# DEVELOPMENT OF FORTIFIED JAM FROM APPLE AND GUAVA PEELS WITH CHIA SEEDS: A SUSTAINABLE STEP TOWARDS FRUIT PEEL UTILIZATION

*Dissertation submitted to Mahatma Gandhi University in partial fulfillment of the requirement for the degree of*

*Bachelor of vocational studies*
*B.Voc. Food Processing Technology*

*By*


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**COLLEGE WITH POTENTIAL FOR EXCELLENCE**

Nationally Re-accredited at "A++" Level (4th cycle)

Affiliated with Mahatma Gandhi University

Kottoyam-686560


March 2025

# DECLARATION

We, **Devalaksmi A P(VB22FPT008), Nandana Nair (VB22FPT016)** and **Razia Noura K P (VB22FPT019)** hereby declare that this project entitled **"Development of fortified jam from apple and guava peels with chia seeds: A sustainable step towards fruit peel utilization"** is a Bonafide record of the project work done by us during the course study and that the report has not previously formed the basis for the award to us for any degree, diploma, fellowship or other title of any other university or society.

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# CERTIFICATE

This is to certify that the project report entitled **"Development of fortified jam from apple and guava peels with chia seeds: A sustainable step towards fruit peel utilization"** submitted in partial fulfilment of the requirements for the award of the degree of B.Voc Food Processing Technology of St. Teresa's College, Ernakulam is a record of Bonafide research work carried out by **Ms. Devalaksmi A P, Ms. Nandana Nair and Ms. Razia Noura K P** under my guidance and supervision and that no part of the project has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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# ACKNOWLEDGEMENT

First and foremost, we would like to thank God almighty for giving us the strength, grace, mercy and provision to undertake this project and to complete it satisfactorily. Without his blessings, this achievement would not have been possible.

We express our sincere gratitude to our Manager **Rev. Sr. Nilima CSST**, our Directors **Rev. Sr. Tessa CSST**, **Rev. Sr. Francis Ann** and our Principal **Dr. Alphonsa Vijaya joseph**, St. Teresa's College, Ernakulam, for availing us the permission to carry out our project work.

We offer a deep sense of gratitude to our beloved guide, Ms. **Sherin Mary Simon**, Assistant Professor, B.Voc Food Processing Technology, for her efficacious advice, expert guidance, untiring attention and support lavished on us. Language is inadequate to voice our deep sense of reverence and gratitude for her sustained encouragement and timely help throughout our research work. We would like to thank Merit Biolabs for providing the facilities and support for the analysis.

We are highly obliged to thank all the teachers of the Department of B.Voc Food Processing Technology for their continuous assistance in our endeavors.

We owe our great thanks to all our friends for their unforgettable help during various stages of our project work.

We are thankful to all those who directly or indirectly helped us throughout the completion of our project work.

# ABSTRACT

This project explores the development of fruit peel jam that incorporates chia seeds, which is aimed at enhancing the nutritional value. The major objective of the project is to explore the potential of utilizing apple and guava peel, a commonly discarded by-product of fruit industry. In the chemical analysis, it was found that the fruit peel jam contains a good amount of protein (2.46 g/100g), which is significantly higher than the protein content in conventional jams. It also showed a relatively lower level of carbohydrate (38.96 g/100g) and energy level (171.17 Kcal/100g). The crude fiber content was found to be significantly high (9.02%), which not only contributes to digestive health but also adds value by supporting blood sugar regulation. The formulation process involves optimizing the processing method to achieve desirable consistency and flavour profile. Sensory evaluation tests were conducted to assess consumer acceptance. In a time when consumers are more aware of health and sustainability than ever, this kind of innovation is more than just a trend—it's a necessary shift in how we think about food production. By embracing fruit by-products in jam production, the food industry has a real opportunity to create more eco-friendly products without compromising quality or taste.

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# LIST OF ABBREVIATIONS USED

| | |
|---|---|
| g | Gram |
| $H_2SO_4$ | Sulfuric acid |
| soln | Solution |
| $H_2O$ | water |
| evpn | Evaporation |
| wt | weight |
| ml | Milliliter |
| $Na_2SO_4$ | Sodium Sulfate |
| % | Percentage |
| NaOH | Sodium hydroxide |
| °C | Degree Celsius |
| Sp gr | Specific gravity |
| Kcal | Kilocalorie |
| & | And |

# CHAPTER 1 INTRODUCTION

## 1.1 Importance of utilizing fruit peels in food product development

One of the major problems faced by the food industry is how to make optimum utilization of the waste material. The problem of food waste is a significant concern that impacts individuals globally, exerting negative effect on the environment, society and economy. According to the Food and Agriculture Organization (FAO), one-third of the total food produced for human consumption is believed to be lost and wasted annually. The fruit processing industry generate a significantly huge amount of by-products (peels, seeds, pomace and wastewater) accounting for 55-60% of fruit weight (Panwar et al., 2019). Fruit peels are often discarded during processing, although they contain several useful components that can be utilised in other ways. Researchers have proved that fruit waste are rich in nutrients (vitamins, dietary fiber and minerals), antioxidants, phytochemicals, and food ingredients such as natural colors, pectin, antimicrobial components, etc. (Hassan et al., 2011). These fruit wastes can be transformed into promising source of functional compounds owing to their nutritional and functional properties.

Fruit peels are inexpensive raw material that can be used in food product development at very less cost. For example, pectin, a polysaccharide extracted from citrus peel or apple pomace is utilised as a commercially acceptable thickening agent in jams and jellies. (May, 1990). Further, mango (Banerjee et al.,), pineapple (Ukiwe and Akinnor, 2011), banana (Castillo-Israel et al., 2015), etc. have also been successfully tested for pectin isolation (Christy et al., 2014). Additionally, fruit peels can function as a substrate for the production of another thickening agent called bacterial cellulose (Kumbhar et al., 2015). There are some possible new products that can be developed from the fruit peels such as candied peel, oil, vinegar and enzymes.

## 1.2 Nutritional and functional Benefits

### 1.2.1 Nutritional benefits of guava peel, apple peel, and chia seed

The residue of guava processing such as the peel is very nutritious and rich in bioactive compounds. These supply nutritional benefits and are high in proteins, carotenoids, polysaccharides, flavonoids, and vitamins. Often disposed of in food and beverage processing, they have significant functional and nutraceutical potential (R Radhakrishnan et al., 2020).Peel of the apple has various biological properties and is considered a functional ingredient, serving as a byproduct of apple processing (RH Liu et al., 2003). It is proclaimed that the polyphenolic compounds found in apple peel include hydroxycinnamates, flavanols, anthocyanins, and dihydrochalcones, which contribute to antihypertensive and anti-inflammatory activities as well as possessing antioxidant activity (N Balasuriya et al., 2012).Anthocyanins and quercetin are the compounds present in apple peel beneficial for lowering blood pressure levels and antihypertensive effects. One of the richest sources of antioxidants is considered as citrus fruits mainly the orange the peel. Recent research has revealed its bioactive compounds highlighting its potential as a valuable ingredient in functional food and nutraceuticals. Orange peel also has the antioxidant capacity mainly due to its various phytochemical properties which includes flavonoids, phenolic acids, carotenoids, and limonoids, among others. These bioactive compounds demonstrate impressive properties, including protection against oxidative damage (A Mohsin et al., 2022).

Chia seeds have been shown to offer health benefits, including an improved blood lipid profile, as well as hypotensive, hypoglycemic, antioxidant, antimicrobial, and immunostimulatory effects (D Kmiecik et al., 2019).

### 1.2.2 Health advantage of incorporating superfood into everyday diets

The increasing demand for nutritional solutions has led to the growing popularity of “superfoods” as effective remedies in recent years. Their distinctive health benefits are contributing to their status as a trendy dietary choice globally(Rios et al., 2022). The Oxford Dictionary describes a superfood as “a nutrient-rich food regarded as particularly advantageous for health and well-being.”(Miller and Buiten, 2022).Superfoods are plant-based foods that are rich in nutrients and offer the highest nutritional benefits with the least amount of calories(Jagdale et al., 2021).These are acknowledged for their advantageous chemical makeup, featuring a high concentration of nutrients like vitamins, minerals, and antioxidants, which are regarded as exceeding basic nutrition(Lucas et al., 2021).It can be viewed as a broad term that describes foods that, beyond their standard nutritional value, offer health benefits and/or the ability to prevent diseases(Jagdale et al., 2021).

## 1.3 Scope of study

### 1.3.1 Potential of transforming under-utilized fruit peels into value-added products

Fruits and vegetables are among the most widely consumed goods worldwide, representing over 42% of total food waste. These plant-based foods can be eaten raw, processed, or used as an ingredient in other dishes (Sridhar et al. 2022).

For years, researchers around the globe have focused on the compaction and binding of large food waste materials as a source of fuel. This interest was developed due to the increase in $CO_2$ emissions from fuel combustion for cooking. With growing environmental and health issues linked to burning wood and coal, there has been a notable shift toward utilizing vegetable and agricultural waste for briquetting (Sridhar et al., 2022).

Citrus peel can be employed in various ways in the food processing sector. The peel serves as a raw material for creating variety of complex sauces that offer a distinctive flavor. These sauces not only provide health benefits but also expand the range of sauce options available. Citrus peel is commonly used to make candy with ideal color, aroma, taste, and medicinal properties. Additionally, it has numerous applications in the beverage industry. Rich in carbohydrates, fats, and vitamins, citrus peel is essential for various animals and is effectively used as animal feed. The peel pomace can also be processed to create biodegradable molded packaging materials (Kim et al., 2022).

