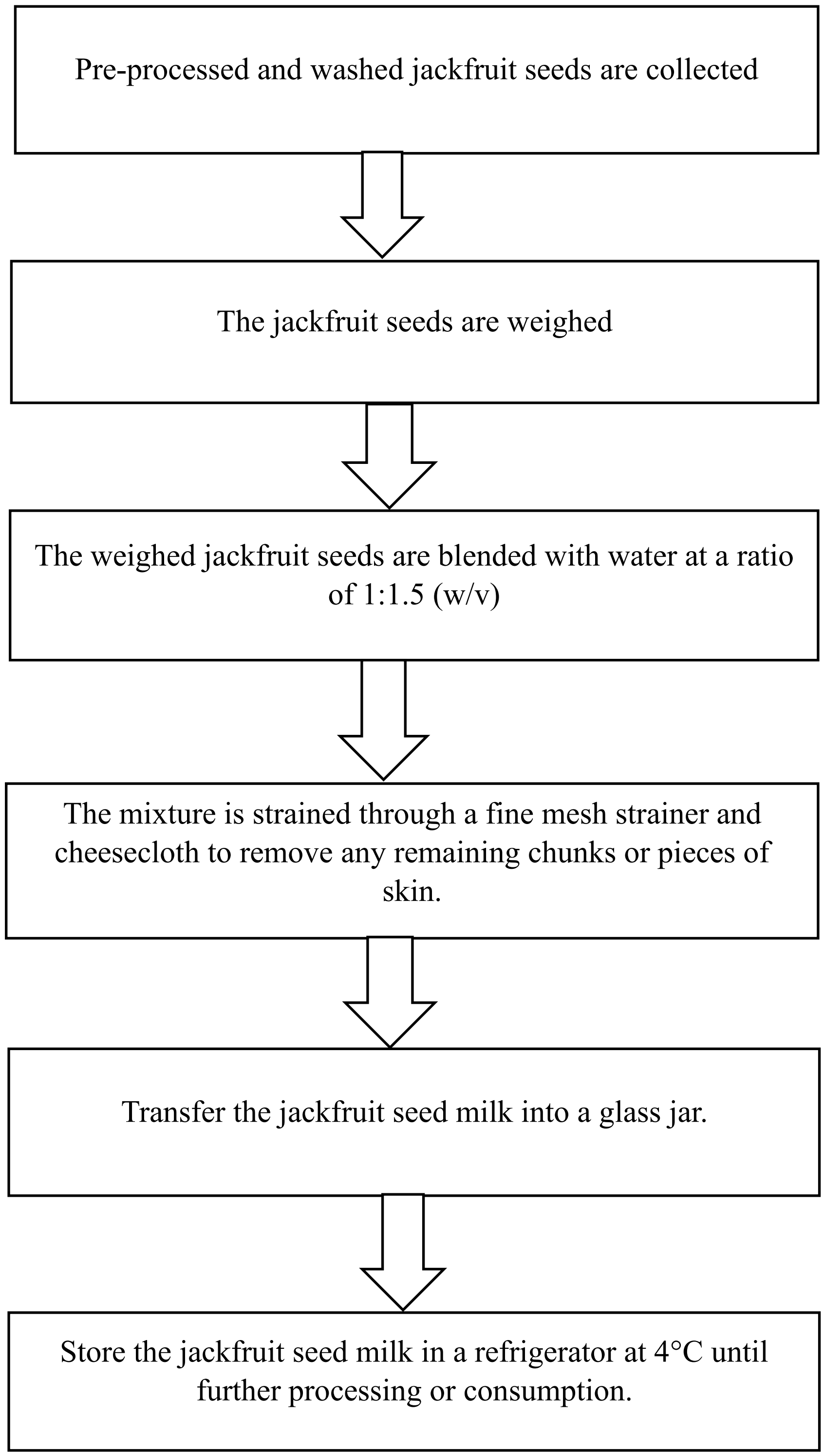


Plate 4: Curd setting of jack fruit seed milk in different Heat treatments



3.3. EXTRACTION OF JACKFRUIT SEED MILK

Figure 1: Flow diagram for extraction of jackfruit seed milk



3.4. SCREENING OF BEST TREATMENT

Jackfruit seed milk obtained from the above 24 treatments were tested for yield ratio, sensory attributes and curd setting properties. The best treatment was chosen for formulation of paneer.

The yield ratio of the developed milk was analyzed using the formula

$$\text{Yield Ratio} = \frac{\text{Final weight of product (g)}}{\text{Weight of ingredient (g)}}$$

(Krishnaja, 2014)

Sensory evaluation is a scientific method used to measure and analyse human responses to sensory stimuli. It provides valuable insights into the sensory attributes of a product and helps determine consumer preferences and acceptability. When it comes to jackfruit seed milk, sensory evaluation allows us to understand how well it performs in terms of sensory characteristics compared to other milk alternatives (Chua *et al.,* 2015).

The evaluation typically involves a panel of trained sensory experts who are familiar with evaluating food and beverage products. These experts follow a standardized procedure to assess various attributes of the jackfruit seed milk. The curd setting properties of jackfruit seed milk have been studied to explore its potential as a viable alternative for traditional dairy curd formation (Akhter *et al.,* 2017).

Setting curd using jackfruit seed milk involves a traditional fermentation process that transforms the milk into a thick, tangy, and nutritious curd. To initiate the curd-setting process, the jackfruit seed milk is first prepared by extracting milk from roasted or boiled jackfruit seeds. The milk is then cooled to a suitable temperature, usually around 40-45 degrees Celsius, to create an ideal environment for bacterial fermentation and kept overnight to set the curd (Manurung *et al.,* 2015).

3.5. DEVELOPMENT OF JACKFRUIT SEED MILK SOFT CHEESE (PANEER)

Jackfruit seed milk paneer is a nutritious and flavourful alternative to traditional paneer that is made from the seeds of the jackfruit. The use of jackfruit seed milk in paneer production is a promising development in the field of plant-based dairy alternatives. With its high nutritional value and unique flavour profile, jackfruit seed milk paneer is a great option for those looking to reduce their consumption of animal products or incorporate more plant-based foods into their diet.

3.5.1. Selection of Coagulum for paneer preparation

Paneer is a type of cheese commonly made from cow's milk. It involves coagulating milk to form curds, which are then pressed to remove the whey and create a solid cheese. The selection of a coagulant plays a crucial role in the texture, flavour, and overall quality of the paneer (Karadbhajne *et al.,* 2010).

The selection of coagulum is a crucial step in the preparation of paneer, a popular Indian cheese. Coagulation is the process of curdling milk, which results in the formation of curds and whey. The coagulum used in paneer preparation can greatly affect the texture, flavour, and yield of the cheese. Traditional coagulants used for paneer production include lemon juice and vinegar, which contains natural acids (citric acid and acetic acid, respectively). These acids lower the pH of the milk, causing it to coagulate and form curds (Kumar *et al.,* 2014). The main coagula used for preparation of jackfruit seed paneer were:

- c_1 = vinegar
- c_2 = lemon juice
- c_3 = 10 % citric acid.

The selection of a coagulant for jackfruit seed milk paneer preparation may require some experimentation to achieve the desired texture and flavor. It's advisable to start with small-scale trials and adjust the coagulant type and quantity based on the results obtained

3.5.2 Formulation for paneer

The best screened jackfruit seed milk was constituted in the following combinations for the formulation of paneer.

- f_1- jackfruit seed milk (100 %)
- f_2- Jackfruit seed milk (50%) + Groundnut milk (50%)
- f_3- Jackfruit seed milk (50%) + soy milk (50%)
- f_4- Jackfruit milk (50%) + soy milk (25%) + groundnut milk (25%)

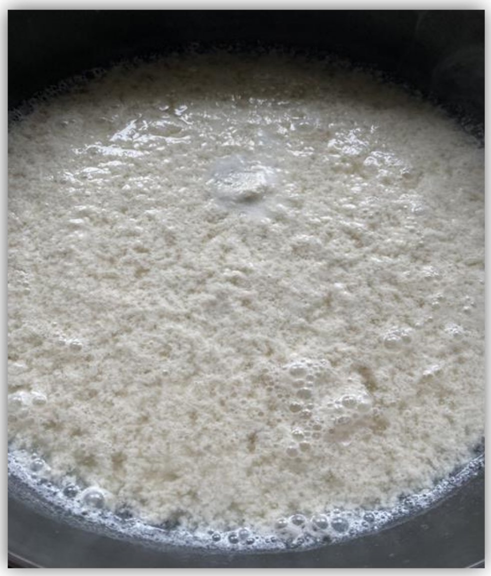
For selecting the desired combination, the preparation of each milk is done as mentioned below.

To extract jackfruit seed milk, the first step is to clean the seeds and soak them for 24 hours. Once the seeds have been soaked the seeds were ground using a blender or food processor with water in a high-speed blender and blended until the mixture becomes milky and smooth. The mixture was strained through a fine mesh sieve or cheesecloth to remove any solids and separate the milk from the pulp as suggested by Muthukumarappan *et al.,* (2018).

To extract groundnut milk, the groundnuts were soaked in water for at least 6 hours or overnight. Once the peanuts have been soaked, the water was drained and rinsed thoroughly. Then, the peanuts were blend with fresh water in a high-speed blender until they are finely ground till the mixture becomes milky, then the mixture was strained through a fine mesh sieve or cheesecloth to remove any solids and separate the milk from the pulp Koppala *et al.,* (2017).

In the process of extracting soy milk, the soya beans were soaked overnight, and was cleaned manually by thoroughly washing the beans to remove the seedcoat. After draining and rinsing, the soaked soybeans were ground in a blender with fresh water to create a milky liquid (Anderson *et al.,* 1995).

Plate 5: Coagulation of milk with different coagulants



Coagulation with vinegar

Coagulation with lemon juice

Coagulation with 10% Ciric acid

Plate 6. Combinations of milk

Extracted milk in different combinations

Plate 7. Paneer from different combination

100% jackfruit seed milk paneer

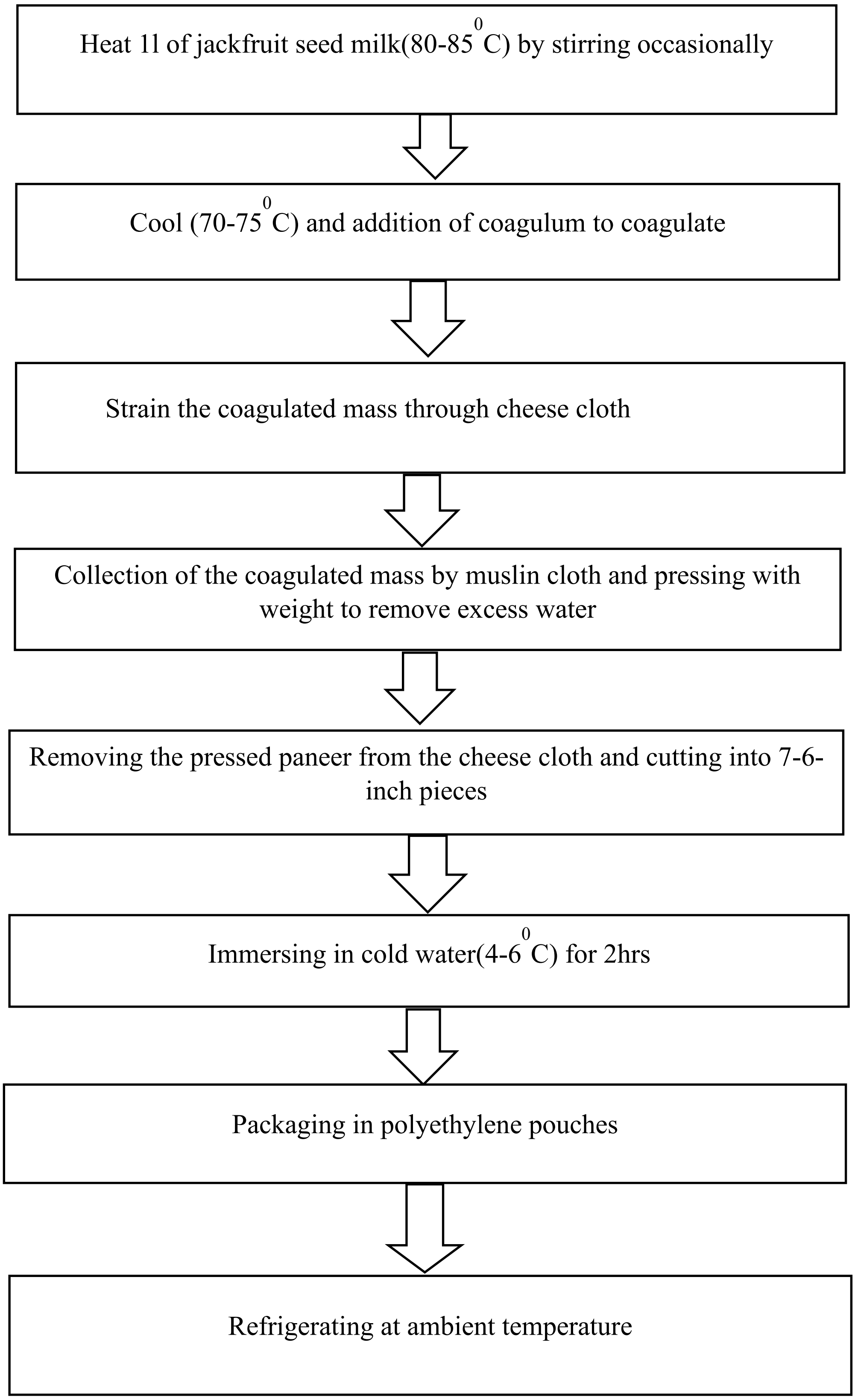
Groundnut milk(50%)+jackfruit seed milk (50%) paneer

Soya milk (50%)+Jackfruit seed milk(50%) paneer

soya milk (25%)+ground nut milk(25%)+jack fruit seed milk(50%) paneer

3.5.2 Preparation of paneer

Figure 2: Flow diagram for preparation of jackfruit seed paneer



3.6 SENSORY ACCEPTABILITY

Sensory acceptability of the developed products (12 treatments) was ascertained by a panel of judges using hedonic rating scale. The best variety of paneer was selected for quality analysis and shelf-life study. Kruskal - Wallis's test was used for comparing the ranks of sensory evaluation. The panel of judges were selected among students and trained teachers. The hedonic score card was prepared in the ranking 1-9 through which the best and least treatment was selected.

3.7 QUALITY ANALYSIS OF PANEER

Total solid content, moisture and other major components like carbohydrate, fat, protein, Fiber, and calcium of the selected paneer was analyzed using standard techniques. Textural profile of the paneer was also analyzed. The techniques are mentioned in table 3

Table 3: Methods of analysis of nutrient composition of jack fruit seed panner

Constituents	**Method adopted**
Total solid content	Babcock Method
Moisture	IS 4333 (Part II)
Carbohydrate	Anthrone method
Fat	Min and Steenson (1998)
Protein	Bradford's method
Fiber	Rahul *et al.,* (2010)
Calcium	Flame photometry

To determine the textural profile of jackfruit seed paneer, sensory evaluation is conducted. Sensory evaluation involves trained panellists who assess the texture of the paneer using various criteria such as creaminess, graininess, firmness, and overall mouthfeel. Panellists can rate these attributes on a scale to provide a qualitative assessment of the textural properties (Khader *et al.,* 2019).

Panellists evaluated the paneer's texture using methods like descriptive analysis or a sensory attribute scoring system. By combining instrumental and sensory analyses, a comprehensive understanding of the textural profile of jackfruit seed

Plate 8. Preparation of Jackfruit seed soya paneer

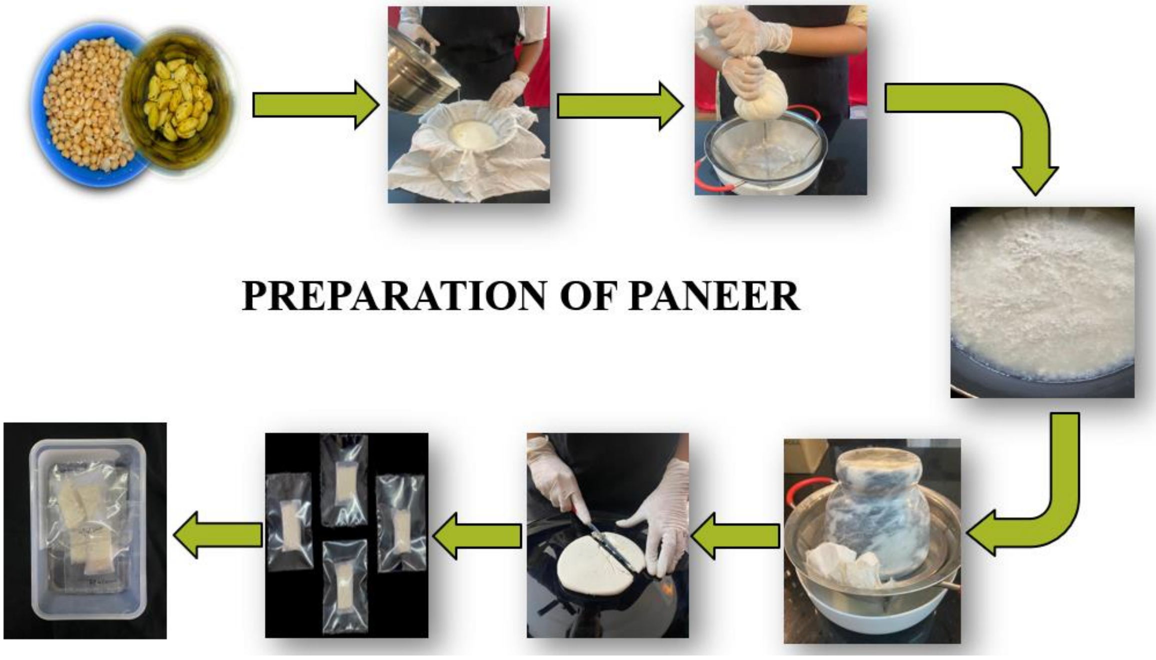


Plate 9. Developed jackfruit seed soya milk paneer

Jack fruit seed soya milk paneer

paneer can be obtained, aiding in quality control, product development, and consumer acceptance (Thakur N *et al.,* 2018).

3.8 SHELF-LIFE STABILITY OF THE JACKFRUIT SEED MILK SOFT CHEESE (PANEER)

Sensory parameters, changes in acidity and microbial growth if any during the period of storage was studied.

3.8.1 MICROBIAL PROFILE

The paneer developed was wrapped in butter paper and tightly heat sealed in polyethylene pouches which was then stored in refrigerator for a period of one week. Total viable count, Yeast, mould and Coliform count were analyzed, number of individual microbes were also counted and reported as CFU/g.

3.9 COST OF PRODUCTION

Cost of the Jackfruit seed paneer was worked out. Variable cost of the product includes cost of food materials, packaging charge and labor cost. The fixed cost of the product includes cost of equipment, and other materials. The total cost of the product was calculated by assessing fixed cost and variable cost. The cost of Paneer was compared with the cost of other paneers available in the market.

3.10 STATISTICAL ANALYSIS

Statistical tests like ANOVA and other suitable tests were used to compare the means. Ranked sensory scores was compared using Kruskall - Wallis test.

RESULTS

4.RESULTS

The results of the present study **"Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk"** are detailed in this chapter under the following headings.

4.1. Standardization of extraction of Jackfruit seed milk

4.2. Pre-processing techniques

4.3. Extraction of Jackfruit seed milk

4.4. Screening of best treatment

4.5. Development of jackfruit seed milk soft cheese (paneer)

4.6. Sensory acceptability of the developed soft cheese (paneer)

4.7. Quality analysis of paneer

4.8. Shelf-life stability of the jackfruit seed milk soft cheese (paneer)

4.9. Cost of production

4.1. STANDARDIZATION OF EXTRACTION OF JACKFRUIT SEED MILK

Jackfruit (*Artocarpus heterophyllus*) is a tropical fruit widely consumed for its distinctive flavour and versatile culinary applications. There is a large amount of waste generated by the Jackfruit (*Artocarpus heterophyllus* Lam), processing industries in the form of peel, seed and latex. These wastes if not disposed correctly are seen to cause serious environmental problems such as water pollution, unpleasant odours, asphyxiation, and greenhouse gas emissions. The utilization of bioactive compound from these waste for its potential applications as antioxidant, antimicrobial, flavouring, colorant, and texturing agents are most important (Zavala *et al.,* 2011).

While the flesh of the jackfruit is well-known, the seeds are often overlooked despite their high nutritional value. Jackfruit seeds are rich in protein, dietary fiber, antioxidants, and minerals, making them a valuable ingredient for various food products. One innovative use of jackfruit seeds is the extraction of milk, which can serve as a plant-based alternative to dairy milk. To ensure consistent quality and to optimize production processes of the end product, standardization of jackfruit seed milk extraction process is essential.