Probiotic yogurt made with pineapple peel powder enhanced anticancer, antioxidant, and antibacterial activities against Escherichia coli, though no significant impact was noted on Staphylococcus aureus. Incorporating apple, banana, and passion fruit peel powder into probiotic yogurt improved its rheological properties and promoted the growth of Lactobacillus casei, Bifidobacterium animalis subsp. lactis, Lactobacillus acidophilus, and Lactobacillus paracasei. The influence of adding mango peels to milk on the growth rates of kefir microorganisms and their antioxidant properties was also assessed in fermented products (Dhanjal et al .,2022).

### 1.3.2 Innovation in jam production using non-conventional ingredients

Jams are created from a combination of fruit and sugar in such proportions that the final product contains at least 30% fruit and a minimum of 45°Brix. Osmotic dehydration using sugar solutions has been recognized as an effective method for largely preserving the quality of fruit. Additionally, the osmotic solution becomes enriched with water-soluble components from the fruit after the osmotic process. A study explored the production of kiwi and orange jam using osmotically dehydrated fruits combined with the osmotic solution, without any thermal treatment. The physical (color and mechanical properties) and physicochemical properties (aw, °Brix, moisture content, pH, acidity) of the resulting products have been analyzed and compared to those of commercially available products ( Chiralt et al .,2002).

Fruit jams are mainly made with sugar used as a preservative, but because of the growing health concerns, a lot of consumers now prefer sugar free or reduced sugar options or other alternative sweeteners. A study examined the preparation of four types of fruit jams: plum, strawberry, apple, and peach. Each variety was produced with and without sugar, and incorporated two types of microalgae biomass—Arthrospira platensis, known as Spirulina, and Chlorella vulgaris—as well as extracts from Dunaliella salina in different concentrations. The researchers assessed the physicochemical, rheological, and textural properties of these jams.

When sugar or fructose syrup was replaced in the jam formulations, changes occurred in pH, soluble solids, and the rheological and textural properties compared to traditional sugar-based jams; however, these changes were not visually apparent. Jams containing microalgae biomass extracts showed improved characteristics compared to their control versions. All jam varieties displayed weak-gel properties typical of fruit jams, but the weak-gel model analysis indicated that the effects of the various ingredients depend on both their concentrations and their interactions within the gel matrix. Interestingly, the strawberry and apple jams did not show significant differences between the samples with microalgae extracts and the control samples, regardless of sugar content, with both types being recognized as the best-performing varieties (Monzó et al., 2021).

### 1.4 Purpose and relevance of the study

The peel waste from fruit processing industry is a rich source of many useful components. This has become a serious problem as the production of fruits and vegetables increases, they influence environment and pollute it. Therefore, it needs to be managed and utilised in proper ways. The combined effort of waste minimization and sustainable utilization of the by-products would sustainably reduce the large quantities of fruit waste accumulated globally.

This study is relevant due to its alignment with sustainability goals, addressing environmental concerns by reducing waste in the food industry. It also draws attention to the nutritional benefits of fruit peels, meeting the growing consumer demand for healthier food options. By focusing on eco-friendly products, the study not only promotes sustainable practices but also creates economic opportunities for local producers, making it significant in today's food landscape.

### 1.5 Objectives

The primary mandate of the study is to explore the potential of utilizing apple peel and guava peel a commonly discarded by-product of fruit industry, in the production of a nutritious and flavorful jam. The study intends to investigate the potential of incorporating chia seeds into jam. This study aims to enhance sustainability of food production by transforming waste into value-added product, while also evaluating the sensory attributes and nutritional benefits of the jam.

1. Develop a nutritious and palatable jam using fruit peel as the primary ingredient.
2. Evaluate the sensory characteristics.
3. Determine the nutritional composition of the developed jam.

### 2.1 Introduction to Fruit Peel Utilisation

In the European Union, the generation of approximately 89 million tons of food waste is alarming, especially with the projection that this could increase by 40-fold in the coming years. Similarly, the Food and Agriculture Organization (FAO) estimates that around 40% of food produced in India is wasted, which is a staggering amount. The reported loss of 10 to 15 percent of total production by the Food Corporation of India further emphasizes the problem. The Ministry of Food Processing Industries (MFPI) in India estimates that fruit and vegetable losses are around 12 million tons and 21 million tons, respectively, leading to a significant economic impact of about 4.4 billion USD in losses, with total food value loss reaching approximately 10.6 billion USD.

The term "fruit and vegetable waste" (FVW) refers to the indigestible parts that are discarded at various stages, including collection, handling, shipping, and processing. It's important to recognize that FVW can be seen as a loss rather than mere waste, as it can be generated at different points in the food supply chain, both before and after consumption.

Moreover, FVW contains high amounts of phytochemical constituents, which have been studied for their dietary fibers, phenolic compounds, and other bioactive compounds. Research indicates that essential nutrients and phytochemicals are often concentrated in the seeds, peels, and other parts of fruits and vegetables. For example, the skins of avocados, grapes, and lemons, as well as the seeds of jackfruits and mangoes, have phenolic concentrations that are significantly higher than that of the fruit pulp. Utilizing these FVWs to extract bioactive compounds can lead to valuable applications in cosmetics, food, textiles, and pharmaceuticals. Additionally, some of the waste originates from horticultural supplies that are currently undervalued. Properly utilizing FVW not only addresses environmental concerns but also promotes a sustainable approach to resource management.(Dhanjal et al., 2022)

### 2.2 Overview of Food by-products in the fruit industry

#### 2.2.1 Dietary fiber

Dietary fiber, particularly from apple pomace, is rich in health benefits, especially in protecting against constipation, cardiovascular diseases, colorectal cancer, obesity and diabetes (Salmeron et al., 1997; Ellegard et al., 2000). Apple pomace is a rich source of non-starch polysaccharides (35-60% dietary fiber), with a significant amount of insoluble fiber (36.5%) as well as soluble fiber (14.6%) (Chen et al., 1988; Gallaher and Schneeman, 2001; Villas-Bˆoas et al., 2003; Sudha et al., 2007). Chen et al. (1988) investigated the effect of fiber source and concentrations on physical and baking properties of bread, cookies and muffins. Modifying baking products with small amounts up to 4% have been shown inclusive, fiber contents without altering levels of acceptable consumer sensory characteristics, while higher levels of pomace up to 10%-30% will create significant negative changes in texture and appearance aspects (Masoodi et al., 2002; Sudha et al., 2007). Additionally, when adding apple pomace, it has been shown to increase the phenolic compounds present in baking products and could provide potential benefit of antioxidants (Sudha et al., 2007). Though results are promising, research will need to substantiate the safety and stability of these products in a commercial setting (Sudha et al., 2007).

### 2.2.2 Pectin

The utilisation of apple pomace for the production of pectin is a feasible method because pectins from fruits are commonly used as gelling agents, thickeners, emulsifiers, and stabilizers for the food, cosmetics, and pharmaceutical industries (Thakur et al., 1997). Generally, apples contain approximately 10%-15% pectin, and extraction methods for the pectin conversion have included, but are not limited to: acid extraction, alkaline extraction, extrusion, and microwave-assisted extraction (Endreß, 2000; Wang et al., 2007). Extraction parameters such as pH, temperature, and solid:liquid ratio can greatly affect the yield and degrees of esterification of pectin produced (Constenla et al., 2002; Garna et al., 2007). For example, citric acid extraction yielded the highest level of pectin and was less expensive (Canteri-Schemin et al., 2005). However, higher pectin extraction temperatures can result in undesired pectin browning due to either enzymatic browning or caramelization (Constenla et al., 2002). Alkaline peroxide bleaching has been used to enhance the pectin color despite lowering the yield and polyphenolic compounds (Renard, 1996). Recently, techniques have been utilized that combine pectin and polyphenol recovery into an extracted pectin product that is light colored with antioxidant capabilities (Schieber et al., 2003).

### 2.2.3 Xyloglucan

Besides pectin, apple pomace is also a significant source of cellulose and hemicellulose-xyloglucan mostly fuco-galactoxyloglucans, which makes up to 18% of apple cell wall polysaccharides (Renard et al., 1995; Watt et al., 1999; Caili et al., 2006). Cellulose is used for producing various industrial products (hydroxypropylcellulose, methylcellulose, carboxymethylcellulose) having wide commercial applications. The xyloglucans are not solubilized during the hot acidic treatment of extracting pectin. There are studies that show yields of xyloglucans can be improved by increasing the concentration of alkali and extraction time (Renard et al., 1995). Enzymatic treatments resulted in a lower molecular weight xyloglucan with less viscosity in comparison to non-enzymatic methods (Watt et al., 1999). Ultrasound-assisted extraction was also reported to reduce extraction time more significantly than other pectin extraction methods, i.e. alkali extraction (Caili et al., 2006). Optimization of extraction conditions including liquid-to-solid ratio, alkali concentration and extraction time resulted in better xyloglucan yields. The potential uses of xyloglucans are a thickening agent, texture modifier and a source of biologically active oligosaccharides with medicinal properties contributing to providing a mechanism towards extracting a higher value biomolecules from apple pomace.

### 2.2.4 Antioxidants

A wide range of polyphenolic compounds have been isolated from apple pomace, such as cinnamic acid and its derivatives, epicatechin dimer (procyanidin B2), epicatechin, trimer, tetramer and oligomer, 3- hydroxyphloridzin and quercetin-3-glycosides phloridzin (Foo and Lu,1999). Polyphenols from apple pomace have shown to inhibit tumour-cell proliferation in vitro (Eberhardt et al., 2000). Polyphenols from apple pomace were found to be effective superoxide scavengers, in comparison to vitamins C and E; however, among themselves, procyanidins were observed to be superior to quercetin 3-glycosides, chlorogenic acid, phloridzin and 3-hydroxyphloridzin. These studies revealed that the polyphenols responsible for the antioxidant activity in apple are present in the pomace, and can easily be extracted for food fortification or nutraceutical product development.

### 2.2.5 Source of Biocatalyst

The intrinsic enzymes system of apple pomace had been employed for biocatalysis. Biocatalysts can be defined as the utilization of natural catalysts, such as enzymes (either isolated or intrinsic to the living cells) to perform chemical transformations on organic compounds. Almosnino and Belin (1991) explored an apple pomace intrinsic enzymes system for the bioconversion of polyunsaturated fatty acids in the production of aromatic compounds. The endogenous enzyme sytems contained a lipoxygenase that converted linoleic acid to 9,13-hydroperoxide (Kim and Grosch, 1979) and these intermediates were further catalysed by hydroperoxide lyase, resulting in the formation of volatile compounds, i.e. 2,4-decadienal and hexanal (Schreier and Lorenz, 1982; Hatanaka et al., 1986). Besides enzyme systems, apple pomace also contains mineral elements such as iron, zinc, calcium, copper and magnesium. As these micro-elements act as cofactors in many biosynthetic processes, they can be investigated for new applications either in biotranformations or bioconversions.

### 2.2.6 Pigment Molecules

Oxidation of polyphenols by polyphenoloxidase leads to the development of yellow-orange colored juice or ciders during processing in the presence of oxygen, which has a direct correlation with the concentrations of hydroxycinnamic acid, flavonols and dihydrochalcones, i.e. phloridzin and phloretin xyloglucoside (Lea, 1984; Nicolas et al., 1994). Phloridzin which is a phenolic compound is present in apple pomace and its enzymatic oxidation has been shown to produce yellow products (Lu and Foo, 1997; Ridgway et al., 1997; Schieber et al., 2003). Recent development in analytical techniques and instrumentation has led to the identification and generation of structural information on compounds such as phloridzin oxidation products (POP). The oxidation of phloridzin by mushroom polyphenol oxidase in POP production of yellow pigment, as an alternative to tartrazine for application as a food dye, was evaluated (Guyot et al., 2007).

### 2.2.7 Fruit peel bar

This study is focused on creating a healthy snack bar using fruit peels, taking advantage of agricultural waste. The bar is made by carefully choosing ingredients using a method called

Response Surface Methodology (RSM) and analyzing its texture. The main ingredients include a mix of sweet lime and apple peels, jaggery, and germinated pearl millet, along with other components like almonds (5 g), corn flakes (10 g), flax seeds (2.5 g), dates (2.5 g), peanuts (2.5 g), and guar gum (2.5 g) to ensure a nutritious product.

The results from the ANOVA tests showed that the best amounts for the key ingredients were approximately 16.95 g of the peel mix, 88.45 g of jaggery, and 13.31 g of millet. This combination resulted in a bar that provides about 395.34 kcal of energy, 11.81 g of protein, and received a score of 8.30 for overall taste. Using fruit peels in snacks can boost their nutritional value and help satisfy kids' hunger while also reducing waste (Abeer sheikh et al., 2023).

### 2.2.8 Fruit and Vegetable Peel Based Edible Coatings/Films

Edible coatings are thin layers applied to food that help prolong its shelf life and keep its qualities intact without high costs. These coatings can enhance the food's functionality by preventing spoilage from microbes and serving as a way to deliver antimicrobial agents. They are particularly useful for preserving fruits and vegetables during transport, as these items are prone to damage from microorganisms, insects, and various conditions before and after harvesting. Coatings also create a modified environment around the food, which can lead to changes in sensory quality, antioxidant levels, color, firmness, ethylene production, microbial growth prevention, and the behavior of organic compounds in low-oxygen conditions. Recently, essential oils (EOs) have gained attention for their strong antimicrobial properties. For example, citral, the main component in lemongrass oil, has shown effectiveness against many foodborne pathogens and is being investigated for use in edible coatings.

Essential oils are generally considered safe because they provide significant benefits with minimal impact on the food's sensory qualities. New advancements in edible coatings include the use of various nanosystems, such as nanoemulsions, polymeric nanoparticles, and nanocomposites, which can release antioxidants and exhibit antibacterial effects on food surfaces. Due to their high antioxidant potential, fruit and vegetable peels are excellent candidates for making films and coatings.

Fish gelatin is also a promising source for creating biofilms because it is biodegradable and rich in myofibrillar protein. Moreover, the differences in amino acid sequences in various fruits and vegetables can influence the properties of these coatings (Dhanjal et al.,2022).

### 2.2.9 Citrus peel utilization

Citrus peels are often thrown away, but they actually contain valuable compounds that can be beneficial. Traditionally, people have used various parts of citrus fruits, including the peels, to help with issues like coughs, digestive problems, infections, muscle pain, and skin inflammation. For instance, the peels of C. reticulata and C. unshiu are used in Japan as herbal medicines known as "Chimpi." Similarly, dried peels of C. aurantium are used in a popular traditional remedy called "Touhi."

Tangerines, a widely enjoyed citrus fruit, have peels that are known as "Chenpi" in China and are used to help with stomach and breathing issues. In Western countries, tangerine peels are also added to drinks and baked goods for their flavor. Citrus peels in Chinese medicine are known to treat muscle pain, stomachaches, coughs, skin inflammation, and high blood pressure.

Additionally, the peels of wampee (Clausena lansium) are used in both Chinese and Indian folk medicine to address bronchitis and stomachaches. Jaboticaba (Plinia peruviana) fruit peels are used for treating diarrhea, skin irritation, coughing up blood, and asthma (Rabnawaz et al.,2022).

### 2.3 Nutritional Composition of fruit peel and seeds

#### 2.3.1 Apple Peel

Apple (*Mallus domestica*), a widely consumed fruit, is one of the most important sources of phenolics (Wolfe et al., 2008). In our diet, the consumption of apple or its products are a rich source of antioxidants and gives up to 22% of total dietary phenolics. Apple peel has approximately two to three times higher flavonoids as compared to the flesh of the apple and the peel also has unique flavonoids like quercetin glycosides, which is absent in the flesh. The extract obtained from the skin of the apple exhibit strong antioxidants activity (Rupasinghe et al., 2010).

Although apples contain different classes of bioactive compounds (Avad et al., 2000), their antioxidant properties are attributed to phenolic compounds. These compounds contain a large number of hydroxyl groups and double bonds, which are responsible for their antioxidant properties (Lee et al., 2003; Tsao et al., 2005). There are five major groups of polyphenolic compounds found in apple peel: hydroxycinnamic acids (primarily chlorogenic acid), flavan-3-ols [(+)-catechin, (-)-epicatechin and anthocyanidins], flavonols (mainly different quercetin glycosides), dihydrochalcones (phloridzin is the most abundant) and anthocyanins (predominantly cyaniding-3-galactoside) (Tsao et al., 2003; Alonso-Salces et al., 2004; Vanzani et al., 2005; Oszmian´ski and Wojdylo, 2008).

The monomeric and polymeric flavan-3-ols constitute about 60% of the total phenolic concentration in apple peel, followed by flavonols (18%), hydroxycinnamic acids (9%), dihydrochalcones (8%), and anthocyanins (5%). Besides these polyphenols, the apple peel also contains additional flavonoids (Gornas et al., 2015). A high amount of polyphenol has protective effects against oxidation, tumoral formation and cell signalling.

#### 2.3.2 Guava Peel

Guava (*Psidium guajava* L.), which grows in the tropical and subtropical areas of the world, contains a number of bioactive compounds, such as flavonoids, guavanoic acid, guajadial, guayavolic acid and guajaverin (Gutierrez et al., 2008). Although several scientific works have been done on the fruit, studies on the peel are limited. According to Bashir and Abu-Goukh (2003), guava peel possesses higher polyphenolic compounds than pulp. Suwanwong and Boonpangrak (2021) also reported similar observations for Thailand cultivars (Paen Sitong, Kimju, and Paen Saidang).

Different parts of the guava plant possess many bioactives, and have been used in traditional medicine for the treatment of various ailments, such as diarrhoea, ulcers, and rheumatism (Anas et al., 2008; Goncalves et al., 2007; Hoque et al., 2007; Wang et al., 2014). Guava peel is abundant in carotenoid (yellow) and chlorophyll (green) pigments (Corrêa et al., 2011), and these pigments are highly correlated with powerful antioxidant capacities (Lu et al., 2021). Guava peel contains significant amounts of phenolic compounds and flavonoids, which are known for their antioxidant properties. For instance, Liu et al., (2018) reported high TPC (39.65 mg GAE/g DW) and TFC (19.72 mg Rutin/g DW) in the guava peel compared with the flesh.

In a study conducted by Bylappa and Nag (2023), the peel of pink guava fruit showed high antioxidant values in all three assays (DDPH, ABTS, and FRAP). Chen et al., (2015) reported that FRAP antioxidant value in guava peel (57.73µmol Fe (II)/g) was much higher than the flesh (13.73µmol Fe (II)/g) and seeds (16.53µmol Fe (II)/g). Liu et al., showed that the DPPH assay in the peel (264.30±5.39µmol TE/g DW) revealed three- and four-fold antioxidant capacities than flesh (98.78±3.40µmol TE/g DW) and seed (62.84±2.81 µmol TE/g DW), respectively.