4.1.1. Selection of fruits for seed collection

When it comes to selecting jackfruit varieties for seed collection, two popular varieties of Kerala, *Varikka cv* and *Koozha cv* were chosen. These varieties are commonly found in South India and are known for their delicious taste and large fruit size.

Jackfruit consist of 10–15% of seed which is rich in digestible starch, protein, minerals, and vitamins and contains phytonutrients such as saponins, lignans, and isoflavones which known to provide beneficial roles for human health. Single jackfruit tree produces 390 kg seed per annum (Ndyomugyenyi *et al*., 2014). It is rich source of carbohydrate (40%) and protein (7%) and very less amount of fat. The starch is major component in jackfruit seed and has similar properties to those present in cereals which is a good alternative for food industries such as in soups, sauces, and creams where transparency is not highly required. Jackfruit seed protein has potential to develop emulsion-based food products (Zhang *et al*., 2019). Jackfruit seed flour can be used as thickener and binding agent in the food systems. The jackfruit seed shows the maximum amount of antioxidant activity which is measured in DPPH (2,2-diphenyl-1-picrylhydrazyl radical) was found 8.76 % (Hossain *et al*., 2020). Various researchers have reported that jackfruit seed extract has anti-inflammatory properties indicating its anti-cancer properties (Yao *et al.,* 2016). The jackfruit starch has wide range of structures and functionalities so that the native starch and modified starch of jackfruit seed provide a strong basis for their innovative applications in the food and non-food industries (Yutong *et al*., 2020).

The seeds of both varieties were selected according to the fruit size, seed viability, appearance, seed maturity and seed quality from local markets.

v_1=*Varikka*

v_2=*Koozha*

4.1.2. Stage of maturity

The stage of maturity of jackfruit seeds is an essential factor to consider for their collection and subsequent use. The colour and texture of the seed was observed. Fully ripe jackfruit seeds typically have a dark brown to black colour, indicating that they have fully developed. In terms of texture, fully matured seeds are firmer and have a denser consistency compared to immature seeds. Immature seeds, on the other hand, are usually white or pale in colour and softer in texture. Seeds of fruits at different maturity levels, i.e., in the 7-8 (immature), 10-12 (mature), and 13-16 weeks after anthesis or after-ripening (ripe) were chosen for the investigation. The sample stages were selected on the basis of the seed removal from the fruit during the processing, as they are more likely to be viable and capable of producing more milk yield.

4.2. PRE-PROCESSING TECHNIQUES

The pre-processing techniques of jackfruit seeds were done to make them more palatable, digestible and versatile for consumption or utilization in various culinary applications. The seeds from both varieties were cleaned manually under running under water to remove any dirt or debris and the white arils (seed coat) were peeled off manually using a stainless-steel knife before further processing. The brown inner skin coat was also removed manually after soaking the seed for 24 hours to obtain the pure white milk.

4.2.1. Soaking media

The jackfruit seeds from both the cultivars were soaked for different time period to find out the best treatment in different soaking media *viz*.

s_1= Water

s_2= 2% Sodium bi carbonate

s_3= 3% Sodium hydroxide

s_4= 2% Salt water (NaCl)

The soaking treatments were standardized and the treatment combinations are depicted in the table 01.

4.2.2. Heat treatments

Both v_1 and v_2 with the different maturity indices were subjected to the following heat treatments.

h_1= Steaming

h_2= Pressure cooking

The pre-treated seeds were cleaned under running water, and the skin was peeled off manually before further processing.

The time and temperature for the heat treatments were standardized and the combinations are depicted in the table 02.

4.3. EXTRACTION OF JACKFRUIT SEED MILK

The pre-processed and washed jackfruit seeds were weighed, and blended with water (ratio 1:1.5 w/v) until they form a smooth and creamy mixture. The mixture was strained through a fine mesh strainer and a cheese cloth to remove any remaining chunks or pieces of skin. The resulting liquid which was rich and creamy was then transferred into a glass jar and stored in refrigerator at 4°C until further processing. The method of extraction is detailed in Fig 01.

4.4. SCREENING OF BEST TREATMENT

Jackfruit seed milk obtained from the 24 treatments (16-soaking and 8-heat) was tested for its yield ratio, sensory attributes and curd setting properties. The best treatment from the 24 treatments was chosen for formulation of soft cheese (paneer).

4.4.1. Yield ratio

Yield ratio of the 24 treatments were calculated as per the procedure quoted in section 3.4. The results of yield ratio are depicted in the table 04 and 05.

Table: 04 Yield ratio of jackfruit seed milk in different soaking media

Soaking treatments	**Yield ratio**
$v_1m_1s_1$	0.67^{a}
$v_2m_1s_1$	0.63^{a}
$v_1m_1s_2$	0.64^{a}
$v_2m_1s_2$	0.61^{b}
$v_1m_1s_3$	0.65^{a}
$v_2m_1s_3$	0.64^{a}
$v_1m_1s_4$	0.65^{a}
$v_2m_1s_4$	0.60^{b}
$v_1m_2s_1$	0.59^{b}
$v_2m_2s_1$	0.61^{b}
$v_1m_2s_2$	0.57^{ab}
$v_2m_2s_2$	0.65^{a}
$v_1m_2s_3$	0.59^{b}
$v_2m_2s_3$	0.54^{ab}
$v_1m_2s_4$	0.63^{b}
$v_2m_2s_4$	0.61^{b}
±SE(m)	0.002
CV (%)	1.927

Treatments with same letters are not significantly different.

The yield ratio of plant-based milk refers to the proportion of milk obtained from a given quantity of seeds during the extraction process. Studies have explored the impact of different soaking media on the yield ratio of plant-based milk. For instance, research conducted by Singh *et al.* (2019) investigated the effects of various soaking media, such as water, and salt solution. They found that the yield ratio of plant-based milk differed significantly, on soaking in water overnight resulting in higher milk yields.

The table 04 represents yield ratio of two varieties of jackfruit seed samples which were soaked in different soaking media. From the above table it is clear that treatment $v_1m_1s_1$ (*varikka* fully ripe soaked in water) had the highest yield ratio (0.67) and $v_2m_2s_3$ (*koozha* fully matured soaked in sodium hydroxide) (0.54) had the least value. It can be noted that when statistically analyzed most of the treatments are on par with each other.

Table: 05 Yield ratio of jackfruit seed milk with different heat treatments

Heat treatments	**Yield ratio**
$v_1m_1h_1$	0.63^a
$v_2m_1h_1$	0.56^b
$v_1m_2h_1$	0.55^b
$v_2m_2h_1$	0.54^b
$v_1m_1h_2$	0.61^a
$v_2m_1h_2$	0.60^a
$v_1m_2h_2$	0.61^a
$v_2m_2h_2$	0.59^b
±SE(m)	0.003
CV (%)	1.251

Treatments with same letters are not significantly different.

The table 05 represents yield ratio of two varieties of jack fruit seed samples which are subjected to different heat treatments. From the above table it is clear that treatment $v_1m_1h_1$ (*varikka* fully ripe in steaming) had the highest yield ratio (0.63) and $v_2m_2h_1$ (*koozha* fully matured in steaming) had the least value (0.54). The values showed a similar pattern to that of the ones depicted in Table 04

4.4.2. Curd setting properties

The curd setting properties of the milk samples were analyzed by keeping the extracted milk overnight to ferment. The curd setting properties were assessed using sensory studies and the results are shown in table 06.

Table: 06 Curd setting properties of the extracted jackfruit seed milk samples in different soaking media.

Treatments	Color and appearance	Taste	Texture & consistency	Flavour	Overall acceptability
$v_1m_1s_1$	7.7^{a}	7.0^{abi}	7.3^{a}	7.3^{a}	7.325^{a}
$v_2m_1s_1$	$7.4^{abcdefgi}$	7.4^{a}	6.5^{bcdefg}	$6.6^{abfhijkl}$	7.025^{ab}
$v_1m_1s_2$	$7.1^{bcdfghi}$	6.3^{abcdeg}	6.2^{bcdeg}	5.5^{cdegj}	6.125^{deghi}
$v_2m_1s_2$	6.7^{fh}	6.2^{abcdg}	5.5^{bcdeg}	5.1^{ceghj}	5.921^{deghi}
$v_1m_1s_3$	6.2^{fgh}	3.7^{h}	5.3^{bcde}	4.3^{cd}	4.825^{cd}
$v_2m_1s_3$	6.5^{fh}	3.5^{h}	5.7^{c}	3.1^{d}	4.776^{cd}
$v_1m_1s_4$	6.5^{fh}	6.2^{abcdg}	6.3^{abdfg}	7.0^{abfikl}	6.112^{abfgk}
$v_2m_1s_4$	6.3^{fh}	5.9^{abcdg}	6.4^{af}	$5.6^{efhijkl}$	6.350^{fghjk}
$v_1m_2s_1$	7.6^{abcegi}	6.1^{abci}	6.1^{bcdeg}	$6.0^{efhijkl}$	6.450^{fghijk}
$v_2m_2s_1$	$7.2^{bcdfghi}$	4.9^{hi}	6.1^{cde}	5.1^{cdeg}	5.365^{cdei}
$v_1m_2s_2$	$6.3^{cdefghi}$	4.7^{hi}	6.3^{abdefg}	4.9^{cdg}	5.568^{cdei}
$v_2m_2s_2$	$7.1^{bcdfghi}$	6.1^{abcdg}	6.5^{abdfg}	$6.3^{afhijkl}$	6.611^{afghjk}
$v_1m_2s_3$	5.6^{abcdei}	5.7^{abci}	4.1^{cd}	4.1^{cdg}	5.237^{cdei}
$v_2m_2s_3$	5.3^{abcdei}	$4.9^{abcdefgj}$	5.3^{c}	3.7^{d}	4.586^{cd}
$v_1m_2s_4$	6.4^{h}	7.1^{abi}	6.3^{bcdefg}	$6.2^{abfhijkl}$	6.481^{fghjk}
$v_2m_2s_4$	6.7^{fh}	5.9^{abc}	7.0^{abfg}	$5.7^{efghijk}$	6.431^{fghik}
$\chi 2$	47.58	98.128	56.135	96.112	93.721
P_value	0.002	0	0	0	0

Treatments combination with same letter are not significantly different

The curd setting for jackfruit seed milk is based on knowledge about the principles of curdling plant-based milks and the recommended practices that was tried with jackfruit seed milk.

From the table 06, it is clear that treatment $v_1m_1s_1$ (*varikka* fully ripe soaked in water) (7.325) had the highest overall acceptability and $v_2m_2s_3$ (*koozha* fully ripe soaked in sodium hydroxide) (4.586) had the least value when tested for the curd setting properties of the extracted milk samples. However, the results show that the mean values are not significantly different to each other.

The treatment $v_2m_2s_3$ (*koozha* fully ripe soaked in sodium hydroxide) had the least overall acceptability because of change in color and off flavour, but it was found that $v_1m_1s_1$ (*varikka* fully ripe soaked in water) had better curd setting properties, good flavour and appearance during the sensory analysis by the trained panelist.

Table: 07 Curd setting properties of the extracted jackfruit seed milk samples in different Heat treatments

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
$v_1m_1h_1$	7.6^{a}	7.0^{bdefg}	6.9^{ab}	7.0^{a}	7.075^{a}
$v_2m_1h_1$	7.4^{abcdef}	7.4^{a}	6.5^{bcdefg}	6.6^{abfh}	7.025^{abf}
$v_1m_2h_1$	7.9^{a}	6.0^{abc}	6.4^{bcdefg}	5.8^{efh}	6.525^{afgh}
$v_2m_2h_1$	6.7^{dfgh}	4.8^{h}	6.3^{bcdefg}	4.1^{cdg}	5.400^{cdeh}
$v_1m_1h_2$	6.7^{dfh}	6.5^{abcdeg}	7.1^{af}	5.9^{efh}	6.550^{afgh}
$v_2m_1h_2$	7.4^{a}	7.1^{bdefg}	7.0^{af}	6.9^{abfh}	7.010^{b}
$v_1m_2h_2$	7.4^{a}	6.5^{bcdefg}	7.4^{ab}	6.6^{abfh}	7.025^{abf}
$v_2m_2h_2$	6.5^{dfgh}	6.9^{bcdefg}	6.7^{abdfg}	7.0^{a}	6.775^{abfg}
$\chi 2$	11.723	26.13	14.218	21.125	27.135
CV (%)	0.012	0	0.001	0	0

Treatments with same letters are not significantly different

The table 07 represents curd setting properties of the two varieties of jack fruit seed samples which were subjected to different heat treatments. From the above table it is clear that treatment $v_1m_1h_1$ (*varikka* fully ripe steaming) had the highest sensory attributes (7.075) and $v_2m_2h_1$ (*koozha* fully matured in steaming) (5.400) had the least value for overall acceptability. However, the treatment $v_1m_1h_2$ (*varikka* fully ripe in pressure cooking) had good taste, flavour and appearance on sensory analysis making it the best treatment for curd setting and $v_2m_2h_1$ (*koozha* fully matured in steaming) had the least acceptability due to its least acceptance of texture, taste, color and the overall acceptability.

4.4.3. Sensory attributes

The sensory attributes of the milk samples were evaluated to select the treatment with highest overall acceptability as the best milk for further processing. The sensory attributes of the 24 samples (soaking and heat treatments) are depicted in table 08 and 09.

Table: 08 Sensory attributes of the extracted jackfruit seed milk samples in different soaking media

Sample	Color and appearance	Taste	Texture	Flavour	Overall acceptability
$v_1m_1s_1$	7.7^{abi}	7.9^{ab}	7.3^{a}	7.5^{b}	7.600^{a}
$v_2m_1s_1$	7.6^{abi}	6.6^{abcdeg}	6.9^{afg}	7.1^{abkl}	7.051^{abfgjk}
$v_1m_1s_2$	$7.2^{abcdefghi}$	5.8^{aci}	7.0^{afg}	5.2^{cdeghj}	6.300^{efghi}
$v_2m_1s_2$	$7.1^{abcdefghi}$	6.3^{abcdeg}	6.2^{bcdeg}	5.0^{cdeghj}	6.125^{deghi}
$v_1m_1s_3$	6.7^{fh}	6.2^{abcdg}	5.6^{bcdeg}	5.2^{cdeghj}	5.925^{deghi}
$v_2m_1s_3$	6.8^{fh}	3.7^{h}	5.3^{c}	3.7^{d}	4.876^{c}
$v_1m_1s_4$	$7.2^{abcdefghi}$	4.7^{hi}	5.8^{bcdeg}	4.6^{cdeg}	5.575^{cdei}
$v_2m_1s_4$	7.6^{abi}	6.4^{abcdg}	6.8^{abfg}	$6.2^{abfhijkl}$	6.751^{abfgjk}
$v_1m_2s_1$	7.4^{abi}	$7.0^{bcdefgj}$	6.9^{afg}	7.0^{abkl}	7.075^{abfgk}
$v_2m_2s_1$	6.7^{dfh}	6.5^{abcdeg}	7.2^{a}	$5.9^{efhijkl}$	6.550^{afghjk}
$v_1m_2s_2$	$7.1^{abcdefghi}$	6.3^{abcdeg}	6.2^{bcdeg}	5.0^{cdegj}	6.126^{deghi}
$v_2m_2s_2$	6.1^{cdefgh}	3.9^{h}	5.5^{bcde}	4.1^{cd}	4.900^{c}
$v_1m_2s_3$	6.7^{fh}	6.2^{abcdg}	5.6^{bcde}	5.2^{ceghj}	5.925^{deghi}
$v_2m_2s_3$	6.7^{fh}	4.5^{hi}	6.3^{bcdeg}	4.1^{cdg}	5.400^{cdehi}
$v_1m_2s_4$	7.6^{a}	6.0^{abci}	6.4^{bcdeg}	$5.8^{efghijk}$	6.525^{afghjk}
$v_2m_2s_4$	$7.0^{abcdefghi}$	4.8^{hi}	5.4^{bcde}	4.6^{cdeg}	5.450^{cde}
χ^2	47.213	121.536	58.691	97.013	98.782
P_value	0.017	0.001	0.021	0.002	0.001

Treatments combination with same letter are not significantly different

4.4.3.a *Color and Appearance*

From the result of sensory evaluation, the mean rank value for color and appearance can be noted. Treatment $v_1m_1s_1$ had the highest score (7.7) for color and appearance. While $v_1m_2s_3$ had the least value (6.1). From the results it can also be noticed that the values of color and appearance for $v_2m_1s_1$, $v_2m_1s_1$, $v_2m_1s_4$ and $v_1m_2s_1$ was on par statistically and had similar values.

4.4.3.b *Taste*

The mean rank value for the attribute taste ranged between 3.7 - 7.9. From the above table it is evident that the proportion $v_1m_1s_1$ had the highest rank (7.9) for taste and $v_2m_1s_3$ got the least rank (3.7).

4.4.3.c *Texture*

From the result it was observed that maximum score for texture was noted for the treatment $v_1m_1s_1$ (7.3). while the least score was noted for the treatment $v_2m_1s_3$ (5.3), the results of $v_1m_2s_1$ (6.9), $v_2m_1s_4$ (6.8) and $v_2m_1s_1$ (6.9) was on par.

4.4.3.d *Flavour*

From the result it was evident that the treatment $v_1m_1s_1$ got maximum score (7.5) for the attribute flavor. While the treatment $v_1m_1s_2$ (5.2) and $v_1m_1s_3$ (5.2) was on par for flavor attribute.

4.4.3.e *Overall acceptability*

From the statistical analysis of overall acceptability, it was found that the treatment $v_1s_1m_1$(7.600) was most preferred than the other treatments. The remaining treatment $v_2m_1s_3$ (4.876) and $v_2m_2s_2$ (4.900) are on par.

Table: 09 Sensory attributes of the extracted jackfruit seed milk samples in different Heat treatment

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
$v_1m_1h_1$	7.7^{abcde}	6.4^{abcdeg}	6.8^{abfg}	6.2^{abfh}	6.775^{abfg}
$v_2m_1h_1$	6.4^{fh}	7.2^{defg}	6.4^{abfg}	6.5^{abfh}	6.625^{afgh}
$v_1m_2h_1$	7.3^{abcdef}	6.7^{abc}	6.8^{adbfg}	6.6^{abfh}	6.900^{abfg}
$v_2m_2h_1$	7.5^{abcdef}	5.5^{ab}	6.6^{abfg}	5.5^{cefgh}	6.275^{efgh}
$v_1m_1h_2$	7.4^{abcdef}	7.1^{defg}	7.0^{a}	6.9^{a}	7.100^{a}
$v_2m_1h_2$	7.6^{abcegf}	6.6^{abcdeg}	6.9^{abdfg}	7.1^{ab}	7.050^{abfg}
$v_1m_2h_2$	6.7^{fh}	6.2^{abcdg}	5.6^{bcbeg}	5.5^{cegh}	5.925^{degh}
$v_2m_2h_2$	$7.2^{abcdefg}$	4.7^{h}	5.8^{bcde}	4.6^{cdeg}	5.575^{cde}
$\chi2$	43.258	96.137	59.384	98.782	107.146
P_value	0.002	0	0	0	0

Treatments with same letters are not significantly different

4.4.4.a *Color and Appearance*

The results showed that the mean rank values for color and appearance ranged from 6.4-7.7. The treatment $v_1m_1h_1$ (7.7) got maximum scores for color and appearance. While v_2m_2h (6.4) got the least score. It can be noted that most of the treatments did not have significant differences in color and appearance when tested statistically.

4.4.4.b *Taste*

It was determined from the preceding table that the range of the mean rank value for the attribute taste is between 4.7- 7.2. The treatment $v_2m_1h_1$ (7.2) had maximum score for taste and treatment $v_2m_2h_2$ (4.7) had the least score for taste.

4.4.4.c *Texture*

The mean rank value for texture ranges between 5.8- 7.0. From the result it is clear that the treatment $v_1m_1h_1$ (7.0) had the highest rank. While $v_1m_2h_2$ (5.6) had the least score for texture.

4.4.4.d *Flavour*

The above results showed that the mean value of the flavour peaked for $v_2m_1h_2$ (7.1) and least score was for $v_2m_2h_2$ (4.6) for its flavour profile.

4.4.4.e *Overall acceptability*

From the results of overall acceptability, it is evident that the treatment $v_1m_1h_2$ (7.100) had the highest score, while $v_2m_2h_2$ (5.575) had the least score for overall acceptability.

From the above findings it could be concluded that on comparing the soaking and heat treatments, $v_1m_1s_1$ (*varikka* fully ripe soaked in water) which has the highest values for yield, sensory qualities and curd setting properties was the best treatment. The milk extracted from this treatment was taken for the development of soft cheese (paneer).

4.5. DEVELOPMENT OF JACKFRUIT SEED MILK SOFT CHEESE (PANEER)

Plant-based diets offer several benefits, including being free from cholesterol, cost-effective, and environmentally friendly. Moreover, individuals following a vegan lifestyle and dealing with lactose intolerance or milk allergies have a strong need for plant-based alternatives that provide diverse and health-promoting nutrients. These alternatives can effectively replace dairy proteins in the production of cream and cheese without containing any dairy ingredients (Grossmann *et al.,* 2021). Lentil, pea, and soybean proteins have been successfully utilized as substitutes for animal proteins in various non-dairy food systems (Ningtyas *et al.,* 2021).

The development of jackfruit seed milk soft cheese (paneer) marks an exciting innovation in the realm of plant-based alternatives. Utilizing the often overlooked and underutilized jackfruit seeds, this unique product will provide a sustainable and nutritious option for individuals seeking a dairy-free alternative to traditional paneer. The jackfruit seeds got transformed into a creamy, cheese-like texture that closely resembles the original paneer.

4.5.1. Selection of Coagulum for paneer preparation

Selection of coagulum depends on the intensity of the jackfruit seed milk to coagulate on addition of a coagula. The temperature of the milk heated before the addition of coagula and percentage of coagula added to coagulate is noted for better coagulation.

c_1 = vinegar

c_2 = lemon juice

c_3 = 10 % citric acid.

Three different coagula were added to the selected jack fruit seed milk to determine the best coagula for the coagulation to prepare jack fruit seed milk paneer.

According to Jain *et al.* (1992) the yield of soy milk increases with increase of coagulation temperature within the tested range of temperature. It was found that hardness, cohesiveness, chewiness and adhesiveness increase with coagulation temperature up to 90ºC. The results of coagulation were examined on introduction of the coagulants under 90ºC. The results of the sensory evaluation to determine the best coagulant is shown in table 10,11 and 12.

4.5.2 Coagulation of combinations of milk with vinegar

Coagulation of jackfruit seed milk using vinegar is an essential step in the process of turning the milk into a solid form, to cheese-making. When vinegar is added to jackfruit seed milk, it triggers a coagulation reaction, causing the proteins in the milk to denature and come together, forming curds. According to Rashmi *et al.* (2020) groundnut milk is heated up to 70°C. As the mixture reaches the desired temperature, citric acid and vinegar is introduced as a coagulant, initiating the curdling process. Continuously stirring the mixture facilitates the separation of soluble solids and whey, resulting in a solid mass.

The combinations of milk were treated with vinegar to evaluate the coagulation and the curdling of milk. The coagulation of the combinations of milk was scored by sensory parameters to select the best coagulum in table no:10.

Table: 10 Sensory parameters of milk with Vinegar

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1	6.0^b	5.7^b	5.5^b	5.5^b	5.613^b
f_2	6.0^b	6.2^a	5.7^b	5.9^b	5.973^b
f_3	7.7^a	7.8^a	7.2^a	7.1^a	7.515^a
f_4	6.2^b	5.9^b	6.1^b	5.7^b	5.975^b
$\chi 2$	16.155	17.137	17.378	11.532	21.117
P_value	0.001	0.001	0.001	0.006	0

4.5.1.a *Color and appearance*

From the evaluation of color and appearance it was found that the proportion f_3 (7.7) had the highest score and the remaining proportions f_1(6.0), f_2(6.0) and f_4(6.2) are on par.

4.5.1.b *Taste*

From the result of sensory evaluation, it was analyzed that the proportion f_3(7.7) had the maximum score for the attribute taste. While the other proportion f_1(5.7), f_2(6.2) and f_4(5.9) was on par.

4.5.2.c *Texture*

From the evaluation of texture, it was found that the mean rank score ranges between 5.5-7.2. The proportion f_3(7.2) had maximum score for the attribute texture and the remaining proportions f_1(5.5), f_2(5.7) and f_4(6.1) are on par.

4.5.2.d *Flavour*

From the above table it was observed that out of the four proportions the proportion f_3(7.1) got the highest score for attribute flavour, while other proportions such as f_1(5.5), f_2(5.9) and f_4(5.7) are on par for flavour.

4.5.2.e *Overall acceptability*

The proportion f_3(7.515) received highest score according to the statistical analysis of overall acceptability, whereas the other proportions f_1(5.613), f_2(5.973) and f_4(5.975) was on par.

4.5.3 Coagulation of combinations of milk with lemon juice

Coagulation of jackfruit seed milk with lemon juice is a common method to transform the liquid into a curd-like texture, making it suitable for various culinary applications. Lemon juice, as an acidic coagulant, contains citric acid, which acts on the proteins in the jackfruit seed milk, causing them to denature and form a gel-like structure.

The combinations of milk were treated with lemon juice to evaluate the coagulation and the curdling of milk. The coagulation of the combinations of milk were scored by sensory parameters to select the best coagulum in table no:11.

Table 11: Sensory parameters of milk with Lemon juice

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1	5.5^b	5.6^b	6.0^a	6.5^a	5.900^a
f_2	6.3^a	6.0^a	5.9^a	6.4^a	6.150^a
f_3	7.1^b	7.2^b	7.1^b	7.3^b	7.175^a
f_4	6.4^b	6.4^a	6.3^b	6.5^a	6.400^b
$\chi 2$	11.821	13.143	11.723	13.689	22.158
P_value	0.0016	0.01	0.0016	0.006	0

4.5.3.a ***Color and appearance***

The outcome showed that the range of the mean rank value for color and appearance is between 5.5-7.1. The proportion f_3(7.1) received the highest possible color and appearance score. F_1(5.5) received the lowest rating for color and appearance.

4.5.3.b ***Taste***

From the result it was observed that the mean rank value for attribute taste ranged between 5.6-7.2. The proportion f_3(7.2) earned the highest score for the attribute taste, according to the sensory evaluation results. Whereas the proportion f_1(5.6) had the least value

4.5.3.c ***Texture***

According to the findings, the mean rank value for the attribute texture ranged from 5.9-7.1. The findings of the sensory evaluation indicated that the proportion f_3(7.1) received the highest rating. While the proportion f_2(5.9) and f_2(6.0) was on par having the least rating.

4.5.3.d ***Flavour***

The mean rank score for the attribute flavour ranged from 6.4-7.3. According to the sensory assessment of flavour, f_3(7.3) received the highest rating, while the other proportions f_1(6.5), f_2(6.4) and f_4(6.5) was on par.

4.5.3.e ***Overall acceptability***

From the result of overall acceptability, it is evident that the proportion f_3(7.175) had the maximum score for overall acceptability than other proportions and it was most preferred one. While the proportion f_1(5.900) had least score.

4.5.4 Coagulation of combinations of milk with 10% Citric acid

Studies by Smita *et al*. (2014) explained that different proportions of soymilk and groundnut milk were combined according to the experimental plan. The mixture was then heated to 70°C, and citric acid was added as a coagulant at a concentration of 2 gm per Liter of milk. The mixture was continuously stirred until the soluble solids and whey were visually separated. The resulting solid was filtered through muslin cloth and pressed in a paneer press for 15-20 minutes at a constant pressure for each sample.

The combinations of milk were treated with 10% Citric acid to evaluate the coagulation and the curdling of milk. The coagulation of the combinations of milk was scored by sensory parameters to select the best coagulum in table no:12.

Table 12: Sensory parameters of milk with 10% Citric acid

Treatment	**Color and appearance**	**Taste**	**Texture**	**Flavour**	**Overall acceptability**
f_1	6.0^a	4.4^b	5.1^b	4.3^b	4.375^b
f_2	6.2^b	5.1^a	5.9^a	5.1^a	5.113^a
f_3	6.0^a	5.2^b	5.1^b	5.3^b	4.875^b
f_4	6.1^a	5.4^b	5.2^b	5.4^b	4.895^b
$\chi 2$	14.855	12.192	15.687	9.771	19.615
P_value	0.001	0	0	0	0

4.5.4.a ***Color and appearance***

From the evaluation of color and appearance it was found that the proportion f_2 (6.2) had the highest score and the remaining proportions f_1(6.0) and f_3(6.0) are on par.

4.5.4.b ***Taste***

From the result of sensory evaluation, it was analyzed that the proportion f_4(5.4) had the maximum score for the attribute taste. While the proportion f_1(4.4) had the least score.

4.5.4.c ***Texture***

From the evaluation of texture, it was found that the mean rank score ranges between 5.1-5.9. The proportion f_2(5.9) had maximum score for the attribute texture and the remaining proportions f_1(5.1) and f_3(5.1) are on par.

4.5.4.d *Flavour*

From the above table it was observed that out of the four proportions the proportion f_4(5.4) got the highest score for attribute flavour, while other proportions such as f_1(4.3) had least score for flavour.

4.5.4.e *Overall acceptability*

The proportion f_2(5.113) received highest score according to the statistical analysis of overall acceptability, whereas the proportions f_1(4.375) had the least score.

4.5.4.f *Selection of best Coagulum*

It was determined from the sensory evaluation of jackfruit seed milk with regard to various factors, such as color and appearance, taste, texture, flavour and overall acceptability, that the jackfruit seed milk was best coagulated with vinegar by receiving the maximum ratings for all the features. So, it was selected for the preparation of paneer.

4.5.5. Formulation for paneer

The best screened jackfruit seed milk was constituted in the following combinations for the formulation of paneer.

- f_1- jackfruit seed milk (100 %)
- f_2- Jackfruit seed milk (50%) + Groundnut milk (50%)
- f_3- Jackfruit seed milk (50%) + soy milk (50%)
- f_4- Jackfruit milk (50%) + soy milk (25%) + groundnut milk (25%)

Table 13: Yield ratio of different combination of milk

Treatment	Value
f_1- jackfruit seed milk (100 %)	0.71[b]
f_2- Jackfruit seed milk (50%) + Groundnut milk (50%)	0.76[a]
f_3- Jackfruit seed milk (50%) + soy milk (50%)	0.79[a]
f_4- Jackfruit milk (50%) + soy milk (25%) + groundnut milk (25%)	0.73[b]
±SE (m)	0.004
CV%	1.757

Values are means of triplicates
Treatments with same letters are not significantly different

The table represents yield ratio of different combinations of milk for the formulation of paneer. (Jackfruit seed milk (50%) + soy milk (50%) (0.79) gives highest yield ratio and (f1- jackfruit seed milk (100 %) (0.71) had the least value. From the table it is also clear that though f_3 had a higher score f_2 values were on par.

Table no:14 Sensory evaluation of combinations of milk for formulation of paneer

Combinations of milk	**Color and appearance**	**Taste**	**Texture**	**Flavour**	**Overall acceptability**
f_1	5.5[a]	5.8[a]	6.0[a]	6.2[a]	5.600[a]
f_2	6.1[a]	6.0[a]	5.7[b]	6.4[a]	6.150[a]
f_3	7.1[a]	7.2[a]	7.1[a]	7.3[a]	7.128[a]
f_4	6.4[a]	6.4[a]	6.3[b]	6.5[a]	6.300[a]
χ^2	11.821	13.143	11.723	13.689	21.158
P_value	0.0016	0.01	0.0016	0.006	0

Values are means of triplicates

4.5.1.a ***Color and appearance***

The outcome showed that the range of the mean rank value for color and appearance is between 5.5-7.1. The proportion f_3(7.1) received the highest possible color and appearance score. F_1(5.5) received the lowest rating for color and appearance.

4.5.1.b ***Taste***

From the result it was observed that the mean rank value for attribute taste ranged between 5.6-7.2. The proportion f_3(7.2) earned the highest score for the attribute taste, according to the sensory evaluation results. Whereas the proportion f_1(5.6) had the least value.

4.5.1.c ***Texture***

According to the findings, the mean rank value for the attribute texture ranged from 5.9-7.1. The findings of the sensory evaluation indicated that the proportion f_3(7.1) received the highest rating. While the proportion f_1(5.9) had the least rating.

4.5.1.d ***Flavour***

The mean rank score for the attribute flavour ranged from 6.4-7.3. According to the sensory assessment of flavour, f_3(7.3) received the highest rating, while the other proportions f_1(6.5), f_2(6.4) and f_4(6.5) was on par.

4.5.1.e ***Overall acceptability***

From the result of overall acceptability, it is evident that the proportion f_3(7.128) had the maximum score for overall acceptability than other proportions and it was most preferred one. While the proportion f_1(5.600) had least score.

4.5.2. Preparation of paneer

The best screened jackfruit seed milk was constituted in four combinations of milk for the formulation of paneer.

In the present study, the preparation of paneer was done by selecting the seeds to prepare the milk. One liter of Jackfruit seed milk (50%) + soy milk (50%) was heated with occasional stirring. The temperature of milk will be raised to 80 - 85 ˚C with holding.

Then it was cooled to 70 - 75 ˚C and coagulum vinegar was added with constant slow stirring till the completion of coagulation. The time taken for addition of the coagulation will be noted. The whey was drained and the coagulated mass was collected later filled in a muslin cloth. Pressure was applied on the top of the paneer by placing a weight of 4-5kg for about 15 minutes. The pressed paneer was then removed from the muslin cloth and after cutting in 7-8 inches size pieces, the pieces was immersed in chilled water (4˚C-6˚C) for two hours. The Paneer was wrapped in butter paper and packed in polyethylene (LDPE) pouches, heat sealed and stored under refrigerated conditions as showed in fig 2.

4.6.SENSORY ACCEPTABILTY OF THE DEVELOPED SOFT CHEESE (PANEER)

Sensory acceptability of the developed products (12 treatments) was ascertained by a panel of judges using hedonic rating scale for selecting the best variety of paneer for quality analysis and shelf-life study. Gunasekara *et al.* (2021) conducted a sensory evaluation with a panel of thirty partially trained individuals. They evaluated jackfruit seed samples using organoleptic methods to assess characteristics such as aroma, texture, appearance, taste, colour, and overall acceptability. The assessors used a scale from 1 (indicating neither liking nor disliking) to 5 (indicating extreme liking) to express their opinions on the sensory attributes. Kruskal - Wallis's test was used for comparing the ranks of sensory evaluation.

Table no:15 Sensory evaluation of the developed soft cheese (paneer) on storage

Storage period	**Color and appearance**	**Taste**	**Texture**	**Flavour**	**Overall acceptability**
Initial stage (0 days)	7.6	7.7	7.2	7.8	7.575
After 1 week (8^{th} day)	5.1	4.3	4.9	4.1	4.952
χ^2	NS	NS	NS	NS	NS
P_value	NS	NS	NS	NS	NS

Values are means of triplicates

The sensory parameters show the evaluation of color and appearance, taste, texture, flavour and overall acceptability of the paneer in the initial stage and final stage. Though the values for sensory parameters have changed after one week of storage, the values are no significant changes to each other over the period of storage.

4.7.QUALITY ANALYSIS OF PANEER

Total solid content, moisture content and other major components like carbohydrate, fat, protein, Fiber, and calcium of the selected paneer was analyzed using standard techniques.

4.7.1 Total solid content

The total solid content of jackfruit seed milk for paneer refers to the percentage of non-water components in the final product. It includes various components such as proteins, fats, carbohydrates, minerals, and other solids present in the paneer. The solid content is essential because it directly affects the texture and mouthfeel of the paneer. Higher solid content generally results in a firmer and more substantial paneer, while lower solid content may lead to a softer and more delicate texture.

Table no:16 Total solid content

Treatment	Initial stage	After 1 week
Jackfruit seed milk (50%) + soy milk (50) paneer	11.63±1.5%	7.19±3.2%

Values are means of triplicates

It is seen that the total solid content of the paneer at the initial stage was 11.63±1.5% and was reduced to 7.19±3.2% after 1 week of storage at refrigerated condition.

4.7.2 Nutrient composition of the developed soft cheese (paneer)

Jackfruit seed milk (50%) + soy milk (50) paneer (f_3) was most accepted by the panelists. So, nutritional analysis of this variant was done. The paneer packed in polyethylene (LDPE) pouches, heat sealed and stored under refrigerated conditions over a period of one week was analyzed.

Table no:17 Nutrient composition of the developed soft cheese (paneer)

Storage period	Carbohydrate (g/100g)	Fat (g/100g)	Protein (g/100g)	Crude fiber (%)	Moisture content (%)	Calcium (mg/100g)
Initial stage (0 day)	1.8[a]	3.4[b]	9.1[a]	2.38[a]	8.75[b]	132.40[a]
After 1 week (8th day)	1.2[a]	2.1[b]	7.9[a]	1.71[b]	5.11[b]	114.38[b]
±SE(m)	0.855	0.092	0.287	0.031	0.35	0.621
CV (%)	2.273	4.231	3.116	2.369	7.276	0.127

Values are means of triplicates

4.7.2.a Carbohydrate

Carbohydrates are an essential component of plant-based paneer, providing energy and various health benefits. The primary source of carbohydrates in plant-based paneer comes from the naturally occurring sugars present in the plant-derived milk used during its preparation. The carbohydrate content was higher in the initial stage of the panner 68g/100g and was reduced to 51.2g/100g towards the final stage of storage for one week.

4.7.2.b Fat

plant-based paneer is derived from non-dairy sources, making it suitable for individuals following a vegan or lactose-free diet. One of the key differences between the two is the type of fats present in each variant. The fats present in plant-based paneer differ from those in traditional dairy paneer, as plant-based options tend to contain predominantly unsaturated fats. These fats offer various health benefits to promote better health. From the analysis fat content was seen to be comparatively higher in the initial stage 3.4g/100g and was reduced to 2.1g/100g in the initial stage after one week.

4.7.2.c Protein

Plant-based paneer is a protein-rich and nutritious alternative to traditional dairy-based paneer. It offers a host of health benefits while maintaining the versatility and deliciousness of its conventional counterpart. Proteins are essential macronutrients found in various foods that play a fundamental role in maintaining the structure, function, and regulation of the body's tissues and organs. They are composed of long chains of amino acids, which are organic compounds that act as the building blocks of life. Protein is a critical component of a balanced diet, and it is crucial for various physiological processes and functions. The protein content was higher (9.1 g/100g) in the initial stage of storage, and was reduced to (7.9g/100g) towards the final stage of storage for one week.

4.7.2.d Crude Fiber

Crude fiber, also known as dietary fiber, is an essential component found in plant-based foods, including plant-based paneer. Crude fiber is a type of carbohydrate that is not easily digestible by the human body. Unlike other carbohydrates, it cannot be broken down by digestive enzymes, and thus, it passes through the digestive system relatively intact. Instead of providing calories or energy, crude fiber serves other crucial functions that benefit our health. It is evident from the above table that in the initial stage (2.38%) the crude fiber content was higher and then reduced to (1.71%) towards the final stage.

4.7.2.e Moisture Content

Moisture content is a critical factor in the production of plant-based paneer, a popular dairy-free alternative to traditional cheese. The moisture content directly influences the texture, taste, and overall quality of the final product. Maintaining the right moisture content is crucial to achieve the desired creamy and slightly crumbly texture of the paneer. The above results show that the moisture content of the paneer at the initial stage (8.75%) was higher compared to the final stage (5.11%) where the moisture content was lowered after one week of storage.

4.7.2.f Calcium

Calcium is a vital mineral found in plant-based paneer, providing several health benefits, particularly in supporting bone health, muscle function, nervous system, cardiovascular health, and dental health. For those following a plant-based diet, incorporating calcium-rich plant-based paneer into their meals can contribute to meeting their daily calcium needs and maintaining overall well-being. From the above table it is evident that in the initial stage (132.40 mg/100g) the calcium content was higher and then reduced to (114.38 mg/100g) towards the final stage of storage.

4.8. SHELF-LIFE STABILTY OF JACKFRUIT SEED MILK SOFT CHEESE (PANEER)

Shelf-life stability refers to the ability of a product to maintain its quality and safety over a specified period while stored under recommended conditions. In the case of jackfruit seed milk paneer, several factors can influence its shelf life, including composition, processing methods, packaging, storage conditions, and the presence of preservatives or additives.

4.8.1 MICROBIAL PROFILE

To establish the shelf-life quality, the paneers microbial profile was examined. The rate of contamination with bacterial colonies, fungal colonies and coliforms were analysed to ascertain the microbial profile. The results are depicted in the following table.

Table no:18 Total bacterial count of paneer

Sample	Initial count (CFU/gram of sample)	After 1 week
Jackfruit seed milk (50%) + soy milk (50%) paneer	TLTC	$43x10^6$

It was evident from the above table that during initial stage of storage period that the bacterial colonies were TOO LOW TO COUNT (TLTC) in paneer. But bacterial colonies were observed in the paneer after one week of storage ($43x10^6$) under refrigerated condition. However, it can be noticed that the values were within the safe consumable limits.

Table no:19 Total fungal count of paneer

Sample	Initial count (CFU/gram of sample)	After 1 week
Jackfruit seed milk (50%) + soy milk (50%) paneer	TLTC	$42x10^7$

Above table depicts the result of total fungal count in the paneer. From the result it was analysed that fungal colonies were absent in the initial stage but was increased to $42x10^7$ during the storage of paneer for one week. However, it can be noticed that the values were within the safe consumable limits.

Table no:20 Total coliform count of paneer

Sample	Initial count (CFU/gram of sample)	After 1 week
Jackfruit seed milk (50%) + soy milk (50%) paneer	TLTC	$36x10^2$

Above table reveals the results of total coliform count of the paneer. From the result it is was observed that there was no presence of coliform colonies in the initial stage of storage period of the paneer, but coliform colonies were analysed ($36x10^2$) after one week of storage. However, it can be noticed that the values were within the safe consumable limits.