Guava peel is also a rich source of catechin. Marina and Noriham (2014) quantified 1523.79 mg catechin from 1g of the guava crude peel extract. Catechin and its derivatives were also reported from different parts of guava, including peel (Liu et al., 2018).

### 2.3.3 Chia seeds

Chia, scientifically referred to as *Salvia hispanica*, is an herbaceous plant belonging to the family Lamiaceae. Chia is Spanish word for "chian" or "chien", which means oily (Kulczynski et al., 2019). Chia seeds are considered under-utilized pseudocereal even though they contain various nutrients such as protein, dietary fiber, lipids, vitamins and minerals (Malik and A.M., 2022). Chia seed is the richest source of omega-3 fatty acids (Prathyusha et al., 2019). Chia seeds contain 15-23% protein content which is higher than the other cereals. Moreover, the seeds possess 10 essential amino acids, of which leucine, arginine, valine, lysine, and phenylalanine are present in more abundant quantities. In addition, chia seeds are a rich source of non-essential amino acids, including glycine, alanine, serine, glutamic and aspartic acids (Kulczynski et al., 2019). The seeds contain 30-34g dietary fiber per 100g, of which 85-93% consists of insoluble dietary fiber and 7-15% of soluble dietary fiber (Kulczynski et al., 2019). Chia seeds possess 25-40% of fat, of which about 83% consists of PUFA. These include omega-3 α-linolenic acid (64%) and omega-6 α-linolenic acid (20%). The ratio of omega-6 to omega-3 acids is approximately 0.3:0.35 (Ciftci et al., 2012; Nitrayova et al., 2014; Villanueva-Bermejo et al., 2019).

Chia seeds are an abundant source of vitamins such as Vitamin B1, Vitamin B2 and Niacin in concentrations of 0.6, 0.3 and 8.8 mg/100g, respectively (Kulczynski et al., 2019). The seeds also possess many minerals such as potassium, magnesium, calcium, and phosphorus in concentrations of 407-726, 335-449, 456-631, 860-919 mg/100g, respectively (Kulczynski et al., 2019). The bioactive potential of chia seeds is due to phenolic compounds with antioxidant properties. Antioxidants in chia seeds are found in free and bound forms with sugars having glycosidic linkages (Lopez and Tecante, 2015). Carotenoids, tocopherols, phytosterols, and polyphenolic compounds are the natural antioxidants found in chia seeds (Hrnˇciˇ et al., 2022). Additionally, vitamin E, tannins, and phytates are also present as antioxidants in chia seeds (Grancieri et al., 2019).

Chia seeds (dry basis) contain 8.8% phenolic compounds, including *p*- coumaric acid, chlorogenic acid, rosmarinic acid, caffeic acid, quercitin, cinnamic, gallic, myricetin, and kaempferol present in more significant amounts. The primary phenolic compounds in chia seeds (in µg per 100g), includes caffeic acid (27.0), quercetin (0.17), kaempferol (0.01), daidzin (6.6), glycitin (1.4), and genistin (3.4) (Hrnˇciˇ et al., 2020). Chia seeds are abundant in oil (~30-39%) and contains phytosterols (~0.02%) such as stigmasterol, stigmastanol, campesterol, Δ5-avenasterol, β-sitosterol (Motyka et al., 2023).

Chia seeds have mucilage consisting of polysaccharides such as 4-O-methyl-α-D-glucopyranosyluronic acid, β-D-xylopyranosyl acid, and α-D-glucopyranosyl acid. It contains ~48% of total sugars and ~4% of protein with high solubility of ~85%. These hydrophilic functional groups are associated with hydrogel network formation of mucilage (Fernández-López et al., 2020; Brütsch et al., 2019).

### 2.3.4 Role of chia seeds in enhancing nutritional quality and functionality

Nowadays, the development of new products plays a significant role in the food industry. Consumers demand food products with high nutritional value that provides additional health benefits, through incorporation of new ingredients and natural products in such foods. Chia seeds can be added in the food to increase its nutritional value as it abundant in nutrients that are of great importance to health, such as antioxidants, proteins, vitamins, amino acids, minerals, and fiber (Chicco et al., 2009; Coates and Ayerza, 2009; Djousse et al., 2007).

## 2.4 Importance of reducing food waste in food industry

In this paper (challenges for reducing food waste) we use the term ‘food waste’ as a general term to refer to material which was produced with the intention to be consumed by people, but ultimately exited the food supply chain (Chaboud and Daviron, 2017).

The food produced has undergone various process steps along the food value chain, starting with agricultural production before reaching the retail or consumer level. These processes require resources as energy, water, and other materials are necessary for the conversion of the raw material to the end product. Hence leftover food also includes discarding all the other resources which have been used during production and transport. Furthermore customers and politicians have called on the food industry to accept social responsibility for its impact on customers, society, and the environment (J.Ruckert John et al.,2017).

## 2.5 Case study or example of sustainable practices evolving fruit by products

The whole food system loses or wastes 30% of all produced foods, and all stakeholders have a responsibility to prevent these food losses, everyday. To decrease the food losses in all responsible sectors, from producers and processors to intermediates until reaching the consumers an overview should be performed of all systems(E.Sznida, 2018).The most widely consumed foods amongst are Fruits and Vegetables (Bakshi M et al.,2013).The wastes of different fruits production of different products, such as juices, juice concentrates, jams, canned fruit, dehydrated fruit and fresh cut fruit, beyond others, having a greatly negative impact in this field(V Ranganthan et al., 2018). Many molecules can be extracted from the secondary raw materials of fruit by-products, and among these the most important economically (higher market value) include the enzymes and vitamins.extraction meanwhile after such other bioactive compounds can be recovered, such as phenolics, alkaloids, flavonoids, carotenoids, glycosides, tannins, saponins and terpenoids(Y Todmor et al.,2010). Nonetheless extracts can be used as functional ingredients due to their biological activities, such as antimicrobial, prebiotics and antioxidants, or be applied to produce functional food products. Also the the ingredients of cellulosic origin can be applied directly in non-food industries, such as paper and biodiesel industries, as well as sustainable packaging, which can help to reduce the environmental impact of secondary raw materials in the environment and increase market acceptance, when compared to those currently available in the market(Y Todmor et al. , 2010).

## 2.6 Conventional method for jam preparation.

Jam is the product prepared from sound, ripe, fresh, dehydrated, frozen or previously packed fruits including fruit juices, fruit pulp, fruit juice concentrate or dry fruit by boiling its pieces with nutritive sweeteners namely sugar, dextrose, invert sugar or liquid glucose to a suitable consistency (Awulachew et al., 2021).

First boiling kettles are charged with fresh fruit, pulp or juice, water, and half the quantity of sugar. The mixture is boiled under continuous stirring for three to four minutes. Steam is then cut off, and the remaining sugar is added. Boiling is continued to near the end-point, and then acid and pectin are added. Flavor and color, if needed, should be added before filling then Dissolution of Pectin, Rapid-set pectin (150 grade) may be used when 1lb jars are used for filling jams. The pectin must be completely dissolved in hot water. Most pectin manufacturers provide clear instructions on how best to dissolve their product. The most satisfactory procedure for pectin dissolution is to add 70 parts of hot water and 20 parts of sugar to each 10 parts of pectin. Mix the pectin and sugar in a dry container and add heated water to the mixture slowly with constant agitation until the pectin is completely dissolved, once this is complete the End Points must be determined and Thermometer Method is used, The thermometer must be accurately calibrated and fast-working. When the designed concentration is reached, the temperature is usually 105°C (Awulachew et al., 2021).

## 2.7 Innovative methods for jam preparation

Prolonged heat treatments, like those used in making jams and juices, can cause a loss of the beneficial properties of citrus fruits.

Osmotic dehydration at lower temperatures is a gentler way to make jam without damaging the fruit as much. Microwave energy has also been suggested as an alternative to traditional pasteurization, as it can preserve the natural taste and nutrients of grapefruit juice better, due to its faster processing time. Osmotic dehydration and microwaves were used instead of conventional heating, and bamboo, apple, and orange fibers were added and compared to regular pectin. The osmotic dehydration method produced jams with less sugar but kept the color close to that of fresh fruit. However, adding fiber was necessary to improve the texture, with bamboo fiber being the most similar to regular jam. On the other hand, microwaving affected the color of the jam like regular heating but made it thicker (Contreras et al., 2010)

## 2.8 Alternative ingredients used in jam preparation

### 2.8.1 Osmotic dehydrated peel

An alternative approach in jam production is to use previously dehydrated fruit, reducing the need for concentration (Gasque et al., 1996). Osmotic dehydration, in particular, helps maintain the fruit's flavor, aroma, and nutritional value while minimizing losses of minerals and vitamins (Jen et al., 1977). This method works by transferring water from the fruit into a concentrated sugar solution (usually sucrose) at low temperatures, avoiding phase changes. Sucrose also helps prevent the fruit from browning due to both enzymatic and non-enzymatic oxidation, keeping the fruit looking fresh and natural (Shi et al., 1996).

Additionally, the osmotic solution used in the dehydration process can be modified with additives and mixed back into the fruit to create jams. This helps recover any solutes that may have been lost during osmotic dehydration. For example, a new jam-making technique was developed that uses both osmotically dehydrated fruit and the osmotic solution directly in the processing of strawberry jam (Shi et al., 1996). Since the fruit is treated at lower temperatures (35-40°C) for only a short period, the resulting jam retains a more natural color, flavor, and overall quality (Monzó et al., 2002).

### 2.8.2 Jam made from fruit peels

Fruit peel waste is highly perishable and seasonal, posing challenges for both processing industries and pollution control agencies. However, fruit peels are nutrient-rich and contain several beneficial phytochemicals, making them potential sources for medicinal use or food supplements. The production of jams from the peels of local fruits such as orange, pineapple, pomegranate, and banana, while also evaluating their sensory, physicochemical, and antimicrobial properties. Pectin was extracted from the peels of these four indigenous fruits—pineapple (Ananas comosus L.), orange (Citrus sinensis L.), pomegranate (Punica granatum L.), and banana (Musa balbisiana Colla)—and used to make jams. Various parameters, including total soluble solids, acidity, pH, and moisture, were analyzed according to AOAC standard methods. Sensory evaluation was performed using a five-point hedonic scale, and the antimicrobial activity of the jams was tested with the disk diffusion method. The results showed an average Brix of 68.5, with pH levels ranging from 4.4 to 5.9, which helps prevent microbial growth and ensures the jams' shelf life. Among the jams, pineapple peel jam was the most preferred by the panel. Pomegranate peel jam exhibited the strongest antimicrobial activity against Shigella. Utilizing fruit peels not only enhances the nutritional value of foods but also expands the food supply, improves living standards, and offers potential for income generation ( D Lydia Esther et al., 2013).

### 2.9 Sensory evaluation of fruit peel based products

Enhancing a food item's quality and safety is possible by incorporating Fruit By Products, provided the optimal doses are selected. It is also important to consider sensory modifications, such as color, flavor, taste, mouthfeel, texture, and overall acceptability descriptors, alongside FBPs.Such as Odor be afected by the presence of monoterpenes (limonene, Mircene), sesquiterpenoids (α and β-sinensal), and sesquiterpene (valencene) found in FBPs(Teixeira et al. 2020). B-Carotene and other carotenoid pigments found in FBPs can enhance the color and appearance of finished foods and beverages (Christaki et al., 2013).

#### 2.9.1 Methods to assess taste, texture, color and overall acceptability

A 20-member panel, randomly selected from the University community, conducted the sensory evaluation of the six samples. Packaged in transportation jam bottles, the samples were presented in a coded manner. Colour, taste, texture, aroma, and acceptability were the sensory quality attributes assessed during the sample evaluation. Panelists were asked to observe and taste each coded sample, then grade them using a 9-point hedonic scale, where 9 = like extremely and 1 = dislike extremely. Qualitative Descriptive Analysis (QDA) was employed to further evaluate the product, identifying areas and intensities for improvement. Judges evaluated the intensity of the perceived attributes using a 15-point A.I Ihekoronye and P.O Ngoddy (1985) unstructured scale.

#### 2.9.2 Customer perception of products made with by- products

The process of making jams, jellies, and marmalades with fruits, sugar, pectin, and edible acids is among the oldest methods of food preservation, enabling fruit consumption beyond its natural season( L.E.;Figueroa,and D.B.Genovese(2019).Consumers widely enjoy fruit jams and jellies for their sweetness, rich flavor, pleasant taste, smooth texture, vibrant color, and appealing aroma(K.J.; Shinwari, and P.S.Rao,2018)were selected from producers, staff, students, and visitors who participated in the seminar titled "Sustainable Innovation to Improve the DOP 'Ciliegia dell'Etna,'" organized by the University of Catania and its partners. Randomized samples were prepared by arranging jam samples X and Y and jelly samples A and B in a balanced manner to ensure that combinations XY and YX (jam), as well as AB and BA (jelly), appeared an equal number of times. (These samples were then randomly assigned to judges. Pagliarini, E (2014.) Each panelist received a questionnaire along with a plate divided into four sections, each labeled with a unique numerical code corresponding to a specific sample. Panelists were advised to cleanse their palates with water between tasting different samples. Everyone had to indicate a preference, even if not perceptible. No statistical difference was found between the tested jellies (19 responses), Rizzo, V.; 2004) possibly due to an insufficient amount of lemon juice to create a noticeable variation in consumer taste.

### 2.10 Studies on physicochemical properties and microbial stability of jam

Research into the physicochemical and microbiological stability of jams has provided insight into the factors controlling jam quality and shelf life. A dietetic functional mixed cerrado fruit jam stored for 180 days at 25 °C and 35 °C was studied by Brandão et al. (2018). These studies have shown decrease in pH, soluble solids, titratable acidity, total sugars, carotenoids, phenolics, vitamin C, and antioxidant activity with time. Yeast and mold were not detectable, indicating that during the period of storage, the jam was microbiologically stable.

Jams made from dates enriched with apple and orange were further research conducted by Makanjuola and Alokun-Adesanya (2019). The pH values ranged between 3.14 and 4.52, with titratable acidity from 0.60% to 0.68% and total soluble solids from 43% to 51%. Microbiological analysis presented total plate count and fungi counts between $10.33\times10^{4}$ and $55.00\times10^{4}$ cfu/g and from $8.33\times10^{4}$ to $44.00\times10^{4}$cfu/g. Even with these microbial counts, levels met acceptable limits. This means that jams made this way possess both physicochemical and microbiological stability. The works referenced represent a noted sharing view of the factors through which jams change in physicochemical properties during storage, but the preservation of microbiological stability with appropriate formulation and processing does allow extended shelf life and safety in any product.

### 2.11 Contribution to environmental sustainability and waste reduction

The use of fruit peels, such as those of apples and guavas, in jam production is the key solution to solving the two crises of food waste and environmental sustainability. The peels, mostly regarded as waste during the processes of extraction, are sources of valuable nutrients: fiber, antioxidants, and vitamins. Using peels to prepare jams minimizes waste while providing a new, nutritious product from what would normally be considered inedible waste products. The incorporation of fruit peels in jam production also ensures better resource utilization. The goal, according to the principles of the circular economy, is to reduce waste and maximize value from resources that already exist. Local sourcing of fruits also cuts down the carbon footprint even further in providing a more sustainable food system. Furthermore, to use fruit peel for value-added products would also create awareness among consumers about sustainable best practices and aspire to further encourage the population to be more environmentally conscious. As greater numbers of people incorporate the reuse of food by-products into their mindsets, one could really make a huge difference by reducing the environmental impacts of food production and consumption, ensuring natural resource conservation and reduction of the overall carbon footprint of the food industry.

## 2.12 Conclusion

This study emphasizes the necessity of using fruit peels, primarily from apples and guavas, for jam-making as one of the sustainable ways of dealing with food waste. The nutrient-rich peels, usually wasted during processing, are converted into a value-added product, thereby reducing landfill waste and optimizing the utilization of resources. Inclusion of functional ingredients, for example, chia seeds, will increase the nutritional value of jams, rendering them healthier and more sustainable options. This adoption upholds circular economy principles, reducing dependence on additional agricultural inputs while decreasing the environmental impact of food production and disposal. Aside from reducing waste, this program gives the food industry another chance to create more sustainable practices while responding to eco-conscious consumer demands. In this way, by introducing fruit by-products into mainstream food production, the industry can contribute toward a more responsible and resource-efficient food system. Further studies and investment in processing technologies, market acceptance, and large-scale production strategies can solidify fruit peel-based jams as a genuinely viable commercial and environmentally significant solution leading to a more sustainable food sector.

### 3.1 Introduction

In this chapter we deal with material and methods used for the development of fruit peel jam fortified with chia seed. This study was carried out at the Department of B. Voc Food Procesing Technology, St. Teresa's College Ernakulam during project work in the year 2024-2024.

### 3.2 Material Required

1. Apple peel
2. Guava peel
3. Chia seeds
4. Citric acid (for acidity balance)
5. Brown sugar (as a sweetener)
6. Pectin
7. Coloring agent
8. Guava flavouring agent

**Fig 1: Apple peel**

**Fig 2: Guava peel**

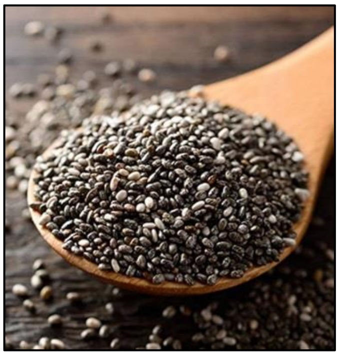


**Fig 3: Chia seeds**

**Fig 4: Brown Sugar**

**Fig 5: Lemon**


**Fig 6: Pectin**


**Fig 7: Guava flavouring agent** **Fig 8: Coloring agent**

### 3.3 Equipments and apparatus used

1. Open Pan Evaporator
2. Mixer
3. Weighing machine
4. Tray dryer

**Fig 9: Open pan**

**Fig 10: Mixer grinder**

**Fig 11: Tray dryer**

**Fig 12: Weighing machine**

### 3.3.1 Open Pan Evaporator

An open pan is a stainless-steel cooking tool with a thick copper bottom that conducts heat. It is used to remove water from a product so that a concentrated version can be obtained. When concentrating, agitation is provided manually at the household level or, in enterprises, mechanically.

### 3.3.2 Mixer grinder

A mixer grinder is a device that mixes and grinds various food ingredients. The ability of the mixer grinders to swiftly and accurately ground and combine various food ingredients is one of their key characteristics. With their precise controls and settings, these machines enable customers to customise the speed and grind size to suit their requirements. These devices are also frequently relatively simple to maintain and clean, which makes them perfect for usage in settings where food is produced.