4.9. COST OF PRODUCTION

Based on the prices of various commodities, a cost analysis of the paneer was performed. This includes the price of seeds, coagulants, LDPE pouches, butter paper, labour and fuel charges.

Table no:21 Cost of production

Sample	Cost (100g)
Jackfruit seed milk (50%) + soy milk (50) paneer	Rs.56/-

The above table depicts the cost of production of paneer. From the table it is evident that Rs. 56/- per 100g was the expense worked out for the Jackfruit seed milk (50%) + soy milk (50%) paneer. The rate of paneer is comparatively less than other commercially available plant-based paneers.

DISCUSSION

5. DISCUSSION

The results of the study entitled- 'Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk' is discussed below, under the following heads:

5.1. Standardization of extraction of Jackfruit seed milk

5.2. Pre-processing techniques

5.3. Extraction of Jackfruit seed milk

5.4. Screening of best treatment

5.5. Development of jackfruit seed milk soft cheese (paneer)

5.6. Sensory acceptability of the developed soft cheese (paneer)

5.7. Quality analysis of paneer

5.8. Shelf-life stability of the jackfruit seed milk soft cheese (paneer)

5.9. Cost of production

Modern lifestyle has initiated a vegan diet through the uptrend in plant-based or non-dairy milk. Attraction of vegan products has shown the way towards emergence of dairy analogues. The need for such products arose in order to accommodate the population with different dietary restrictions including people with conditions like lactose intolerance, food poisoning, heart diseases and increasing cost (Singh *et al*., 2019).

Dairy analogue is a food product which is designed as an alternative to traditional animal-derived foodstuff. Dairy analogues were used mainly because of their cost-effectiveness and the substitution of selected milk components by cheaper vegetable products. Nowadays, production of dairy analogues is not only focused on cost reduction during manufacturing, but also concentrates on reception of health-promoting products, or with new functional properties (Mohmmed *et al.*, 2013; Saleet *et al.*, 2014; Solowiej *et al*., 2015)

The most commonly known examples of dairy analogues are cheese analogues (imitation cheeses, cheese-like products, processed cheese analogues, processed cheese foods, processed cheese spreads), fermented dairy analogues (yoghurt-like products), butter analogues (butter-like products), and dairy dessert analogues (dairy dessert-like products) (Sołowiej and Nastaj, 2015).

South India is blessed with a large number of jackfruit varieties. Though cultivation of the crop is high in Kerala, its utilization as a popular table fruit is confined more to other states. *Varikka* and *koozha* are the two ecotypes found in all areas which differ only in the flake texture. The crop is propagated mainly through seed and there is very large variability in fruit quality attributes.

Jackfruit seeds are underutilized and less acknowledged by people, but they have considerable nutritional benefits and constitute about 10% to 15% of the fruit weight (Hossain *et al.,* 2014). In many parts of South India, the seeds are collected from the ripe fruit, dried in sunlight and stored adequately for use in the rainy season. Due to the difficulties encountered during processing and storage, massive amounts of seeds are annually wasted.

5.1. Standardization of extraction of Jackfruit seed milk

Jackfruit (*Artocarpus heterophyllus*) is a tropical fruit known for its large size, distinct flavour, and versatility. While the ripe fruit is commonly consumed, the seeds are often discarded or underutilized. However, jackfruit seeds are rich in nutrients and can be processed into various products (Dhivya *et al.,* 2018).

Plant based milk substitutes are often perceived as healthy. In reality the nutritional properties vary greatly, as they depend strongly on the raw material, processing, fortification and the presence of other ingredients. Milks produced using legumes other than soy, such as peanut and cowpea have protein content as high as 4% (Yadav *et al*., 2010). The main treatment for Lactose Intolerance is the avoidance of lactose containing foods and replacing milk and dairy products with lactose free dairy or dairy free alternatives. Functional food market is dominated by dairy based probiotic products mainly yoghurt. There is a need to develop dairy alternatives due to allergenic milk proteins, lactose intolerance.

Jackfruit seed milk is not only a delicious beverage but also a nutritious one, offering a rich source of protein, dietary fiber, vitamins, and minerals. Moreover, being lactose-free, it serves as an excellent alternative for individuals with lactose intolerance or dairy allergies. This innovative approach to using jackfruit seeds helps reduce food waste while providing a sustainable and healthful option for consumers (Kumar *et al.*, 2012). Furthermore, as jackfruit is a tropical fruit that grows abundantly in various regions, the extraction of jackfruit seed milk has the potential to support local economies and promote food security.

The extraction of jackfruit seed milk presents a valuable and sustainable way to utilize a part of the jackfruit fruit that is often discarded. The process involves collecting, cleaning, boiling, peeling, and grinding the seeds to create a fine paste. By mixing the paste with water and straining the mixture, a creamy and nutritious liquid, the jackfruit seed milk, is obtained.

5.1.1. Selection of fruits for seed collection:

Krishnan *et al.* (2015) reported that selection process involves careful inspection and discernment of seeds based on several criteria. Ripe *Varikka* seeds are chosen for consumption due to their sweet taste and firm texture, making them suitable for direct consumption or culinary purposes. On the other hand, *Koozha* seeds are preferred for seedling propagation due to their relatively smaller size and uniformity, which leads to better germination rates and seedling growth. The expertise in selecting *Varikka* and *Koozha* jackfruit seeds has been passed down through generations of farmers and horticulturists in Kerala, where jackfruit is considered a significant fruit crop.

In the present study to obtain jackfruit seed milk paneer the cultivars *Koozha* and *Varikka* was selected. The fruits were collected from local markets.

5.1.2. Stage of fruit maturity

The seeds of the jackfruit, commonly referred to as *varikka* and *koozha*, undergo distinct stages of maturity, each offering unique culinary and nutritional characteristics. In a study Ravindran *et al.* (1999) reported that in the early stage of maturity, the *varikka* seeds are young and tender, possessing a slightly crunchy texture. They are often boiled, steamed, or roasted and enjoyed as a nutritious snack or incorporated into various dishes. As the seeds progress in the *koozha* cultivar, they become fully mature and take on a starchy consistency. The results of the present study shows that *varikka* fully ripe was found to be the best stage of maturity for the preparation of paneer as it has less starchy consistency than fully mature jackfruit seed which results in easy blending and extraction of the jackfruit seed milk.

5.2. Pre-processing techniques

The pre-processing techniques employed in the extraction of jackfruit seed milk played a crucial role by cleaning the seeds to prepare the seeds for extraction ensuring the preparation of a nutritious and flavourful dairy-free alternative.

5.2.1. Soaking Media

Soaking *varikka* (ripe) and *koozha* (unripe) jackfruit seeds is a traditional practice in many South Asian cuisines that enhances their culinary use and nutritional value. According to Ambigaipalan *et al.* (2016) before incorporating jackfruit seeds into various dishes, the seeds are typically soaked in water for 24 hours or overnight. The soaking process softens the tough outer skin of the seeds, making them easier to peel and cook. Additionally, soaking also helps to remove any bitterness that might be present in the seeds. Another study conducted by Prakash *et al.* (2017) has also reported that soaking the seeds to make plant-based milk may also improve their digestibility, making it easier for the body to absorb the nutrients they contain. Jackfruit seed milk is a nutritious and dairy-free alternative to traditional cow's milk, suitable for those with lactose intolerance or seeking plant-based options.

For the preparation of jackfruit seed milk, one must first soak the jackfruit seeds to soften them for easier blending. There are several soaking medium that can be used, each offering a unique twist to the final product. Water is the simplest and most common soaking medium, allowing the natural flavour of jackfruit seeds to shine through. Experimenting with different soaking media tailored the taste and consistency to personal preferences.

In the present study it was found that *varikka* fully ripe soaked in water for 24hrs was the best soaking media for the preparation of jackfruit seed milk as it was easier to follow the pre-processing techniques due to soaking of the seed for 24hrs making to more convenient to peel, clean and blend the seeds.

5.2.2. Heat Treatments

Heat treatment of *varikka* and *koozha* jackfruit seeds involves subjecting the seeds to controlled heating processes to enhance their nutritional value and reduce potential antinutrients. This treatment is essential as raw jackfruit seeds may contain certain anti-nutritional factors like tannins and trypsin inhibitors, which can hinder nutrient absorption. Studies have shown that heat treatment methods like boiling, roasting, or steaming can effectively reduce these antinutrients, thereby improving the digestibility and bioavailability of nutrients in the seeds (Hemalatha, *et al.,* 2016). Moreover, heat treatment can increase the protein content, decrease the levels of toxic compounds, and enhance the overall sensory attributes of jackfruit seeds (Chandrasekhara *et al.*, 2016). Therefore, incorporating heat-treated *varikka* and *koozha* jackfruit seeds into the diet can not only provide a tasty addition but also offer improved nutritional benefits. In the current investigation the heat treatments were not acceptable because of the difficulty in extracting the milk which resulted in off flavour and curdled consistency.

5.3. EXTRACTION OF JACKFRUIT SEED MILK

Plant based milk substitutes are water extracts of legumes, oil seeds, cereals or pseudo cereals that resemble animal milk in appearance and consistency. There is a wide variety of traditional plant-based beverages around the world. The most widely consumed plant-based milk substitute is soy milk. The first commercially successful product was launched in Hong Kong in 1940 and the market grew rapidly during the seventies and early eighties in Asia after the development of technologies for large scale production of mild flavored soy milk. The demand for soy milk in the Western world was initiated by consumers intolerant to cow's milk or lactose (Patisaul and Jefferson, 2010).

Soy products are still dominating the market in the Western world, but the emergence of alternative products from other plant sources such as coconut, oat, peanut and almond have decreased its share. According to an estimate, 15% of European consumers avoid dairy products for a variety of reasons, including medical reasons such as lactose intolerance (LI), cow's milk allergy (CMA), cholesterol issues and phenylketonuria, as well as lifestyle choices like a vegetarian/vegan diet or concerns about growth hormone or antibiotic residues in cow's milk (Jago, 2011).

According to Bear *et al.* (1997), the researchers obtained jackfruits (*Artocarpus heterophyllus*) from a traditional market in Bandung, West Java, and separated them into flesh and seeds. The jackfruit seeds were soaked in 2% salt water (NaCl) along with 5 drops of lemon juice. After soaking, the seeds were filtered to remove the water and then cooked in a pressure cooker with water (using a 1:1 w/v ratio) for 1 minute once the pressure regulator emitted a sound and released steam. Subsequently, the cooked jackfruit seeds were allowed to cool down to room temperature. Once cooled, the seeds were weighed and blended with water (using a 1:1.5 w/v ratio). The blended mixture was then filtered through cheesecloth into a glass jar to obtain jackfruit seed milk, which was refrigerated at 4°C overnight.

The composition of the end product is notably affected by the extraction process. To improve efficiency and yield, several techniques can be used. These include adjusting the pH with bicarbonate or NaOH, elevating temperatures, or using enzymes. An alkaline pH enhances the extraction of proteins, whereas higher temperatures increase fat extraction. However, protein denaturation caused by elevated temperatures may lead to reduced solubility and yield. Nonetheless, the incorporation of enzymes derived from plants, animals, or microorganisms can enhance protein extraction (Chauahn et al., 2003).The peanut milk was prepared using a developed method involving steaming de-skinned peanut kernels in an autoclave for 3 minutes at 1.05 kg/cm^2, followed by soaking in water for 6 hours. The peanuts were then ground in the presence of steam at 1.05 kg/cm^2, and the resulting mixture was deodorized under vacuum (300–400 Hg) and filtered through double-layered muslin cloth (Yadav *et al.*, 2009).

After hydrolyzing peanut and soy milk with papain and a crude enzyme extract, an increase in protein content was observed. Additionally, a combination of amyloglucosidase and a cellulase cocktail improved carbohydrate recovery in peanut milk. In soymilk extraction, the use of neutral or alkaline proteinases at their optimum pH resulted in the highest protein and total solids yield (Eriksen *et al.,* 1983). Proteolytic enzymes not only increase extraction yield but also enhance suspension stability. Treatment with cellulase after homogenization reduced particle size and resulted in a more stable suspension.

Following extraction, coarse particles are removed from the slurry using filtration, decanting, or centrifugation. For materials with high fat content, like peanuts, excess fat can be separated using a separator, similar to dairy processing. The separated cream-like product can be heat treated to obtain oil or used as it is in ice-cream formulations and the bakery industry, thus optimizing the process. Removing excess oil/fat from the extract also contributes to a more stable beverage formulation (Rawson *et al.,* 2021).

For comparison one can also use similar techniques to extract jackfruit seed milk but without any heat treatments. In this case, the jackfruit seeds were soaked in water for 24 hours.

5.4. SCREENING OF BEST TREATMENT

Plant based milk substitutes contain insoluble particles, such as protein, starch, fibre, and other cellular materials. Due to density difference, these particles get settled down, making the product unstable. The suspension stability can be increased by decreasing ;l .m, the particle size or by using hydrocolloids and emulsifiers (Durand *et al.,* 2003). Thermal treatment of many plant-based milk substitutes can cause coagulation due to protein unfolding. This unfolding expose non-polar amino acids to water, leading to increased protein-protein interactions, which results in aggregation, sedimentation, or gelling (Phillips *et al.,* 1994). The stability of these proteins under heat depends on factors such as pH, ionic strength, and the presence of other compounds like minerals and carbohydrates. Conventional dairy processing homogenization at pressures around 20MPa improves the stability of plant-based milk substitutes by disrupting aggregates and lipid droplets, thereby reducing particle size distribution. Ultra-high-pressure homogenization (UHPH) at 200-300MPa has been shown to decrease stability in soy milk (Arvind *et al.,* 2017). In the case of peanut milk, higher homogenization temperatures have been found to enhance stability (Hinds *et al.*, 1997). For soy milk, protein denaturation through heat treatment is necessary for suspension stability.

The best treatment for preparing paneer from jackfruit seed milk was determined by selecting the one with the highest yield ratio, optimal sensory attributes, and desirable curd setting properties

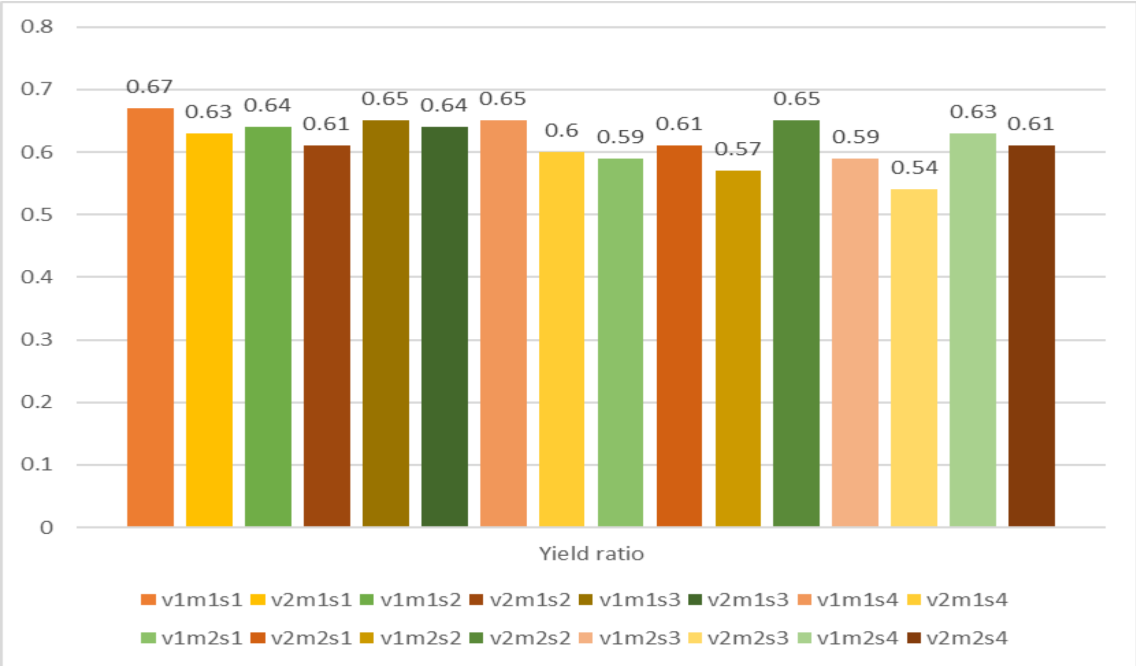
5.4.1. Yield ratio

Finding the yield ratio of jackfruit seed milk involves determining the amount of milk obtained from a given quantity of jackfruit seeds. The process begins with cleaning and removing the seed coat, followed by grinding and blending the seeds with water to extract the milk. The yield ratio is calculated by dividing the volume or weight of the extracted milk by the initial weight of the seeds used for processing. It is important to consider variations in processing techniques and the type of jackfruit seeds used when determining the yield ratio.

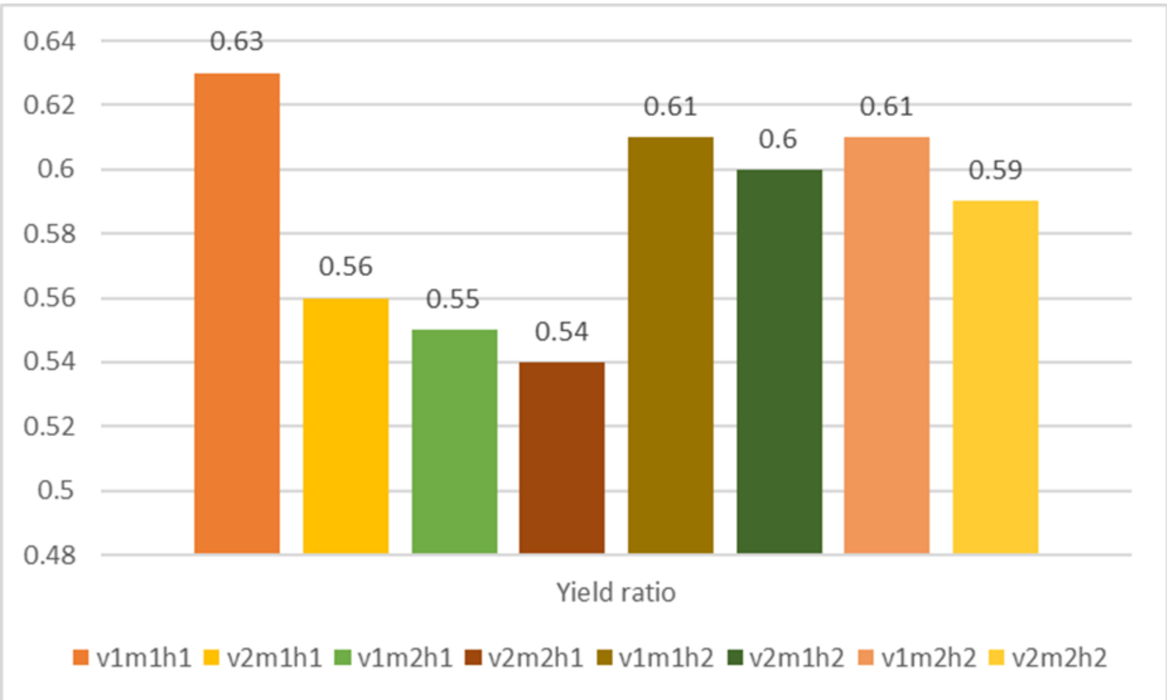
In the present study the yield ratio was found by dividing the total weight of the product by weight of final product from which the highest yield ratio for soaking treatment it is clear that treatment $v_1m_1s_1$ (*varikka* fully ripe soaked in water) (0.67) had the highest yield ratio and $v_2m_2s_3$ (*koozha* fully matured soaked in sodium hydroxide) (0.54) had the least value. In yield ratio of two varieties of jack fruit seed samples which were soaked in different soaking media for two heat treatment it is clear that treatment $v_1m_1h_2$ (*varikka* fully ripe in pressure cooking) (0.33) had the highest yield ratio and $v_2m_2h_1$ (*koozha* fully matured in steaming) (0.29) had the least value.

The yield of the soy-groundnut paneer varies with different proportion. The maximum yield was obtained in the 100:0 and 90:10 proportions 17.1% and 15.6% respectively, whereas the minimum yield was obtained from the proportion 50:50. This may be due to more fat content in the groundnut milk. The yield of the soy-groundnut paneer decreased with increasing groundnut milk percentage. The study of Khodke *et al.* (2014) revealed that the 50:50 proportion soy-groundnut paneer produced very low yield of soy-groundnut paneer. It was observed during experimentation that the groundnut milk increases, coagulation of milk was not properly and whey was separated from the solids. This may be the reason for the reduction of yield as percentage of groundnut milk increase also it was observed that prepared soy-groundnut paneer from 50:50 proportion was not good (Harjai and Singh, 2007).