### 3.3.3 Weighing Machine

It is an instrument used in measuring the weight or mass of an object. The digital weighing scale is easy to operate and features a small LCD display where the weight is shown. The digital weighing scale operates on external power source mainly battery. There are two variants of weighing. The analog scales use spring to indicate the weight of the object, while digital scales convert the force of weight to an electric signal.

### 3.3.4 Tray dryer

A tray dryer is convectional drying equipment with enclosed insulated chambers and trays placed on top of each other in a trolley. In the tray dryer, moisture is removed from the solids that are placed in the tray by a forced convectional heating. The drying process is usually done under controlled temperature and humidity conditions.

## 3.4 Processing Method

| **Samples/ Ingredients** | Apple peel (g) | Guava peel (g) | Brown sugar (g) | Chia seeds (g) | Water (ml) | Pectin (g) |
|---|---|---|---|---|---|---|
| P1 | 10 | 10 | 10 | 3.75 | 65 | 1.25 |
| P2 | 10 | 10 | 10 | 3.75 | 65 | 1.25 |
| P3 | 10 | 10 | 10 | 3.75 | 65 | 1.25 |
| P4 | 10.40 | 5.60 | 8 | 4 | 70 | 2 |

**Table 3.1: Processing method**

Four different processing methods were used to produce fruit peel jam, resulting in distinct characteristics and quality attributes. The methods employed were boiling, soaking, blending and reconstitution from dried peel. Each method yielded a unique jam with varying textures and flavors, highlighting the versatility of fruit peel jam production.

### 3.4.1 Sample 1

**Ingredients required (100g)**

- Apple peel – 10g
- Guava peel – 10g
- Pectin – 1.25g
- Chia seeds – 3.75g
- Sugar – 10g
- Water – 65ml

**Method of preparation**

To prepare this fruit peel jam, first the apple and guava peels were washed and chopped into small pieces. Then, the peels were pulped in a mixer and the mixture was then combined with sugar and water in a saucepan. The mixture was then simmered over medium heat and stirred frequently. The mixture continued simmering for 15-20 minutes, and then pectin was added once the mixture started to concentrate. Once the mixture started thickening, the chia seeds were added. To enhance the flavour of jam 2-3 drops of guava flavour flavouring agent were added. For colour 2-3 drops of colouring agents were added. Once it reached the desired consistency the mixture was removed from heat and the jam was let to cool slightly after that, the jam was transferred into sterilised jars and stored in the refrigerator.

**Fig 13: Pulped peel jam**

### 3.4.2 Sample 2

**Ingredients required (100g)**

- Apple peel – 10g
- Guava peel – 10g
- Pectin – 1.25g
- Chia seeds – 3.75g
- Sugar – 10g
- Water – 65ml

**Method of preparation**

Good quality fruits were selected. The fruits were washed in cold water and the peels were removed and weighed. In a saucepan, these peels were added followed by 260 ml of water for boiling. When it started boiling, 40 g of sugar crystals were added and mixed until it dissolved completely. 5 g pectin was added to it for thickening and was mixed immediately to break down the lumps. 15 g chia seeds were added to it and to enhance flavour 2-3 drops of guava flavour flavouring agent were added. For colour 2-3 drops of colouring agents were added. These were mixed immediately and until it falls in the form of sheet flakes. Hot jam was filled into clean dry sterilized glass jars. The jam was allowed to cool and fix the sterilized lid to the jars. It was stored in a refrigerator.

**Fig 14: Boiling peel jam**

**3.4.3 Sample 3 (100g)**

**Ingredients required**

- Apple peel – 10g
- Guava peel – 10g
- Pectin – 1.25g
- Chia seeds – 3.75g
- Sugar – 10g
- Water – 65ml

**Method of preparation**

To prepare this fruit peel jam, first the apple and guava peels were washed and chopped into small pieces. Then, the peels were soaked overnight. The following day, the peels were pulped in a mixer and the mixture was strained using a sieve. The mixture was then combined with sugar and water in a saucepan. The mixture was then simmered over medium heat and stirred frequently. The mixture continued simmering for 15-20 minutes, and then pectin was added once the mixture started to concentrate. Once the mixture started thickening, the chia seeds were added. 2-3 drops of guava flavouring agent was added to enhance the flavour of the jam. For colour 2-3 drops of colouring agent was added. Once it reached the desired consistency the mixture was removed from heat. The jam was transferred hot into sterilised jars and stored in the refrigerator.

**Fig 15: Soaked peel jam**

### 3.4.4 Sample 4 (100g)

**Ingredients required**

- Apple peel – 10.40g
- Guava peel – 5.60g
- Pectin – 2g
- Chia seeds – 4g
- Sugar – 8g
- Water – 70ml

**Method of preparation**

Good quality fruits were selected. The fruits were washed well in cold water. The peels of fruits were removed and accurately weighed, before drying the weight of both apple peel and guava peel was 40 g each. For drying, the guava and apple peels were placed in tray drier at 45 °C for 8 hours. The dried peels were weighed. The guava and apple peels were processed in a grinder to obtain a fine powder. In a saucepan, the peel powder was added followed by 70 ml of water for boiling. When it started boiling, sugar crystals were added and mixed until it dissolved completely. Pectin was added to it for thickening and was mixed immediately to break down the lumps. Once the mixture started thickening, chai seeds were added and to enhance flavour 2-3 drops of guava flavour flavouring agent were added. For colour 2-3 drops of colouring agents were added. The hot jam was filled into clean dry sterilized glass jars. It was stored in the refrigerator.

**Fig 16: Dried peel jam**

## 3.5 Chemical Analysis

### 3.5.1 Determination of Total Ash

The determination of total ash in fruit peel jam was done using IS 12711:1989 method.

#### 3.5.1.1 Apparatus

*Silica dish*
*Desiccator*
*Muffle furnace*

#### 3.5.1.2 Procedure

1. Weigh accurately about 5 g of the sample in a tared, clean and dry silica dish.
2. Ignite the material in the dish with the flame of a suitable burner for about one hour. Complete the ignition by keeping in a muffle furnace at 500 ± 10$^{o}$C until grey ash results. Cool in a desiccator and weigh.
3. Repeat the process of igniting, cooling and weighing at one hour intervals until the difference between two successive weighings is less than 1 mg. Note the lowest mass.

#### 3.5.1.3 Calculation

$$\text{Total ash (on dry basis), percent by mass} = \frac{(M_2 - M) \times 10{,}000}{(M_1 - M)(100 - W)}$$

Where,

$M_2$ = mass, in g, of the dish with the ash
$M$ = mass, in g, of the empty dish
$M_1$ = mass, in g, of the dish with material taken for the test
$W$ = percent moisture in the sample

### 3.5.2 Determination of Moisture Content

Determination of moisture content in the fruit peel jam was done using IS 12711: 1989 method.

#### 3.5.2.1 Apparatus

*Moisture dish: made of porcelain, silica, glass, aluminium or stainless steel.*
*Oven: Electric, maintained at 105 ± 2°C.*
*Desiccator*

#### 3.5.2.2 Procedure

1. Weigh accurately about 5 g of the sample in the moisture dish, previously dried in the oven at 105°C and weighed.
2. Place the dish in the oven maintained at 105 ± 2°C for 4 hours.
3. Cool in the desiccator and weigh.
4. Repeat the process of drying, cooling and weighing at 30-minute intervals until the difference between two consecutive weighings is less than one mg. Record the lowest mass.

#### 3.5.2.3 Calculation

$$\text{Moisture, percent by mass} = \frac{100\,(M_1 - M_2)}{M_1 - M}$$

Where,

$M_1$ = mass, in g, of the dish with the material before drying

$M_2$ = mass, in g, of the dish with the material after drying to constant mass

M = mass, in g, of the empty dish

### 3.5.3 Determination of Fat Content

The determination of fat content in fruit peel jam was done using IS 12711: 1989 method.

#### 3.5.3.1 Apparatus

*Soxhlet Extraction Apparatus*

#### 3.5.3.2 Reagent

*Petroleum Ether: Distilling between 40$^o$ and 60$^o$* C.

#### 3.5.3.3 Procedure

1. Weigh accurately about 10 to 30 g of the material sufficient to give about 1 g of fat in a suitable thimble and dry for 2 hours at 100 ± 2°C.
2. Place the thimble in the Soxhlet Extraction Apparatus and extract with the solvent for about 16 hours.
3. Dry the extract contained in the Soxhlet flask, the empty mass of which has been previously determined by taring at 95 to 100°C for an hour.
4. Cool in a desiccator and weigh.
5. Continue the alternate drying and weighing at 30 minutes intervals until the loss in mass between two successive weighings is not more than 2 mg. Record the lowest mass.

#### 3.5.3.4 Calculation

$$\text{Fat, percent by mass} = \frac{100\,(M_1 - M_2)}{M}$$

Where,

$M_1$ = mass, in g. of the Soxhlet flask with the extracted fat

$M_2$ = mass, in g. of the empty Soxhlet flask, clean and dry

M = mass, in g, of material taken for the test.

### 3.5.4 Determination of Protein Content

The determination of protein content in fruit peel jam was done using IS 7219 (Kjeldahl method).

#### 3.5.4.1 Procedure

1. Accurately weigh 0.7 to 2.2 g of the sample into the digestion flask. Add 0.7 g mercury oxide or 0.65 g mercury and 15 g powdered potassium sulphate or anhydrous sodium sulphate, and 25 ml sulphuric acid.
2. Ratio of salt to acid (m/v) should be approximately 1:1 at the end of digestion for proper temperature control. Place the flask in an inclined position on a heater and heat gently until foaming ceases. Boil vigorously until the solution becomes clear and then continue boiling it for 1 to 2 hours.

3. Cool, add about 200 ml distilled water, and in order to avoid complex formation, add 25 ml of the sulphide or thiosulphate solution. Mix to precipitate the mercury.
4. Add a few zinc granules to prevent bumping, incline flask, and add without agitation 25g of sodium hydroxide as solid or equivalent as solution, to make solution strongly alkaline (thiosulphate or sulphide solution may be mixed with the sodium hydroxide solution before addition to the flask).
5. Immediately connect flask to distillation bulb or trap on condenser, and, with tip of the condenser immersed in a measured quantity standard acid (usually 50 ml, 0.5 N or an appropriate quantity of 0.1 N) in the receiver, rotate flask to mix the contents thoroughly; then heat immediately until all ammonia has distilled over (at least 150 ml distillate).
6. Lower the receiver before stopping distillation and wash tip of condenser with distilled water. Back-titrate excess acid with standard 0.1 N sodium hydroxide, using methyl red as indicator. Correct for blank determination in reagents.

#### 3.5.4.2 Calculation

Nitrogen content (N) in g= (a - 0.2b) - (c – 0.2d) × 0.007

Where,

a = volume in ml 0.5 N acid measured for main distillation

b = volume in ml 0.1 N alkali used for back-titrating a

c = volume in ml 0.5 N acid measured for blank distillation

d = volume in ml 01 N alkali used for back-titrating c

$$\text{Protein, percent by mass} = \frac{N \times 100 \times \text{Conversion factor}}{W}$$

Where,

N = mass of nitrogen content in g of original sample

W = mass of sample in g

### 3.5.5 Determination of Carbohydrate Content

Determination of carbohydrate content in fruit peel jam was done using AOAC method. Total carbohydrates are calculated as follows after determining the percentage of moisture, total protein, fat and total ash.

**Calculation:**

Total carbohydrates = 100 – (A+B+C+D)

A = Percent by mass of moisture

B = Percent by mass of total protein

C = Percent by mass of fat

D = Percent by mass of total ash

### 3.5.6 Determination of Energy

Use the following conversion factors for calculating the energy values corresponding to the carbohydrate, protein and fat contents of fruit peel jam.
Carbohydrate – 4kcal/g
Protein – 4kcal/g
Fat – 9kcal/g

Calculate the energy value (total calories) per 100g of the food as follows:

Energy (kcal/g) = $4 \times C + 4 \times P + 9 \times F$

Where, C = Carbohydrate content in g/100g

P = Protein content in g/100g

F = Fat content in g/100g

### 3.5.7 Determination of Crude Fiber

The determination of crude fiber was done using AOAC 21 (920.86) method.

#### 3.5.7.1 Procedure

Extract 2 g ground material with ether or petroleum ether (initial boiling temp., 35-38$^o$; dry-flask end point, 52 - 60$^o$; $\geq$ 95% distg < 54 $^o$ and $\leq$60% distg < 40 $^o$; sp gr at 60°F, 0.630-0.660; evapn residue $\leq$0.002% by wt). If fat is < 1% extraction may be omitted. Transfer to 600 mL reflux beaker, avoiding fiber contamination from paper or brush. Add 0.25-0.5 g bumping granules, followed by 200 mL near-boiling 1.25% $H_2SO_4$ solution in small stream directly on sample to aid in complete wetting of sample. Place beakers on digestion apparatus at 5 min intervals and boil exactly 30 min, rotating beakers periodically to keep solids from adhering to sides. Near end of refluxing place California buchner, previously fitted with No. 9 rubber stopper to provide vacuum seal, into filtration apparatus, and adjust vacuum to ca 25 mm Hg (735 mm pressure). At end of refluxing, flow near-boiling $H_2O$ thru funnel to warm it; then decant liquid thru funnel, washing solids into funnel with minimum of near-boiling $H_2O$. Filter to dryness, using 25 mm vacuum, and wash residue with four 40-50 mL portions near-boiling $H_2O$, filtering after each washing. Do not add wash to funnel under vacuum; lift funnel from apparatus when adding wash.

Wash residue from funnel into reflux beaker with near-boiling 1.25% NaOH soln. Place beakers on reflux apparatus at 5 min intervals and reflux 30 min. Near end of refluxing, turn on filtration apparatus, place crucible in apparatus, and adjust vacuum to ca 25 mm. Flow near-boiling $H_2O$ thru crucible to warm it. (Keep near-boiling $H_2O$ flowing thru jacket during filtration and washing.) At end of refluxing, decant liquid thru crucible and wash solids into crucible with minimum of near-boiling $H_2O$. Increase vacuum as needed to maintain filtration rate. Wash residue once with 25-30 mL near-boiling 1.25% $H_2SO_4$ soln, and then with two 25-30 mL portions near-boiling $H_2O$, filtering after each washing. (Filtering and washing takes 3-5 min/sample.) Do not add wash to crucible under vacuum.

Dry crucible with residue 2 hr at 130±2° or overnight at 110° cool in desiccator, and weigh. Ash 2 hr at 550±10°, cool in desiccator, and weigh. Do not remove crucibles from furnace until temp. is ≤250°, as fritted disk may be damaged if cooled too rapidly.

**3.5.7.2 Calculation**

$$\text{Crude fiber, \% by weight} = \frac{\text{Loss in weight on ignition} \times 100}{\text{Weight of sample}}$$

**3.6 Sensory Evaluation**

Sensory analysis was done by using hedonic scale, where all 4 samples were tested by 10 panelists.

In the hedonic scale method, the stimuli (actual samples and food names) are presented singly and are rated on a scale where the 5 categories range from; dislike a lot to like a lot.

**Table 3.2: Hedonic Scale**

| | |
|---|---|
| 5 | Like a lot |
| 4 | Like a little |
| 3 | Neither like nor dislike |
| 2 | Dislike a little |
| 1 | Dislike a lot |

**FIG 17: SENSORY EVALUATION**

### 4.1 Sensory Evaluation

A sensory evaluation was carried out on jams prepared from apple and guava peels using four different methods: pulping the peels directly before jam preparation (P1), boiling the peels before making the jam (P2), soaking the peels overnight (P3), and drying and grinding the peels into powder (P4). The jams were evaluated based on color, texture, taste, aroma, and overall acceptability. Among all the samples, the jam made using the pulped peel method (P1) was the most preferred. The pulping method likely helped retain more of the fruit's natural essence and nutrients, resulting in a jam that was both flavorful and visually attractive. In comparison, the jams prepared by boiling (P2), soaking (P3), and drying (P4) showed lower scores in taste and consistency, with the dried powder method (P4) producing a grainier texture that was least liked by the panelists. The mean values for the sensory attributes against each sample are given in the table.

| **Attributes** | Sample 1 (P1) | Sample 2 (P2) | Sample 3 (P3) | Sample 4 (P4) |
|---|---|---|---|---|
| **Appearance** | 5 | 3.6 | 4.8 | 3.9 |
| **Aroma** | 4.9 | 4 | 4.4 | 4 |
| **Taste** | 5 | 4.2 | 4.5 | 3.4 |
| **Texture** | 4.5 | 3.2 | 4.4 | 3.2 |
| **Overall Acceptability** | 4.5 | 3.6 | 4.3 | 3.5 |

**Table 4.1 Sensory Analysis**

Chemical analysis (energy, total fat, carbohydrate content, crude fibre, protein content, total ash, moisture content) was done for the nutritional comparison of accepted jam sample 1.

### 4.2 Proximate Analyis

The proximate analysis of the developed product was carried out to determine its nutritional composition. The tested parameters included total ash, moisture, fat, protein, carbohydrate, energy, and crude fiber. Standard analytical procedures such as IS 12711, IS 7219, AOAC Method 920.86, and FAO-recommended methods for nutritional evaluation were employed. The results are compared with those of a conventional product—**mixed fruit jam**—which is commonly available in the Indian market.

| SI.NO | Quality Parameters | Unit | Sample 1 |
|---|---|---|---|
| 1. | Moisture content | % | 57.21 |
| 2. | Protein content | g/100g | 2.46 |
| 3. | Fat content | g/100g | 0.61 |
| 4. | Total Ash | % | 0.76 |
| 5. | Carbohydrate | g/100g | 38.96 |
| 6. | Energy | Kcal/100g | 171.17 |
| 7. | Crude Fiber | % | 9.02 |

**Table 4.2 Proximate Analysis**

### 4.2.1 Total Ash

The total ash content of the sample was found to be **0.76%**, indicating the presence of mineral constituents. This value is slightly higher than that of standard mixed fruit jam, which generally ranges from **0.3–0.5%** (FSSAI, 2011). The increased ash content may be attributed to the inclusion of naturally mineral-rich ingredients in the formulation, reflecting a potentially better mineral profile.

### 4.2.2 Moisture Content

The moisture content in the sample was **57.21%**, which is considerably higher than that of mixed fruit jam (approximately **30–35%**) (Bureau of Indian Standards [BIS], 1971). Higher moisture may affect the shelf life and stability of the product but can also contribute to a softer texture and improved palatability. It emphasizes the need for appropriate preservation techniques if commercial viability is intended.