Graph 1: Yield ratio of jackfruit seed milk samples in different soaking media



Graph 2: Yield ratio of jackfruit seed milk samples in different heat treatments



5.4.2. Sensory attributes

Finding the sensory attributes of jackfruit seed milk involves conducting sensory evaluation tests to assess its taste, aroma, texture, and overall acceptability. Trained panellists or consumers were typically involved in these evaluations. Attributes such as sweetness, bitterness, creaminess, and any off-flavours are considered. Additionally, the appearance and colour of the milk are evaluated. Sensory analysis provides valuable insights into the sensory profile of jackfruit seed milk, enabling researchers and food technologists to optimize its processing methods and formulations for enhanced consumer acceptance and marketability. Sensory evaluations are crucial in understanding consumer preferences and tailoring the product to meet their expectations (Lasekan *et al.*, 2015).

Flavour plays a crucial role in consumer acceptance of food products. It is primarily generated by volatile compounds in the food, and when consumed, the aroma is detected by the olfactory system in the nose (Winarno *et al.,* 2004). According to the organoleptic flavour tests, the scores ranged from 3.63 (like) to 4.13 (like), with an average value of approximately 3.99 (like). The highest organoleptic flavour score of 4.13 (like) was achieved when 15% maltodextrin (M3) was added with a drying time of 16 hours (T3), while the lowest score of 3.63 (like) was obtained with 10% maltodextrin (M2) and a drying time of 12 hours (T1).

Based on the analysis of variance, it was found that the addition of maltodextrin, drying time, and their interaction had no significant effect ($P \leq 0.05$) on the organoleptic flavour test of jackfruit seed powder milk. The relationship between drying duration and the hedonic value of flavour indicated that longer drying times led to a decrease in the panellists' dislike toward the flavour of jackfruit seed powder milk. This decrease in flavour liking was attributed to the loss of jackfruit seed flavour during the drying process, which aligns with Iqbal's statement (2014) that drying can cause changes in taste. During the drying process, some volatile substances are carried away as water evaporates from the food's surface. Moreover, the higher concentration of dextrin resulted in a higher hedonic value for jackfruit seed powder milk. A 5% concentration did not provide a distinctive flavour, with a dominant burnt flavour being detected.

However, with a concentration of 15% maltodextrin, the flavour of jackfruit seed powder milk could be better preserved (Sunartaty *et al.*, 2019)

In the present study the sensory evaluation was done by 10 trained panellists to determine the overall sensory acceptability of the treatments performed from which treatment $v_1m_1s_1$ (*varikka* fully ripe soaked in water) (7.600) had the highest yield ratio and $v_2m_1s_3$ (*koozha* fully ripe soaked in sodium hydroxide) (4.876) had the least value. However, from the results it is very clear that treatment $v_2m_1h_2$ (*koozha* fully ripe pressure cooked) (7.050) had the highest yield ratio and $v_2m_2h_2$ (*koozha* fully matured pressure cooked) (5.575) had the least value in heat treatments.

5.4.3 Curd setting properties

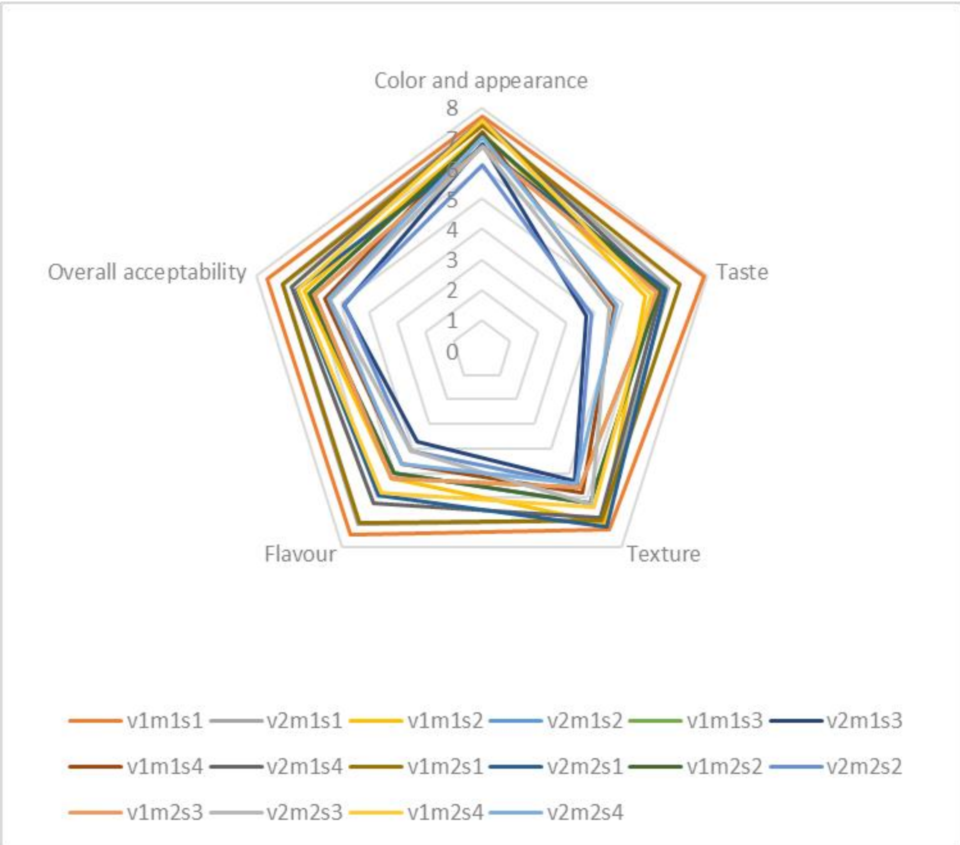
Curd setting property is the term used to describe the setting of the milk after being fermented overnight. According to Rai *et al.* (2018) Curd or yogurt in the developed milk is made by gently heating the milk until it becomes lukewarm. After that, a starter culture is introduced by breaking open 2-3 Vizylac Capsules, which is then thoroughly mixed into the milk. The mixture is covered and allowed to set for a period of 6-8 hours. From the study by Ramesh *et al.* (2020) it is noted that preparation of peanut paneer was done by extracting the peanut milk followed by inoculating the milk by chilly stokes overnight before incubation.

Peanut milk was preheated up to 60 ± 5^0C and mixed with sucrose (@ 6% w/v), SMP and carboxy methyl cellulose, homogenised (2500 psi), boiled for 5 min, cooled to 37 $\pm 2^0$C, inoculated with culture (@2.5% w/v) and incubated at 37^0C (Yadav *et al*., 2010).

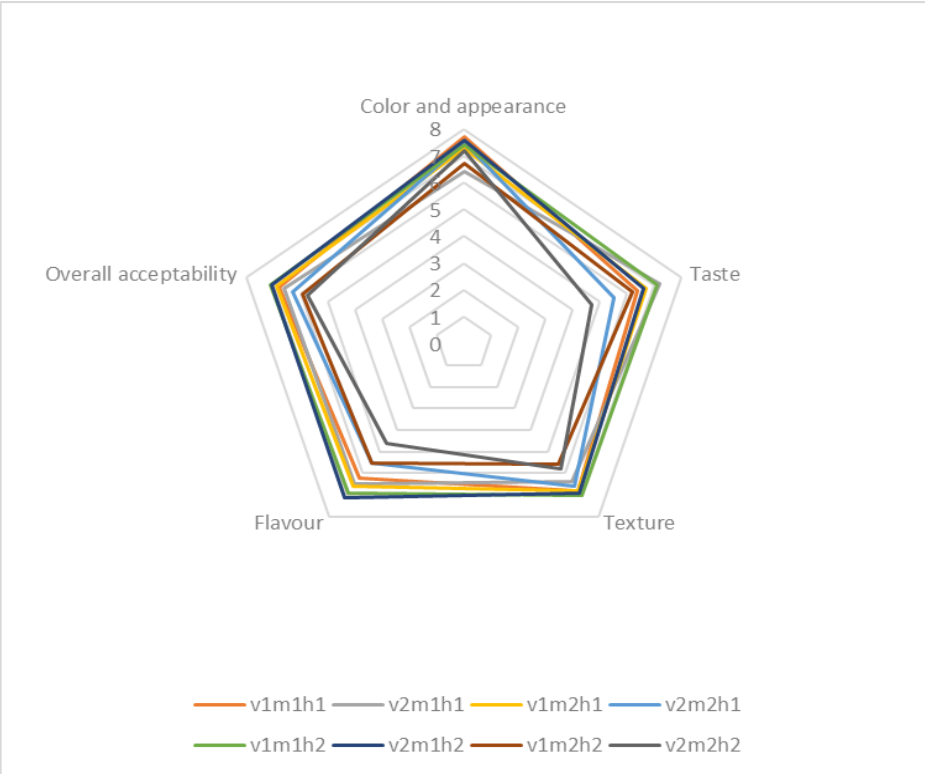
In the present study the extracted jackfruit seed milk was fermented over night with chilly to set the curd, such that from the results it is clear that treatment $v_1m_1s_1$ (*varikka* fully ripe soaked in water) (7.325) had the highest curd setting properties and $v_2m_1s_3$ (*koozha* fully ripe soaked in sodium hydroxide) (4.586) had the least value. From the results it is also clear that treatment $v_1m_1h_1$ (*varikka* fully ripe steamed) (7.075) had the highest curd setting properties and $v_2m_2h_1$ (*koozha* fully matured steamed) (5.400) had the least value.

Thus, from the above findings it was concluded that $v_1m_1s_1$ (*varikka* fully ripe soaked in water) which has the highest values for yield, sensory qualities and curd setting properties was the best treatment. The milk extracted from this treatment was taken for the development of soft cheese (paneer).

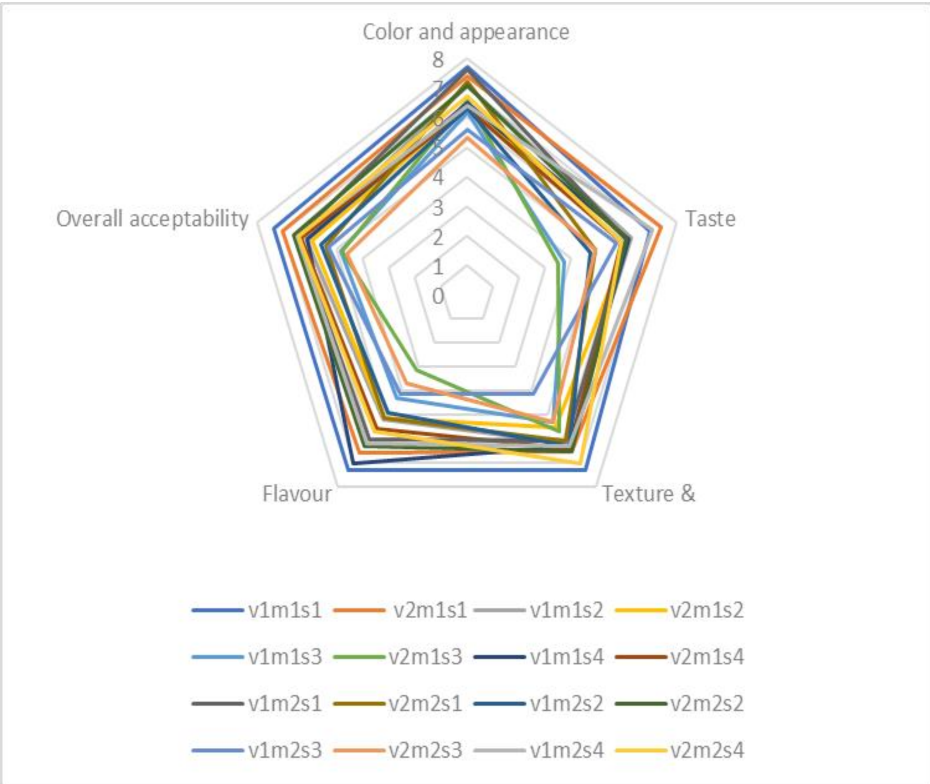
Graph 3: Sensory evaluation of jackfruit seed milk sample in different soaking media



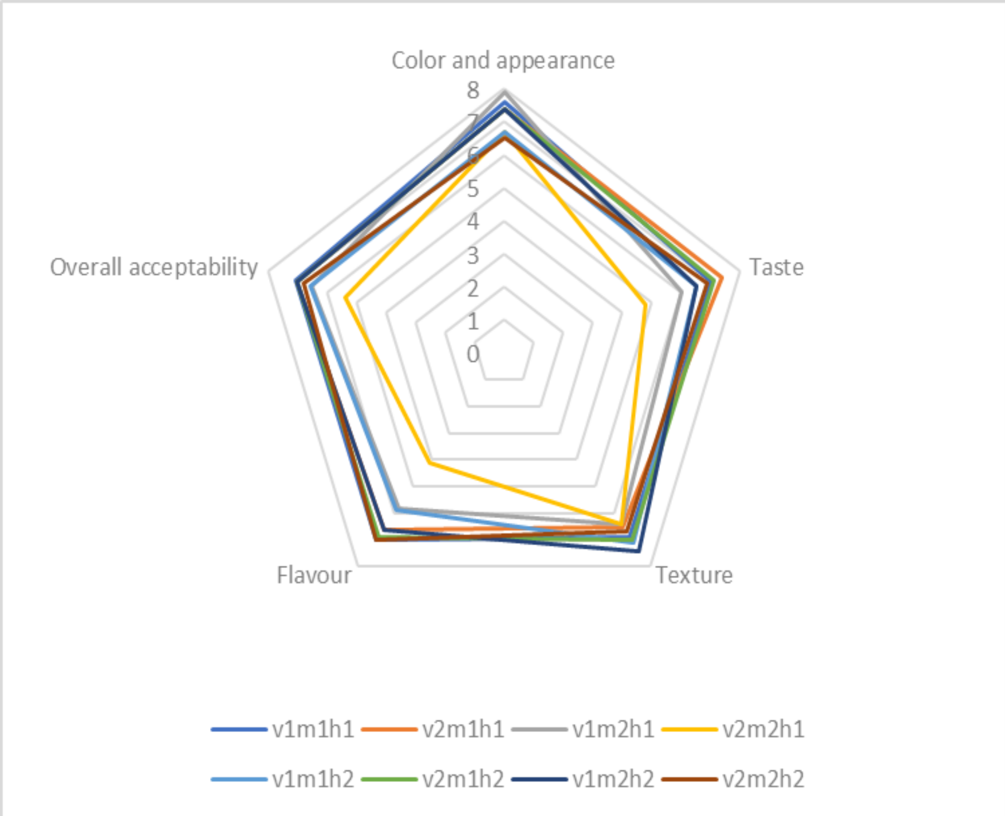
Graph 4: Sensory evaluation of jackfruit seed milk samples in different heat treatments



Graph no:5 curd setting properties of jackfruit seed milk in different soaking media



Graph no:6 curd setting properties of jackfruit seed milk in different Heat treatments



5.5. DEVELOPMENT OF JACKFRUIT SEED MILK SOFT CHEESE (PANEER)

The paneer was developed by selecting the combination of milk suitable to coagulate and selecting the coagulant to coagulate the milk to form the whey.

5.5.1. Selection of Coagulum for paneer preparation

According to Choi *et al.* (2019) the selection of coagulants plays a crucial role in the production of paneer and plant-based cheese-like product. Several coagulants can be used to curdle the milk extracted from jackfruit seeds, each with its own unique characteristics. Traditional coagulants used for paneer production include lemon juice and vinegar, which contain natural acids (citric acid and acetic acid, respectively). These acids lower the pH of the milk, causing it to coagulate and form curd. However, when using jackfruit seed milk as a base, the acidity of these coagulants may not be sufficient or suitable for curdling the milk effectively.

Instead, an alternative approach is to use commercially available coagulants specifically designed for plant-based milk coagulation. These coagulants are typically derived from microbial or plant-based sources and offer consistent and reliable outcomes. Examples of such coagulants include calcium sulphate (gypsum), calcium chloride, or food-grade enzymes like microbial rennet or plant-derived proteases (Masoodi *et al.*, 2014).

In a study conducted by Sughanya and Lalitha (2017), coconut milk was prepared from fresh coconut kernels. This coconut milk was blended with cow's milk in various ratios (75:25, 50:50, 25:75, and 0:100). The blend was heated to 82°C and then cooled to 72°C before being coagulated with vinegar. After draining off the whey from the curd, the paneer was pressed and soaked in chilled water (4-5°C) for 2-3 hours. It was then allowed to drain for 10 minutes to remove excess water.

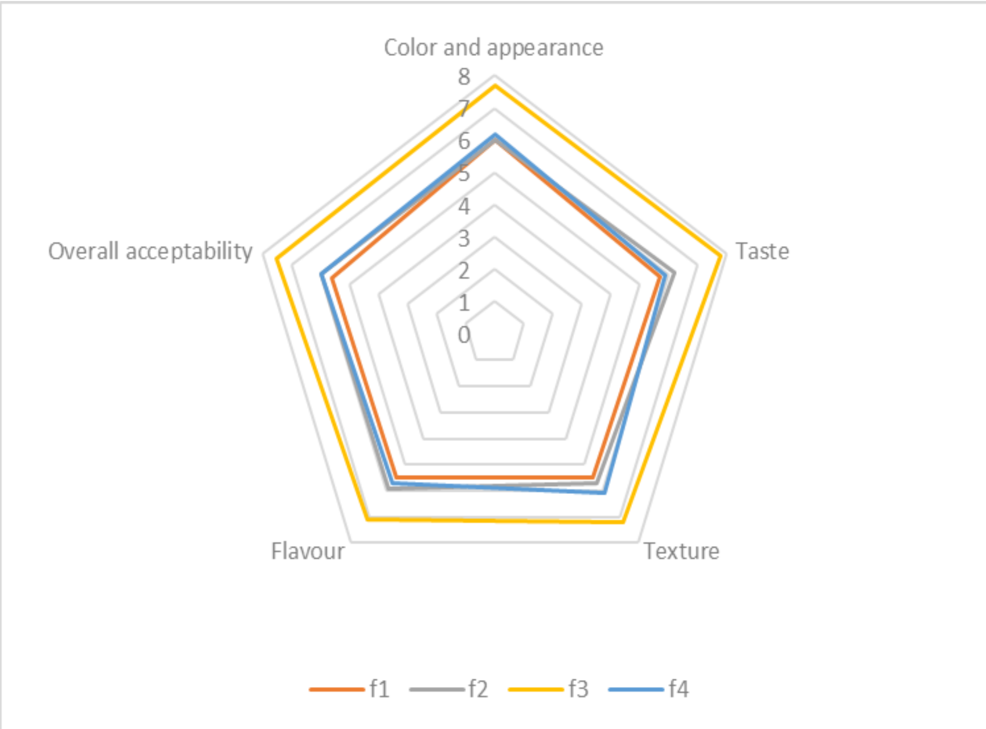
For the soybean variety JS-335 and the groundnut variety SB-11, seeds were obtained from the seed processing plant, VNMKV, Parbhani. The selected soybean variety was cleaned, soaked in tap water (1:3 W/V) for 8 to 10 hours at room temperature, and then the skins were removed. The washed beans were ground with water (1:8 W/V) in a mixture cum grinder for 3-5 minutes. The resulting slurry was heated for 20 minutes with continuous stirring and filtered through a double-layered muslin cloth to obtain soymilk.

For groundnuts, the whole selected variety was added to boiling water, soaked for 7 minutes, and then the skins were removed. The cotyledons were soaked in 2% sodium bicarbonate overnight, rinsed with tap water, and blended with water (1:5 W/V). The blended slurry was heated for 15-20 minutes with continuous stirring and filtered through a double-layered muslin cloth to obtain groundnut milk.

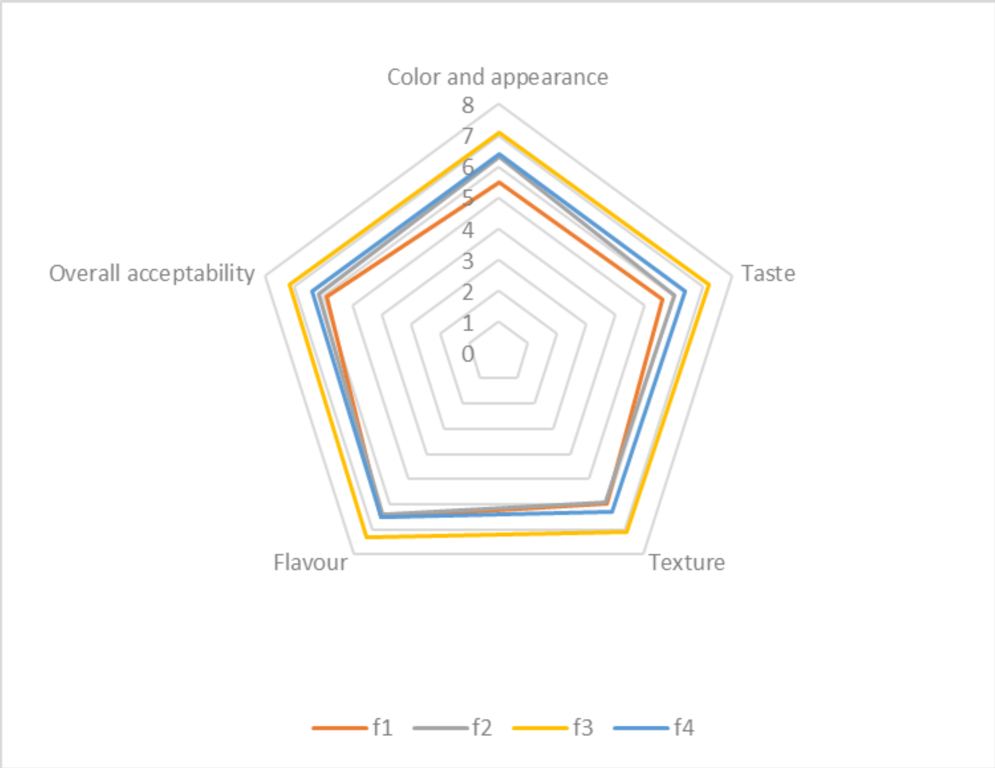
The obtained soymilk and groundnut milk were mixed in different proportions as per the experimental plan. The mixture was heated to 70°C, and citric acid (2 gm/Liter of milk) was used as a coagulant. Continuous stirring was done until the soluble solids and whey visually separated. The resulting solid was then filtered through a muslin cloth and pressed in a paneer press for 15-20 minutes at a constant pressure for each sample. The pressed solids were removed from the press box and immediately transferred to chilled water and stored in the refrigerator (Khodke *et al.,* 2014).

From the results of the study, it is clear that coagulation with lemon juice had the least curdling in all combinations of milk. However, citric acid had better coagulation than lemon juice but had an unpleasant sour taste making it least acceptable on sensory evaluation. The highest coagulation was found with vinegar giving more coagulated mass and was easy to wash out the sour taste on immersing the whey in water, making it the best coagulant with highest overall acceptability.

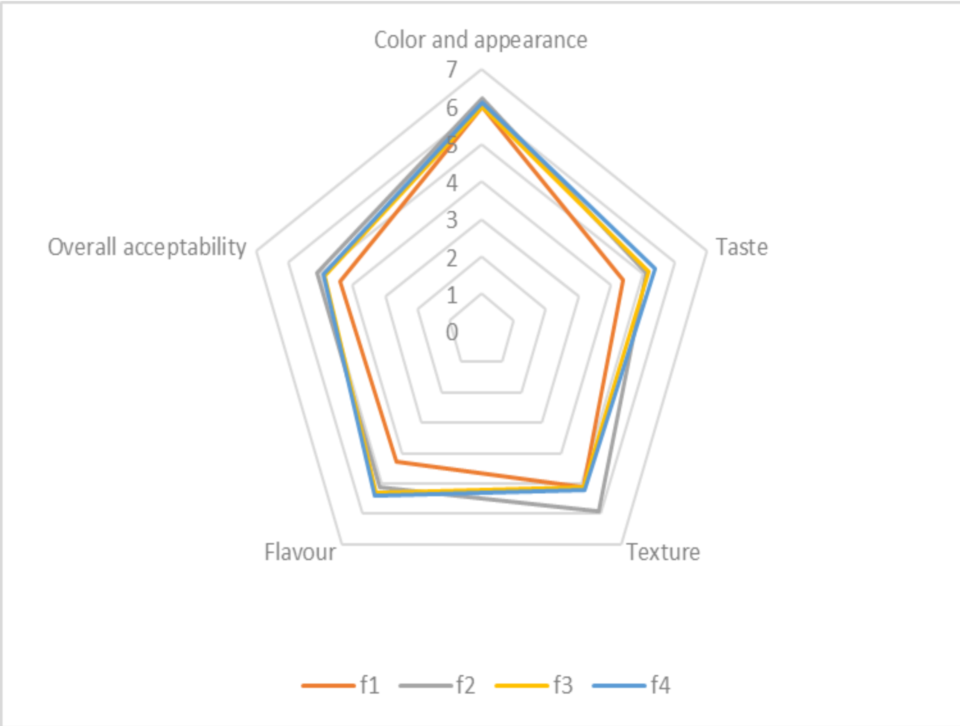
Graph 7: Sensory parameter of milk in vinegar



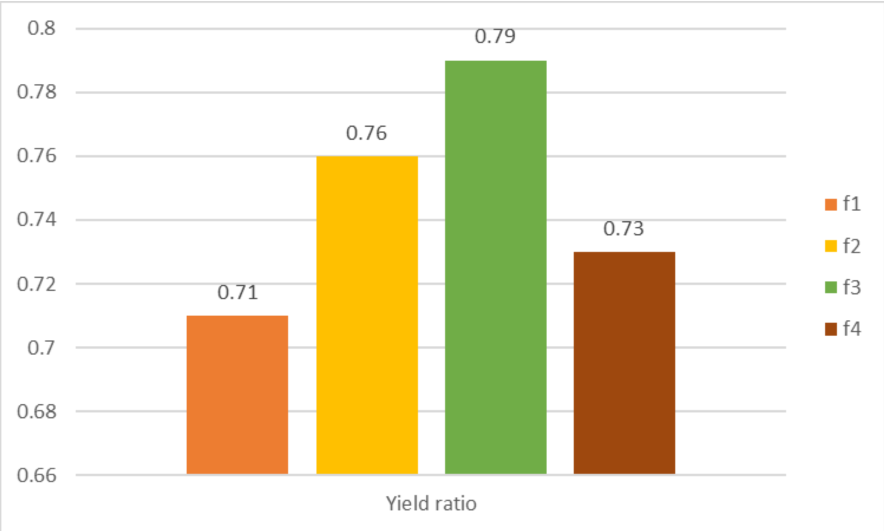
Graph 8: Sensory parameter of milk in lemon juice



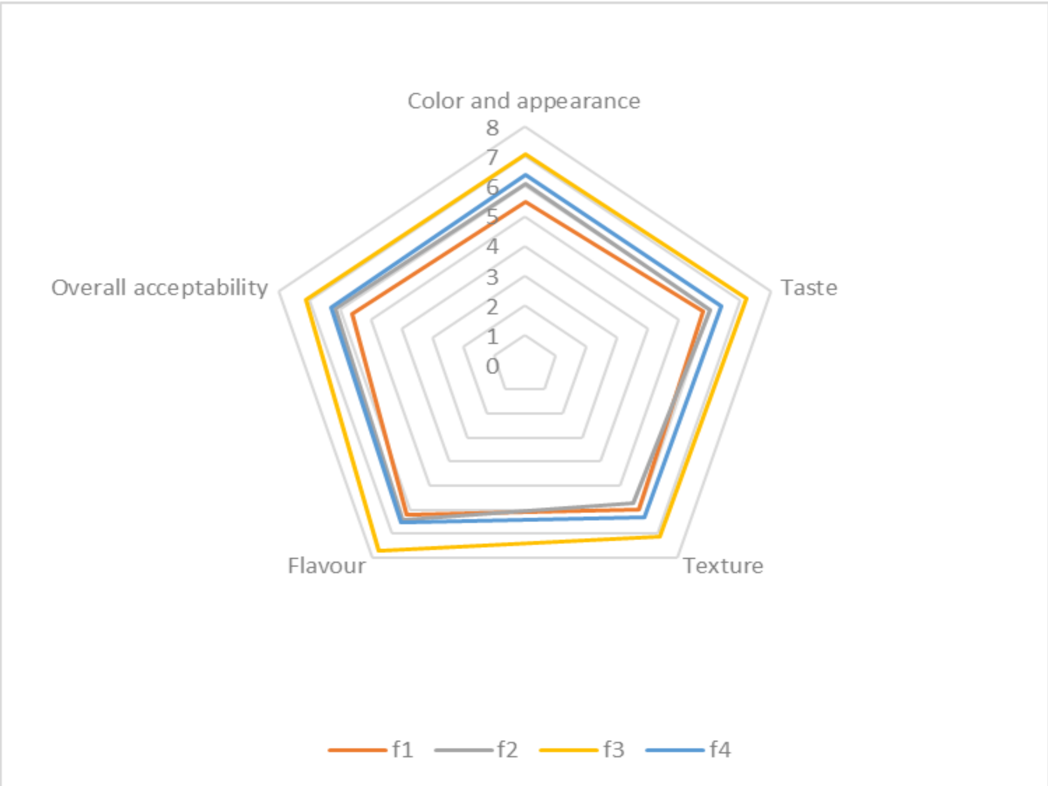
Graph 9: Sensory parameter of milk in 10% Citric acid



Graph 10: Yield of combinations of jackfruit seed milk



Graph 11: Sensory evaluation of combination of milk for formulation of paneer



5.5.2 FORMULATION OF PANEER

The four combinations of milk f_1-jackfruit seed milk (100%), f_2 -jackfruit seed milk (50%) + groundnut milk (50%), f_3- jackfruit seed milk (50%) + soy milk (50%) and f_4-jackfruit seed milk (50%) + soy milk (25%) + groundnut milk (25%) was analyzed for their yield ratio and sensory attributes, each combination of milk was treated with the coagulum's vinegar, lemon juice and 10% citric acid. From the results of yield ratio and sensory evaluation of selecting the combination of milk it is evident that f_3 Jackfruit seed milk (50%) + soy milk (50%) had (0.79) highest yield ratio compared to other combinations of milk giving more coagulated mass on introducing vinegar as coagulum, whereas both lemon juice and 10% acid gave least coagulated mass and change in flavour. Moreover, f_3 had the highest sensory attributes (7.175) making it the best combination for preparation of paneer.

5.5.3 Preparation of jackfruit seed milk paneer

In the present study, the preparation of paneer was done by selecting the seeds to prepare the milk. One liter of Jackfruit seed milk (50%) + soy milk (50%) was heated with occasional stirring. The temperature of milk will be raised to 80 - 85 ˚C with holding. Then it was cooled to 70 - 75 ˚C and coagulum vinegar was added with constant slow stirring till the completion of coagulation. The time taken for addition of the coagulation will be noted. The whey was drained and the coagulated mass was collected later filled in a muslin cloth. Pressure was applied on the top of the paneer by placing a weight of 4-5kg for about 15 minutes. The pressed paneer was then removed from the muslin cloth and after cutting in 7-8 inches size pieces, the pieces was immersed in chilled water (4˚C-6˚C) for two hours. The Paneer was wrapped in butter paper and packed in polyethylene (LDPE) pouches, heat sealed and stored under refrigerated conditions as showed in fig 2.

The paneer was prepared using the direct acidification process with 10% citric acid. In a steel bowl, 1 Liter of coconut milk was taken and heated, with occasional stirring to prevent skin formation. The milk's temperature was raised to 85°C and held there, then cooled to 75°C before adding 10% citric acid with continuous slow stirring until coagulation was complete. The coagulation process took approximately 40-50 seconds.

After draining the whey, the coagulated mass was collected and placed in a muslin cloth. A pressure of 4-5kg was applied on top of the coconut paneer by placing a weight for about 15 minutes. Subsequently, the pressed coconut paneer was removed from the muslin cloth, cut into 7-8 inches size pieces, and immersed in chilled water (4°C-6°C) for two hours (Shristi and Gita, 2019).

5.6 SENSORY ACCEPTABILITY OF THE DEVELOPED SOFT CHEESE (PANNER)

Sensory acceptability plays a crucial role in the success of plant-based paneer products as it directly influences consumer preference and purchasing decisions. Several studies have explored the sensory characteristics of various plant-based paneer alternatives. Research by Singh *et al.* (2019) examined the sensory attributes of paneer made from almond milk, soy milk, and coconut milk, highlighting differences in taste, texture, and aroma. Additionally, a study by Jain and Khetra (2020) investigated the sensory acceptance of paneer derived from pea protein and cashew milk, revealing differences in mouthfeel and flavor profiles. Furthermore, Mohapatra *et al.* (2021) examined the sensory properties of paneer formulated with rice milk and oat milk, indicating variations in appearance and overall liking. These studies collectively demonstrate the importance of sensory evaluation in developing and improving plant-based paneer products, catering to diverse consumer preferences and ensuring their widespread acceptance in the market.

The jackfruit seed milk soy milk paneer was ascertained by a panel of judges using hedonic rating scale to determine the quality analysis and shelf-life study of the paneer using Kruskall- Wallis's test.

5.7 QUALITY ANALYSIS OF PANEER

The quality analysis of the paneer was evaluated for various sensory attributes like color and appearance, taste, texture, flavour and overall acceptability, the results are discussed here.

5.7.1.a Color and appearance

Colour and appearance evaluation is a critical aspect of assessing the sensory acceptability and consumer appeal of soy paneer, a popular plant-based alternative to traditional dairy paneer. Researchers have conducted studies to investigate the visual attributes of soy paneer products. For instance, a study by Mondal *et al.* (2017) explored the influence of different processing methods on the colour and appearance of soy paneer, revealing that variations in processing conditions significantly affected the product's visual characteristics. These studies emphasize the importance of colour and appearance evaluation in optimizing soy paneer formulation, ensuring a visually attractive product that can rival its dairy-based counterpart and increase consumer acceptance and marketability.

In the present study the color and appearance of the paneer in the initial stage and final stage after one week had a huge difference. In the initial stage the color and appearance of the paneer was (7.6) which toward the end of storage was reduced to (5.1) which showed difference in color and appearance.

5.7.1.bTaste

Taste evaluation of different plant-based paneer varieties has become a subject of interest among consumers seeking alternatives to dairy-based products. The evaluation of taste is crucial in understanding the diverse options available to consumers in the plant-based market, guiding both manufacturers and consumers to choose the best-suited option according to individual preferences and dietary requirements. In the present study the taste of the paneer in both initial and final stage was different as in initial stage the taste was higher (7.7) and in the initial stage it had least score (4.3) and acceptance due to souring in the refrigerated condition.

5.7.1.c Texture

Texture evaluation is a crucial aspect in assessing the quality of plant-based paneer, a popular dairy-free alternative to traditional paneer made from milk. Researchers and food scientists have employed various methods to objectively analyse the texture of these products. In a study by Teng *et al.* (2019), instrumental techniques such as texture profile analysis (TPA) were used to evaluate the firmness, cohesiveness, springiness, and chewiness of different plant-based paneer samples derived from sources like soy, almond, and cashew. Another study by Gupta *et al.* (2021) applied sensory evaluation using a trained panel to assess attributes like smoothness, creaminess, and mouthfeel. These evaluations are essential for ensuring consumer acceptance and providing insights for further improvement in the formulation and processing of plant-based paneer products, thus texture is the is a good sign of food quality and has significant on the acceptance of the developed paneer, in the initial stage it had the highest sensory acceptability (7.2) and lowered to (4.9) after one week of storage.

5.7.1.d Flavour

Flavour evaluation of different plant-based paneer options is an essential aspect of assessing their culinary appeal and consumer acceptance. A study by Raja *et al.* (2014) explained the sensory evaluation of soy paneer where flavour had the highest score helped differ the sensory attributes from different samples. Since flavour sets one dish apart from another the flavor of the paneer was analyzed from which the initial stage had the highest score (7.8) and reduced to (4.1) towards the end of storage.

5.7.1.e Overall acceptability

The overall acceptability of different plant-based paneer alternatives has been a subject of growing interest in recent years, owing to the increasing popularity of plant-based diets and the environmental concerns associated with traditional dairy paneer production. The sensory attributes and consumer preferences of various plant-based paneer have promising results indicating that plant-based paneer can offer comparable taste, texture, and nutritional qualities to its dairy-based counterpart. A study Khodke *et al.* (2014) explained the sensory evaluation of groundnut soy paneer where the highest overall acceptability was for combination 100:0 having all the attributes at highest score making it highly acceptable.

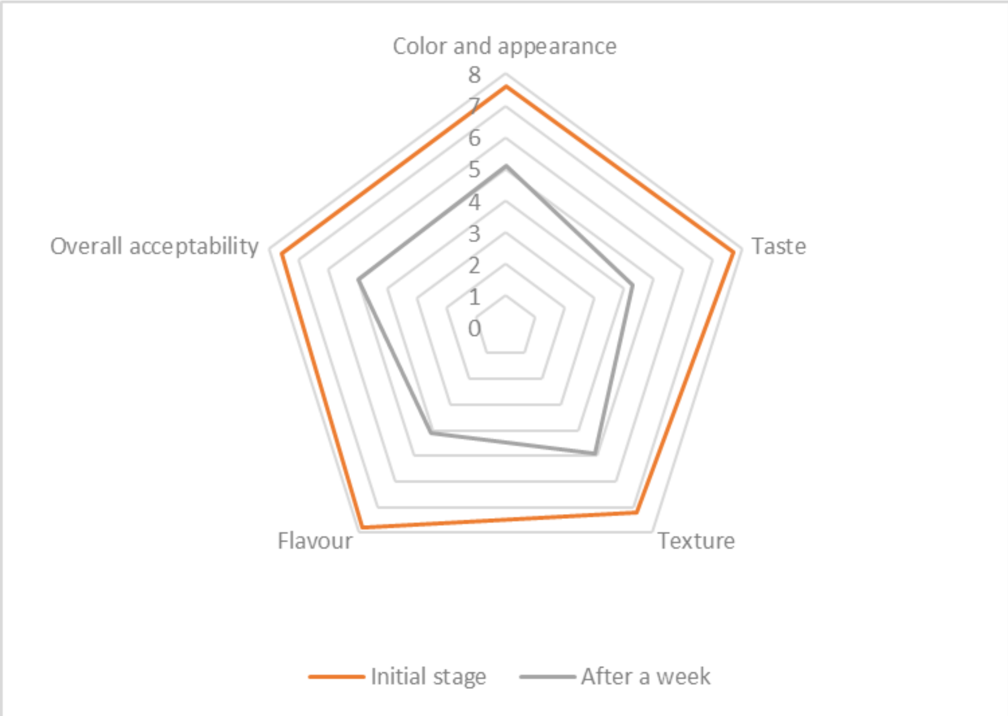
Shristi and Gita (2019) investigated the preparation of coconut paneer using different proportions of coconut milk mixed with cow's milk. The attempt to prepare paneer using pure coconut milk (100% coconut milk) was not successful. In the sensory analysis, the mean scores for 40% coconut paneer (A) made with coconut milk showed slight variations in attributes like colour, appearance, flavour, texture, taste, mouthfeel, chewiness, and overall acceptability compared to the standard paneer made with 100% cow's milk (S). The 40% coconut paneer (A) received moderate likability scores (7.1±0.87-7.8±0.78).

On the other hand, the sensory evaluation results for coconut paneer (B) made with 60% coconut milk and 40% cow's milk showed high likability in attributes such as colour, appearance, flavour, texture, taste, mouthfeel, chewiness, and overall acceptability (8.4±0.69-8.9±0.31) compared to the standard paneer. The mean scores for sensory evaluation of coconut paneer (C) made with 80% coconut milk ranged from moderate to high likability (7.4±0.72-8.1±0.93) compared to the standard paneer.

Based on the mean scores from the sensory evaluation, coconut paneer (B) made with 60% coconut milk and 40% cow's milk was found to be the most acceptable paneer. It received the highest scores among all the samples and was extremely liked in all sensory attributes by the semi-trained panel members on a 9-point hedonic scale

Result of the sensory evaluation of the present study revealed that paneer at the initial stage had the highest score (7.575) making it the most suitable for consumption at initial stage, however even after one week the overall acceptability is reduced to (4.952) which also was acceptable for consumption.

Graph 12: Sensory evaluation of paneer



5.8 SHELF-LIFE STABILITY OF JACKFRUITSEED MILK SOFT CHEESE (PANEER)

The shelf-life stability of different plant-based paneer alternatives has been a critical aspect of their commercial viability. Several studies have investigated the storage properties and shelf life of plant-based paneer made from various ingredients. For instance, a study by Gupta *et al.* (2018) evaluated the shelf life of soy paneer and found that it remained stable for up to three weeks under refrigerated conditions, maintaining its sensory attributes and nutritional content. These studies collectively indicate that various plant-based paneer alternatives possess reasonable shelf-life stability, making them viable options for consumers seeking sustainable and longer-lasting dairy-free alternatives.

Total solid content, moisture content and other major components like carbohydrate, fat, protein, Fiber, and calcium of the selected paneer was analyzed using standard techniques. Textural profile of the paneer was also analyzed.

5.8.1. Total Solid Content

The minimum acceptable number of total solids in coconut milk as specified by the International Food Standard, should be 12.17±1.3%. However, during testing, the total solids content in the coconut milk paneer was found to be slightly lower at 9.67± 2.6%, which is slightly below the aforementioned minimum standard value. However, according to a report by Aubrey *et al*. (2022), it is possible to increase the total solids content by raising the extraction temperature and extending the duration of the extraction process. From the results of the present study, it is seen that the total solid content of the jackfruit seed milk panner was 11.63±1.5% meeting the specified food standards.

5.8.2 Nutrient composition of jackfruit seed soy milk paneer

Major nutrients like carbohydrate, protein, fat, calcium, crude fiber and moisture content of the jackfruit seed milk paneer were analysed using standard techniques.

5.8.2.a Carbohydrate

Carbohydrates are essential macronutrients that serve as a primary source of energy for the human body. carbohydrates are broken down into glucose, which is then used by cells for fuel or stored as glycogen in the liver and muscles for future energy demands. Balancing carbohydrate intake is crucial for maintaining a healthy diet and ensuring optimal bodily functions. A study conducted by Chang *et al.* (2018) the carbohydrate content in soy paneer varies generally from 1 to 2 grams of carbohydrates per 100 grams of serving. The result study shows carbohydrate content of the jackfruit seed milk panner was 1.8g/100g which is the optimum carbohydrate content needed for a plant-based paneer.

5.8.2.b Fat

Fat is a crucial macronutrient that plays several essential roles in the human body. It is a concentrated source of energy, beyond its energy function, fats are vital for the absorption of fat-soluble vitamins (A, D, E, and K) and serve as building blocks for cell membranes. Studies by Mäkinen *et al.* (2008) showed that fat content in soy paneer ranges from 4 to 8 grams per 100 grams serving, with the majority of the fats being unsaturated fats, such as polyunsaturated and monounsaturated fats.

From the results it is evident that fat content in jackfruit seed paneer is seen to be 3.4g/100g which is slightly lower than the normal fat content present in other plant-based paneer because jackfruit seed contains less fat content making it suitable for a low-fat healthy consumption (Shristi and Gita, 2019).

The results show that fat content of coconut milk paneer was 25.6±1.0 g/100g which was higher than the standard cow's milk paneer that contain 24.5±0.43 g/100g fat.

5.8.2.c Protein

Proteins are fundamental and versatile biomolecules that play crucial roles in the structure, function, and regulation of living organisms. The human body relies on an extensive array of proteins to maintain health and carry out its biological processes, making them indispensable players in the intricate symphony of life. The protein content in soy paneer can vary from 8 to 10 grams per 100-gram serving (Li *et al.*, 2019). But from the results of the present study it shows that protein content in the jackfruit seed milk paneer was (9.1 g/100g) making it the optimal protein consumption rather than normal dairy paneer available in the market.

The results of (Shristi and Gita, 2019) revealed that the protein content of coconut milk paneer was found 20.5±1.10 g/100g which was lower than the standard cow's milk paneer that contain 15.2±1.0 g/100g protein content.

5.8.2.d Crude fiber

Crude fiber, also known as crude dietary fiber, is a vital component of nutrition often found in plant-based foods. It refers to the indigestible portion of plant materials, such as cellulose, hemicellulose, and lignin, which cannot be broken down by digestive enzymes in the human body. According to a study by Kumar *et al* (2017) the crude fiber content in paneer was found to be approximately 0.15 g per 100g but crude fiber in plant-based paneer is significantly higher than regular milk paneer. Results of jackfruit seed milk paneer, the crude fiber content was (3.17%) which is higher than other plant-based paneer because jackfruit seed contains more crude fiber than other seeds.

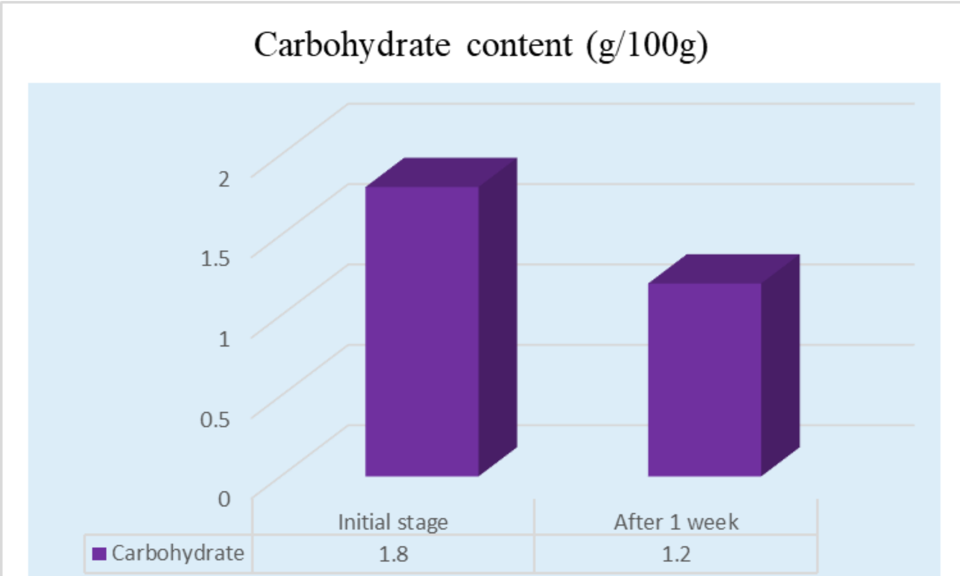
5.8.2.e Moisture content

Moisture content is a critical parameter in food that refers to the amount of water present in a given product. It plays a significant role in determining the product's quality, stability, and shelf life. Food products with high moisture content tend to be more susceptible to spoilage and microbial growth, leading to a shorter shelf life. Studies by Smita *et al.* (2014) reported that paneer from groundnut and soy milk has 6-17.8% of moisture content whereas the results of jackfruit soy paneer shows that the moisture content of the jack fruit seed milk paneer was (8.75%) which is a normal amount of water that can be present in the paneer.

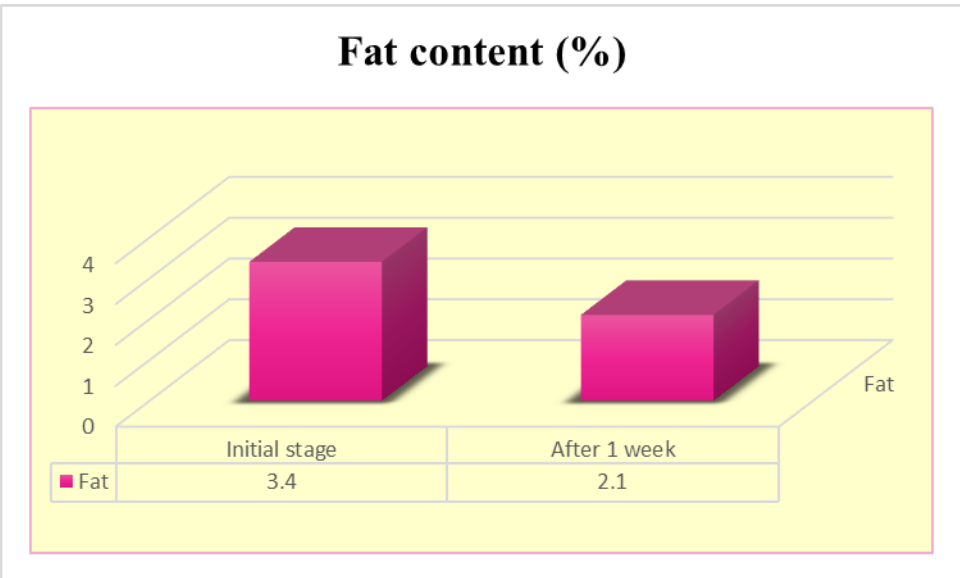
5.8.2.f Calcium

Calcium is an essential mineral that plays a crucial role in maintaining strong bones and teeth, as well as supporting proper muscle function, nerve transmission, and blood clotting. It can be found in various foods, making it accessible for people with different dietary preferences. Dairy products such as milk, cheese, and yogurt are well-known for their high calcium content. According to research conducted by Smitha *et al.* (2016), soymilk paneer contains approximately 160 mg of calcium per 100g serving, representing a considerable percentage of the recommended daily intake. From the results of jackfruit soy paneer, it is evident that the paneer contains (132.40 mg/100g) which is lower than other plant-based paneer because jackfruit seed milk has lowered calcium content.

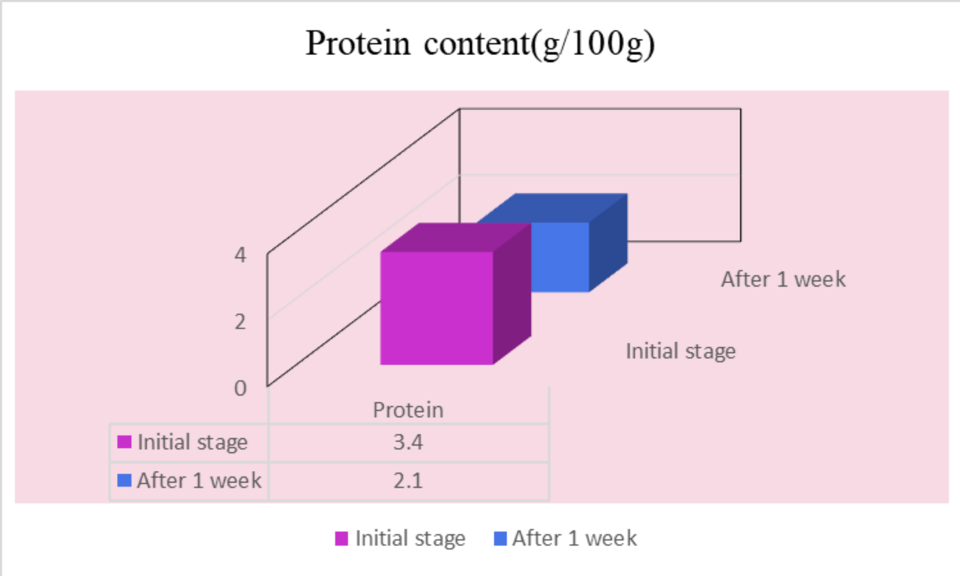
Graph 13: Carbohydrate content of paneer



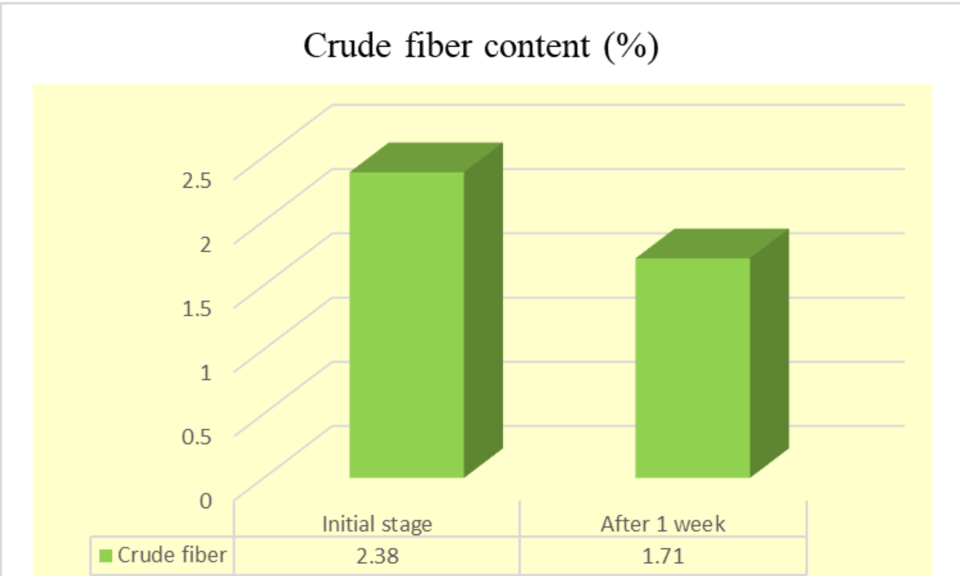
Graph 14: Fat content of paneer



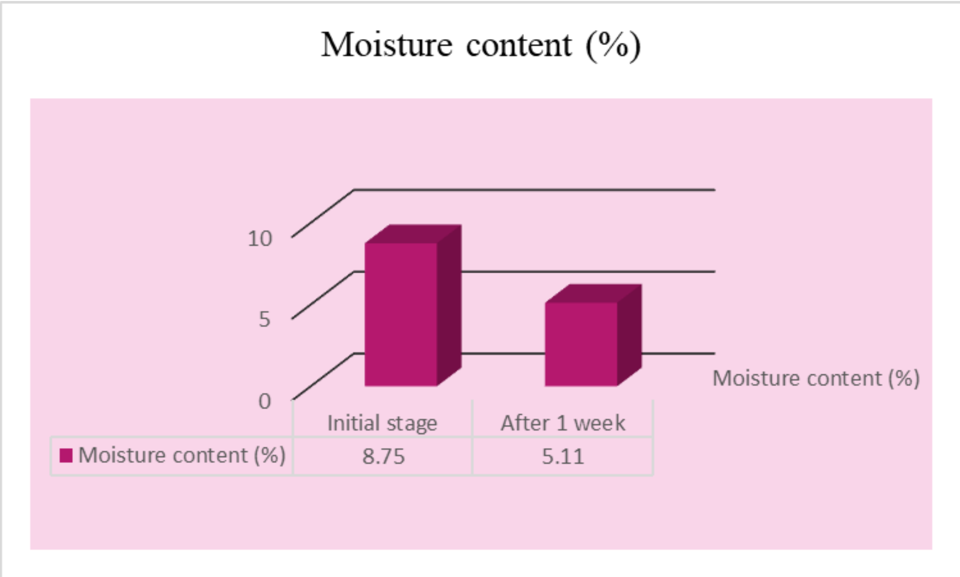
Graph 15: Protein content of paneer



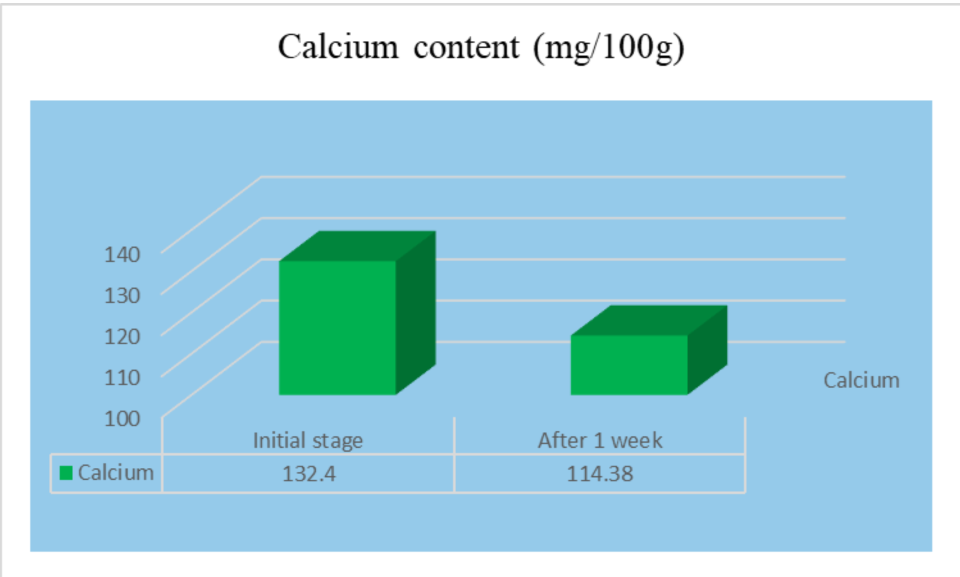
Graph 16: Crude fiber content of paneer



Graph 17: Moisture content of paneer



Graph no: 18 Calcium content of paneer



5.8 MICROBIAL PROFILE

The microbial profile in food refers to the diverse community of microorganisms present in various food items. These microorganisms can include bacteria, yeasts, Molds, and viruses. The microbial composition in food is influenced by factors such as the raw materials used, processing techniques, storage conditions, and hygiene practices.

In the present investigation bacterial colonies ($43x10^6$) along with total fungal count ($42x10^7$) and total coliform count ($36x10^2$) were observed in the paneer after one week of storage under refrigerated condition. According to Ahmed *et al.* (2020), the study results indicated that the total viable bacterial counts were highest in the control sample, measuring 68.33×10^5 cfu/g, while the lowest count was observed in sample F, with a value of 20.00×10^5 cfu/g. Samples treated with 0% jackfruit seeds powder showed lower total viable bacterial counts compared to the control sample. The bacterial load in the control sample aligns with the findings of Olorunnisomo *et al.* (2015), and the results for sample F are similar to those reported by Rahman *et al.* (2001) and Hatijah *et al.* (2019). The study also revealed that increasing the level of jackfruit seeds powder led to a decrease in the total viable bacterial load, which is consistent with the findings of Vahedi *et al.* (2008). The sample treated with 3% jackfruit seeds powder showed a total viable count of 20.00×10^5 cfu/g, while the sample treated with 0% jackfruit seeds powder had a count of 46.67×10^5 cfu/g, which is similar to the results reported by Oladipo *et al.* (2014). The total viable count varied significantly among all the samples ($p<0.01$).

Regarding coliform counts, the yoghurt samples ranged from 2.67 to 4.33 cfu/g. The highest coliform count was observed in the sample with 3% jackfruit seeds powder. The sample with 2.25% jackfruit seeds powder had a coliform count of 4.0 cfu/g, while the sample treated with 0% jackfruit seeds powder showed a count of 3.33 cfu/g. The control sample and the samples fortified with 0.75% and 1.5% jackfruit seeds had the same coliform count, which is consistent with the findings of Sarmini *et al.* (2012). Statistical analysis showed no significant differences between the coliform counts of the yoghurt samples ($p>0.05$).

5.9 COST OF PRODUCTION

The cost of the paneer was calculated on the basis of market value of ingredients used. The final cost of jackfruit seed soya paneer was worked out at the lowest expenses for the rate Rs. 56/- per 100g which is low cost compared to other commercially available plant-based paneers, for instance soy paneer available in the market is sold for Rs. 84/- per 100g explaining that jackfruit seed soya paneer is very cost effective to the consumers.

Jackfruit seed milk paneer possesses several excellent qualities that make it a unique and nutritious plant-based alternative to traditional dairy paneer having good nutritional properties similar to other plant-based paneers in the market. Overall, jackfruit seed milk paneer offers a host of beneficial qualities that appeal to health-conscious consumers seeking sustainable and delicious dairy-free options in their diet.

SUMMARY

6. SUMMARY

The study entitled "Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk" was aimed at standardization of the procedure for extraction of jackfruit seed milk and developing a dairy analogue – soft cheese (Paneer) from Jackfruit seed milk. The development of Paneer was standardised from seeds of two varieties of Jackfruit *varikka cv* and *koozha cv* which are most popular in Kerala. The two varieties of jackfruit seeds were soaked in four different soaking media viz. Water, 2 % Sodium bicarbonate, 3% Sodium hydroxide and 2% NaCl. From the sensory evaluation and yield ratio analysis *varikka* fully ripe soaked in water was found to have the highest yield ratio (0.67) and *koozha* fully matured soaked in sodium hydroxide (0.54) had the least value.

From the sensory attributes of 16 samples in four different soaking media, *varikka* fully ripe soaked in water (7.600) had the highest overall acceptability while *koozha* fully ripe soaked in sodium hydroxide (4.876) had the least value. When the curd setting properties of 16 samples of four different soaking media was analysed, *varikka* fully ripe soaked in water (7.325) had the highest curd setting and *koozha* fully ripe soaked in sodium hydroxide (4.586) had the least value.

Two heat treatments (steaming and pressure cooking) of eight samples were done. And the results showed that *varikka* fully ripe steamed (0.63) has the highest yield ratio. While *koozha* fully matured steamed (0.54) had the least value. The results of the sensory attributes of the eight samples in two different heat treatments proved that, *koozha* fully ripe pressure cooked (7.050) had the highest value and *koozha* fully matured pressure cooked (5.575) had the least value. The curd setting property analysis of eight samples in two different heat treatments showed that, *varikka* fully ripe steamed (7.075) had the highest curd setting property and *koozha* fully matured steamed (5.400) had the least value. From the experiment I, it was clear that on comparing the soaking and heat treatments, $v_1m_1s_1$ (*varikka* fully ripe soaked in water) which has the highest values for yield, sensory qualities and curd setting properties was the best treatment.

The milk extracted from this treatment was taken for the development of soft cheese (paneer).

For selecting the right coagulum for paneer preparation, three coagulants viz. vinegar, lemon juice and 10 % citric acid was chosen. From the yield ratio and sensory evaluation, vinegar was found to be the best coagulant for coagulating jackfruit seed milk. On coagulation and further analysis, it was proven that the highest sensory scores (7.515) was for the paneer from combination of jackfruit seed milk (50%) +soy milk (50%) in vinegar and jackfruit seed milk (100%) in 10 % citric acid (4.375) had the least value. The yield ratio of different combination of milk viz. jackfruit seed milk (50%) + soy milk (50%) (0.79) had the highest value and jackfruit seed milk (100%) (0.63) had the least value. The sensory evaluation of different combination of milk for formulation of paneer was done, jackfruit seed milk (50%) +soy milk (50%) in lemon juice was (7.175) had the sensory attribute. Jackfruit seed milk in citric acid (5.900) had the least value. The sensory evaluation, yield ratio and curd setting property was conducted by ten semi-trained panellists. The difference in scores were analysed by using Kruskal-Walli's test and it was analysed that there is no significant difference between the treatments for different attributes *viz.* Colour and appearance, taste, texture, flavour and overall acceptability. The best treatment was selected based on the result of functional qualities and sensory evaluation. The selected milk combination was used for the preparation of the paneer. The preparation of paneer was done by extracting the milk from soy and jackfruit seeds followed by soaking in water for 24 hours and extracting the milk and boiling to 90°C. Vinegar was used for the coagulation and the coagulated mass was collected and pressed with weight to cut into 7-6-inch pieces and immersed in cold water and wrapped in butter paper and polyethylene pouches and refrigerated at 4°.

The best selected paneer was analysed for nutritional properties, sensory attributes and microbial analysis. From the nutrient composition analysis of jackfruit seed and soy milk paneer, it was found that the carbohydrate content was 1.8(g/100g) in the initial stage and after one week it is reduced to 1.2(g/100g). Similarly, the fat content at initial stage was 3.4(g/100g) and after one week it was reduced to 2.1(g/100g). The same pattern of decrease was seen in protein i.e., at initial stage the protein content which was

9.1(g/100g) reduced after one week reduced to 7.9(g/100g). It could also be noted that the crude fibre which at initial stage was 2.38% decreased after one week to 1.71%. The moisture content at the initial stage was 8.75% and after one week it declined to 5.11%. Calcium at initial stage was 132.40(mg/100g) and after one week it was got reduced to 144.38(mg/100g).

Microbial analysis of the paneer was done at weekly intervals to ascertain the shelf life of the product. The total bacterial count of the paneer at the initial stage was TLTC and after one week it was 43×10^6. The total fungal count of the paneer at the initial stage was TLTC and after one week increased to 43×10^7. The total coliform count of paneer at the initial stage was TLTC and after one week increased to 36×10^2 and total solid content of the paneer at the initial stage was 12.17+- 1.3% and after one week it was reduced to 9.67+-2.6%. It could be noted that the all the counts are within the limits prescribed by FSSAI.

Cost of the developed product was calculated. The cost estimate of the paneer ranged from Rs 50/- to Rs 56/-. The lowest expense was worked out for preparation of paneer (Rs 56/-) per 100g. The rate of the paneer was less when compared to commercially available plant- based paneers.

The study concludes that the jackfruit seed milk paneer is rich in nutrients and easy to prepare. The paneer is inexpensive and a good source of nutrients than other commercially available plant-based paneer. Hence the jackfruit seed milk paneer can be considered as a novel food product. The opportunity to develop novel, healthy plant-based food products are increased along with the consumer consciousness about sustainable living. Currently consumers are aware about plant-based food products and its health benefits which help them to implement a coherent food strategy.

The functional characters of the jackfruit seed milk paneer can be used in replacing dairy based paneer for better nutritional quality and cost effectiveness which increases consumer acceptance the preparation of jackfruit seed milk paneer will provide more convenience in both domestic and commercial level in packaging, handling and storage. Therefore, the present study has thrown justice on new insights on developing plant-based products from underutilized parts of plant of nutritional significance.

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APPENDICES

APPENDIX-I

Score card for sensory evaluation of jackfruit seed milk in different soaking media

Name: **Date:**

Product: jackfruit seed milk

Treatments	Color and appearance	Taste	Texture & consistency	Flavour	Overall acceptability
$v_1m_1s_1$					
$v_2m_1s_1$					
$v_1m_1s_2$					
$v_2m_1s_2$					
$v_1m_1s_3$					
$v_2m_1s_3$					
$v_1m_1s_4$					
$v_2m_1s_4$					
$v_1m_2s_1$					
$v_2m_2s_1$					
$v_1m_2s_2$					
$v_2m_2s_2$					
$v_1m_2s_3$					
$v_2m_2s_3$					
$v_1m_2s_4$					
$v_2m_2s_4$					

Score value assigned:

Dislike extremely - 1
Dislike very much -2
Dislike moderately -3
Dislike slightly - 4

Neither like nor dislike – 5
Like slightly – 6
Like moderately – 7Like very much – 8 Like extremely – 9

APPENDIX-II

Score card for sensory evaluation of jackfruit seed milk in different heat treatments

Name: **Date:**

Product: jackfruit seed milk

Treatment	**Color and appearance**	**Taste**	**Texture**	**Flavour**	**Overall acceptability**
$v_1m_1h_1$					
$v_2m_1h_1$					
$v_1m_2h_1$					
$v_2m_2h_1$					
$v_1m_1h_2$					
$v_2m_1h_2$					
$v_1m_2h_2$					
$v_2m_2h_2$					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like slightly – 6

Like moderately – 7Like very much – 8 Like extremely – 9

APPENDIX-III

Score card for Curd setting properties of jackfruit seed milk in different soaking media

Name: **Date:**

Product: jackfruit seed milk

Treatments	Color and appearance	Taste	Texture & consistency	Flavour	Overall acceptability
$v_1m_1s_1$					
$v_2m_1s_1$					
$v_1m_1s_2$					
$v_2m_1s_2$					
$v_1m_1s_3$					
$v_2m_1s_3$					
$v_1m_1s_4$					
$v_2m_1s_4$					
$v_1m_2s_1$					
$v_2m_2s_1$					
$v_1m_2s_2$					
$v_2m_2s_2$					
$v_1m_2s_3$					
$v_2m_2s_3$					
$v_1m_2s_4$					
$v_2m_2s_4$					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-IV

Score card for Curd setting properties of jackfruit seed milk in different heat treatments

Name: **Date:**

Product: jackfruit seed milk

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
$v_1m_1h_1$					
$v_2m_1h_1$					
$v_1m_2h_1$					
$v_2m_2h_1$					
$v_1m_1h_2$					
$v_2m_1h_2$					
$v_1m_2h_2$					
$v_2m_2h_2$					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-V

Score card for Sensory parameters of milk with Vinegar

Name: **Date:**

Product: jackfruit seed milk

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1					
f_2					
f_3					
f_4					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-VI

Score card for Sensory parameters of milk with lemon juice

Name: **Date:**

Product: jackfruit seed milk

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1					
f_2					
f_3					
f_4					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-VII

Score card for Sensory parameters of milk with 10% Citric acid

Name: **Date:**

Product: jackfruit seed milk

Treatment	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1					
f_2					
f_3					
f_4					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-VIII

Score card for Sensory evaluation of combinations of milk for formulation of paneer

Name: **Date:**

Product: jackfruit seed milk

Combinations of milk	Color and appearance	Taste	Texture	Flavour	Overall acceptability
f_1					
f_2					
f_3					
f_4					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

APPENDIX-IX

Score card for Sensory evaluation of the developed soft cheese (paneer) on storage

Name: **Date:**

Product: jackfruit seed milk Soy paneer

Storage period	Color and appearance	Taste	Texture	Flavour	Overall acceptability
Initial stage (0 days)					
After 1 week (8^{th} day)					

Score value assigned:

Dislike extremely - 1

Dislike very much -2

Dislike moderately -3

Dislike slightly - 4

Neither like nor dislike – 5Like

slightly – 6

Like moderately – 7Like

very much – 8 Like

extremely – 9

ABSTRACT

DEVELOPMENT OF TECHNOLOGY FOR PREPARATION OF SOFT CHEESE (PANEER) FROM JACKFRUIT SEED MILK

by

FATHIMA SANAM

(2020-16-007)

ABSTRACT OF THE THESIS

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ABSTRACT

The study entitled **"Development of Technology for Preparation of Soft Cheese (Paneer) from Jackfruit Seed Milk"** was conducted at the department of Community Science, College of Agriculture, Vellayani, during the period 2020-2023. The objective of the study was to develop a dairy analogue using jackfruit seed milk and to evaluate its quality and sensory attributes.

Seeds from jackfruit cultivars *Varikka* and *Koozha* with two maturity indices (m_1) fully ripe, (m_2) fully matured, were selected for the study. The jackfruit seeds were manually peeled off using a stainless-steel knife. Seeds were soaked in different soaking media such as (s_1) water, (s_2) 2% sodium bicarbonate, (s_3) 3% sodium hydroxide, (s_4) 2% salt water Treatments: 2x2x4 =16, Replication: 3. The seeds from both varieties were cleaned and white arils was peeled off for further processing. The two varieties of seeds with different maturity indices were undergone two heat treatments (h_1) steaming, (h_2) pressure cooking. Treatments: 2x3= 8, Replication: 3

The extraction of jackfruit seed milk was done by washing and weighing the Pre-processed jackfruit seeds and blend with water (ratio 1:1.5 w/v). The blended mixture was then filtered through cheese cloth into a glass jar, the extracted jackfruit seed milk was stored in refrigerator at 4°C. The screening of the jackfruit seed milk obtained from the 24 treatments were tested for yield ratio, sensory attributes and curd setting properties. The soaking time was standardised to 24 hours. The heat treatments (steaming and pressure cooking) were standardised at 100°C for 20 minutes.

Functional characters like yield ratio, sensory attributes, curd setting of the samples were examined. After statistical analysis of sensory evaluation, yield ratio and curd setting properties of the 24 samples varikka fully ripe soaked in water ($v_1m_1s_1$) with no heat treatments was chosen as the best milk for the preparation of paneer.

For the preparation of paneer four combinations of milk was extracted (f_1) jackfruit seed milk (100%), (f_2) jackfruit seed milk (50%) + groundnut milk (50%), (f_3) jackfruit seed milk (50%) + soymilk (50%) and (f_4) jackfruit seed milk (50%) + soymilk (25%) +

groundnut milk (25%) and selection of coagulum for paneer preparation was done. (c_1) vinegar, (c_2) lemon juice and (c_3) 10% citric acid, these combinations were tested for yield ratio sensory evaluation and coagulation. (c_1) vinegar had the highest coagulation among the 3 coagulants. jackfruit seed milk (50%) + soy milk (50%) was selected as the best combination for the preparation of paneer.

The preparation of paneer was done by soaking and blending the selected combination and straining it through cheese cloth, extracted milk was coagulated using vinegar and the coagulated mass was collected by keeping weight, the collected paneer was cut into 7-6-inch pieces and immersed in cold water, the paneer was then wrapped in butter paper and stored in polyethylene pouches and refrigerated at ambient temperature.

The quality analysis of the paneer show (9.1g/100g) protein, crude fiber (2.38 %), carbohydrate (1.8 mg/100g), calcium (132.40 g/100mg), fat (3.4 g/100g) moisture content (8.75%) and total solid content (12.17±1.3%) the total bacterial count, total fungal count, total coliform count was accessed using microbiological methods. The presence of bacterial colonies, fungal growth and coliforms was not observed in the initial stage (TLTC) but after one-week bacterial count (43×10^6), fungal count (42×10^7) and coliform count (36×10^2) was detected.

The preparation of the jackfruit seed milk + soy milk paneer is convenient to prepare, nutritious and will becomes more in demand as a diary alternative once introduced to the market therefore jackfruit seed milk paneer is a great choice as a dairy analogue without preservatives and harmful chemicals to target broader consumer base.

സംഗ്രഹം

2020 - 2023 കാലയളവിൽ വെള്ളായണിയിലെ അഗ്രിക്കൾച്ചർ കോളേജിലെ കമ്മ്യൂണിറ്റി സയൻസ് ഡിപ്പാർട്മെന്ററിൽ "ചക്കയുടെ വിത്ത് പാലിൽ നിന്ന് സോഫ്റ്റ് ചീസ് (പനീർ) തയ്യാറാക്കുന്നതിനുള്ള സാങ്കേതിക വിദ്യയുടെ വികസനം" എന്ന തലകെട്ടിൽ പഠനം നടത്തി. ചക്ക വിത്ത് പാൽ ഉപയോഗിച്ചു് ഒരു ഡയറി അനലോഗ് വികസിപ്പിക്കുങ്ങയും അതിന്റെ ഗുണനിലവാരവും സെൻസറി ഗുണങ്ങളും വിലയിരുത്തുകയും ചെയ്യുക.

ചക്ക ഇനങ്ങളായ വരിക്ക, കൂഴ എന്നിവയിൽ നിന്ന് പൂർണമായും പാകമായ (m_1), പൂർണ്ണമായി പാകമായ (m_2), രണ്ട് പക്വത സൂചികക്കുള്ള വിത്തുകളാണ് പഠനത്തിനായി തിരഞ്ഞെടുത്തത്. സ്റ്റെയ്ൻലെസ്സ് സ്റ്റീൽ കത്തി ഉപയോഗിച് ചക്കയുടെ വിത്തുകൾ സ്വമേധയാ തൊലികളഞ്ഞു. (s_1) വെള്ളം, (s_2) 2% സോഡിയം ബൈകാർബോണ റ്റ്, (s_3) 3% സോഡിയം ഹൈഡ്രോക്സൈഡ്, (s_4) 2% ഉപ്പ് വെള്ളം എന്നിങ്ങനെ വിവിധ സോക്കിങ് മീഡിയങ്ങളിൽ വിത്തുകൾ കുതിർത്തു. ചികിത്സ : 2x2x4 = 16, ആവർത്തനം കൂടുതൽ സംസ്കരണത്തിനായി രണ്ട് ഇനങ്ങളിൽ നിന്നുമുള്ള വിത്തുകൾ വ്യതിയാക്കി വെളുത്ത അരിലുകൾ തൊലികളഞ്ഞു. വിവിധ ഇനങ്ങളിൽ നിന്നുള്ള വിത്തുകൾ ഒരു കൂടാതെ മെച്യൂരിറ്റി സൂചികകളും രണ്ട് ചൂട് ചികിത്സകൾക്ക് വിധേയമാക്കി (h_1) സ്റ്റീമിംഗ്, (h_2) പ്രഷർ പാചകം.

ചികിത്സ :2x3 = 8, ആവർത്തനം.

മുൻകൂട്ടി സംസ്കരിച്ച ചക്കയുടെ വിത്തുകൾ കഴുകി തൂക്കി വെള്ളത്തിൽ കലർത്തിയാണ് ചക്ക വിത്ത് പാൽ വേർതിരിച്ചെടുക്കുന്നത് (അനുപാതം 1:1.5%) മിശ്രിതം ചീഫ് തുണി യിലൂടെ ഒരു ഗ്ലാസ് പാത്രത്തിലേക്ക് ഫിൽട്ടർ ചെയ്തു. എടുത്ത ചക്ക വിത്ത് പാൽ 4 ഡിഗ്രി സെൽഷ്യസിൽ ഫ്രിഡ്ജിൽ സൂക്ഷിക്കുന്നു. 24ൽ നിന്ന് ലഭിച്ച ചക്ക വിത്ത് പാലിന്റെ പ്രചോദന വിളവ് സെൻസറി ആട്രിബ്യൂട്ട് കൾ, തൈര് ക്രമീകരണ ഗുണങ്ങൾ എന്നിവയ്ക്കായി ചികിത്സകൾ പരീക്ഷിക്കുന്നു. കുതിർന്ന സമയം 24 മണിക്കൂറായി നിശ്ചയിച്ചു. ചൂട് ചികിത്സകൾ (സ്റ്റീമിംഗ്, പ്രഷർ കുക്കിംഗ്) യഥാക്രമം 100 ഡിഗ്രി സെൽഷ്യസിൽ 20 മിനിറ്റിലും 121 ഡിഗ്രി സെൽഷ്യസിലും 15 മിനിറ്റിനുള്ളിൽ മാനദണ്ഡമാക്കി.

വിളവ് അനുപാതം, സെൻസറി ആട്രിബ്യൂട്ട് കൾ, സാമ്പിളുകളുടെ തൈര് ക്രമീകരണം തുടങ്ങിയ പ്രവർത്തനക്ഷമമായ പ്രതീകങ്ങൾ പരിശോധിച്ചു. 24 സാമ്പിളുകളുടെ സെൻസറി മൂല്യം നിർണയം, ഫലപ്രാപ്തി, തൈര് ക്രമീകരണം എന്നിവയുടെ ഗുണ വിശേഷതകൾ, പൂർണ്ണമായും പാകമായ വരിക്ക വെള്ളത്തിൽ കുതിർത്ത് ($v_1m_1s_1$) മികച്ച ഹീറ്റ് ട്രീറ്റ്മെന്റ് ആയി തിരഞ്ഞെടുത്തു.

പനീർ തയ്യാറാക്കുന്നതിനായി, വേർതിരിച്ചെടുത്ത പാൽ 4 വ്യത്യസ്ത അനു പാദങ്ങളിൽ സംയോജിപ്പിച്ച് ഇരിക്കുന്നു f_1 -ചക്ക വിത്ത് പാൽ (100%), f_2- ചക്ക വിത്ത് പാൽ (50%) നിലക്കടല പാൽ (50%), f_3 -ചക്ക വിത്ത് പാൽ (50%) +സോയാ മിൽക്ക് (50%), f_4- ചക്ക വിത്ത് പാൽ (50%) +സോയാ മിൽക്ക് (25%) +നിലക്കടല പാൽ(25%). മൂന്ന് വ്യത്യസ്ത ഗോകുലം (c_1) വിനാഗിരി, (c_2) നാരങ്ങ നീരും, (c_3) 10% സിട്രിക് ആസിഡും പനീർ തയ്യാറാക്കാൻ തിരഞ്ഞെടുത്തു. വ്യത്യസ്ത ശീതീകരണ ത്തോടു കൂടിയ നാലു പാലിൽ നിന്ന്

തയ്യാറാക്കിയ പനീർ വിളവ് അനുപാതം, സെൻസറി ഗുണങ്ങൾ, ശീതീകരണ ഗുണങ്ങൾ എന്നിവ പരിശോധിച്ചു.

മൂന്ന് കൊയാഗുലന്റുകളിൽ (c_1) വിനാഗിരി ആണ് ഏറ്റവും കൂടുതൽ കട്ട പിടിക്കുന്നതും f_3- ചക്കക്കുരു പാൽ (50%) + സോയാ പാൽ (50%) എന്ന കോമ്പിനേഷൻ പനീർ തയ്യാറാക്കുന്നതിനുള്ള മികച്ച കോമ്പിനേഷൻ ആയി തിരഞ്ഞെടുത്തു എന്നും കണ്ടെത്തി.

തിരഞ്ഞെടുത്ത കോമ്പിനേഷൻ കുതിർത്ത് യോജിപ്പിച്ച് ചീസ് തുണിയുടെ അരിച്ചെടുത്ത് താണ് പനീർ തയ്യാറാക്കുന്നത്, വിനാഗിരി ഉപയോഗിച്ച് വേർതിരിച്ചെടുത്ത പാൽ കട്ടിയെടുത്തു. അന്തരീക്ഷ ഊഷ്മാവ് പനീർ ഗുണനിലവാര വിശകലനത്തിൽ പ്രോട്ടീൻ (9. 1ഗ്രാം\100ഗ്രാം), ക്രൂഡ് ഫൈബർ (2. 38%), കാർബോഹൈഡ്രേറ്റ് (1. 8 മില്ലിഗ്രാം \100ഗ്രാം) കാൽസ്യം (132. 40 ഗ്രാം \100ഗ്രാം) കൊഴുപ്പ് (3. 4 ഗ്രാം\100 ഗ്രാം), ഈർപ്പം (8. 75%) മൊത്തം സോളിഡ് ഉള്ളടക്കവും (12. 17±1. 3%) മൈക്രോബയോളജി കൽ രീതികൾ ഉപയോഗിച്ച് മൊത്തം ബാക്ടീരിയകളുടെ എണ്ണം, മൊത്തം ഫംഗസിനെ എണ്ണം, മൊത്തം കോളിഫോം എണ്ണം, എന്നിവ പരിശോധിച്ചു. ബാക്ടീരിയയുടെ സാന്നിധ്യം എന്നിവ മൈക്രോ രീതികൾ ഉപയോഗിച്ച് പരിശോധിച്ചു. ബാക്ടീരിയയുടെ സാന്നിധ്യം കോളനികൾ, ഫംഗസ് വളർച്ച, കോളിഫോം രൂപങ്ങൾ എന്നിവ പ്രാരംഭ ഘട്ടത്തിൽ നിരീക്ഷിക്കപ്പെട്ട ഇല്ല, എന്നാൽ ഒരാഴ്ച്ചയ്ക്കുശേഷം ബാക്ടീരിയകളുടെ എണ്ണം ($43x10^6$), ഫങ്കൽ വളർച്ച ($42x10^7$), കോളിഫോം വളർച്ച (36x102) എന്നിവ കണ്ടെത്തി.

ചക്ക കുരു പാൽ തയ്യാറാക്കൽ, സോയാ പാൽ പനീർ സൗകര്യപ്രദമായി തയ്യാറാക്കുന്നതും പോഷക പ്രദവും വിപണിയിൽ അവതരിപ്പിച്ചു കഴിഞ്ഞാൽ ഒരു ഡയറി ബദൽ എന്ന നിലയിൽ കൂടുതൽ ആവശ്യകത ആകും. അതിനാൽ

വിശാലമായ ഉപഭോക്ത അടിത്തറയെ ലക്ഷ്യമിട്ട് പ്രിസർവേറ്റീവ് കളും ഹാനികരമായ രാസവസ്തുക്കളും ഇല്ലാത്ത ഒരു ഡയറി അനലോഗ് എന്ന നിലയിൽ ചക്ക വിത്ത് പാൽ പനീർ മികച്ച തെരഞ്ഞെടുപ്പാണ്.