### 4.2.3 Fat Content

The fat content was recorded as **0.61 g/100g**, slightly above the negligible fat levels generally found in mixed fruit jam (<0.1 g/100g). This minor increase could be due to the inclusion of fat-containing ingredients such as seeds or nuts, which can provide healthy fats and improve the nutritional quality of the product.

### 4.2.4 Protein Content

The protein content of the sample was **2.46 g/100g**, which is significantly higher than the protein content in mixed fruit jam (<0.5 g/100g) (FSSAI, 2011). This indicates an improved nutritional profile, likely due to the use of protein-rich ingredients such as legumes, seeds, or whole grains. The elevated protein level enhances the product's value as a functional food item.

### 4.2.5 Carbohydrate Content

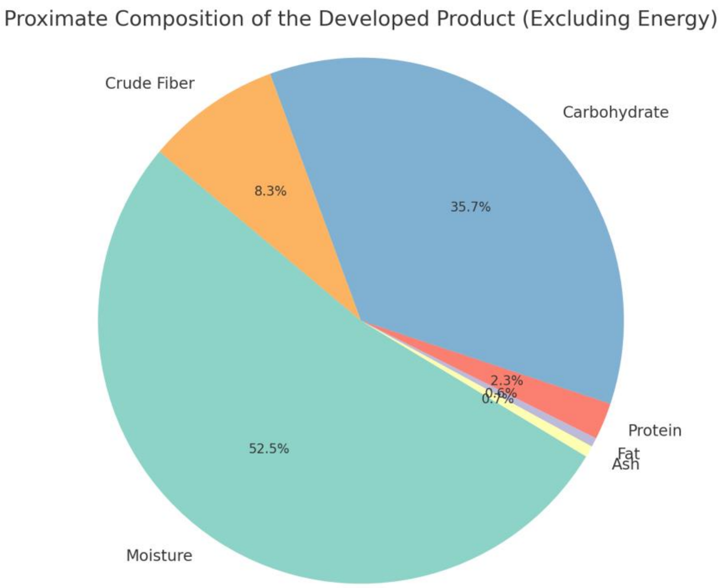
The carbohydrate content was calculated to be **38.96 g/100g**, which is lower than that found in conventional mixed fruit jam (**60–70 g/100g**) (FAO/WHO, 2003). The reduced carbohydrate content, likely due to less added sugar, positions the product as a healthier alternative, particularly for consumers looking to manage sugar intake.

### 4.2.6 Energy Value

The energy value of the sample was **171.17 Kcal/100g**, considerably lower than that of standard mixed fruit jam (**250–280 Kcal/100g**) (FAO/WHO, 2003). This supports the suitability of the product for calorie-conscious consumers and those aiming for weight management, without compromising on taste and nutrient density.

### 4.2.7 Crude Fiber

The crude fiber content was found to be **9.02%**, which is significantly higher than that in mixed fruit jam (generally <0.5%) (AOAC, 2000). This high fiber content not only contributes to digestive health but also adds value by promoting satiety and supporting blood sugar regulation. The inclusion of whole or fibrous ingredients in the formulation has likely contributed to this benefit.



### 4.3 Conclusion

In comparison to conventional mixed fruit jam, the developed sample exhibits superior nutritional attributes, particularly in terms of higher protein and fiber content and lower sugar and energy values. These properties make it an attractive option for health-conscious consumers, offering a functional and wholesome alternative. However, the higher moisture content necessitates consideration of preservation strategies to ensure shelf stability and product safety.

The analysis of the developed product revealed a unique and nutritionally rich profile when compared to conventional mixed fruit jam. The moisture content was relatively high at 57.21%, which may influence the product's shelf stability. However, the formulation exhibited a commendable protein content of 2.46 g/100g and crude fiber content of 9.02%, indicating its potential as a functional food. The fat content was low at 0.61 g/100g, and the carbohydrate and energy values stood at 38.96 g/100g and 171.17 Kcal/100g respectively. These results suggest that the developed product could serve as a healthier alternative to traditional jams, which are typically high in sugar and calories but lack significant protein and fiber content.

The inclusion of protein- and fiber-rich ingredients enhances its nutritional value and makes it more appealing to health-conscious consumers. The reduced carbohydrate and energy content aligns with dietary preferences aimed at weight management and metabolic health. Compared to commercial jams, which usually contain over 60% carbohydrates and negligible protein and fiber, the current formulation offers a balanced and nutrient-dense option.

Despite these positive findings, the high moisture content could potentially compromise shelf life and microbial stability. This highlights the need for further investigation into appropriate preservation methods. Thus, while the product shows strong promise nutritionally, further studies are essential to optimize its safety, sensory attributes, and market readiness.

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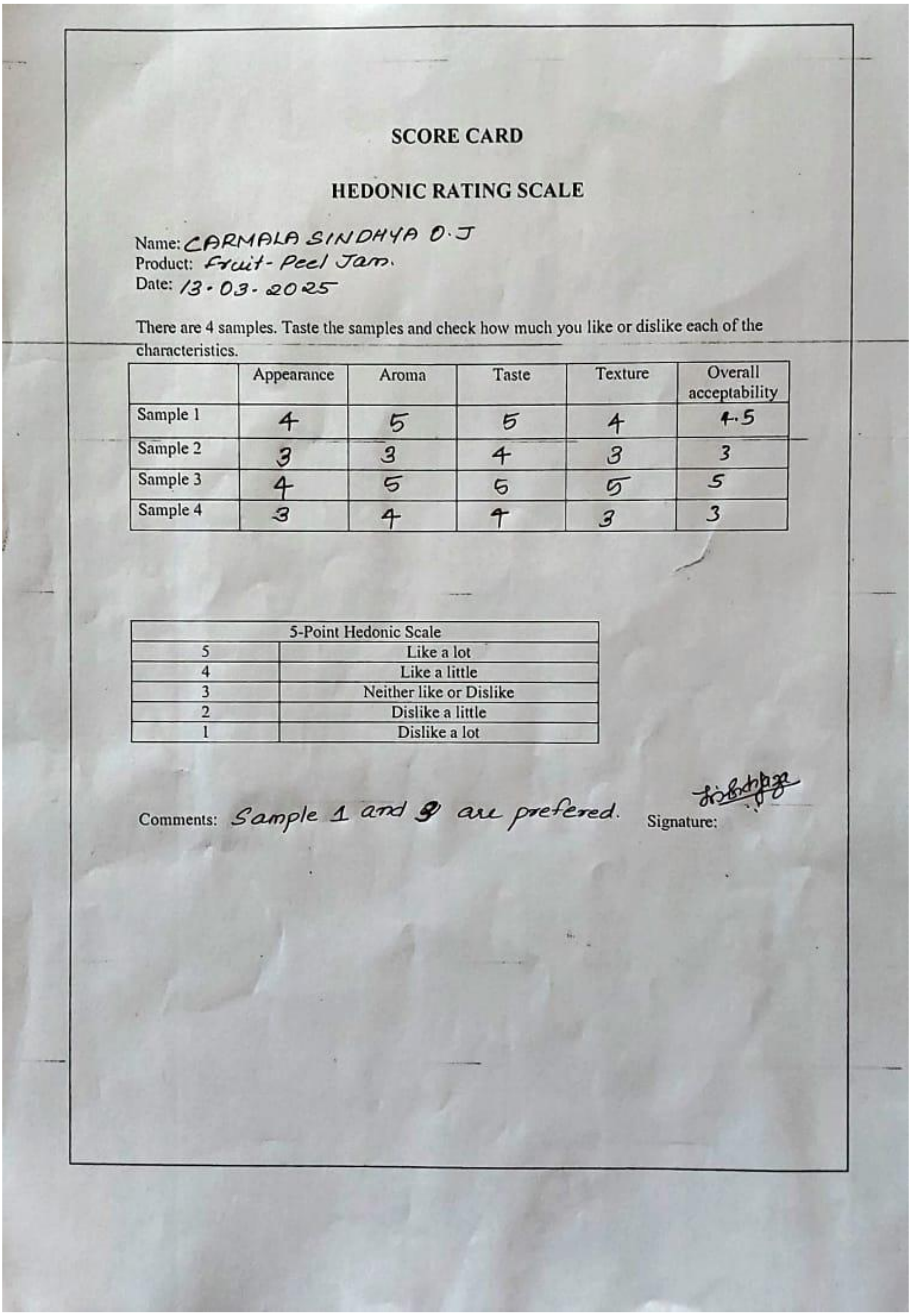
# APPENDIX I

# SENSORY EVALUATION SCORE CARD



**SCORE CARD**

**HEDONIC RATING SCALE**

Name: CARMALA SINDHYA O·J
Product: Fruit- Peel Jam.
Date: 13·03·2025

There are 4 samples. Taste the samples and check how much you like or dislike each of the characteristics.

| | Appearance | Aroma | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| Sample 1 | 4 | 5 | 5 | 4 | 4.5 |
| Sample 2 | 3 | 3 | 4 | 3 | 3 |
| Sample 3 | 4 | 5 | 5 | 5 | 5 |
| Sample 4 | 3 | 4 | 4 | 3 | 3 |

| 5-Point Hedonic Scale | |
|---|---|
| 5 | Like a lot |
| 4 | Like a little |
| 3 | Neither like or Dislike |
| 2 | Dislike a little |
| 1 | Dislike a lot |

Comments: Sample 1 and 3 are prefered. Signature:

**SCORE CARD**

**HEDONIC RATING SCALE**

Name: Aiswarya Unni
Product: Fruit-Peel Jam
Date: 13-03-2025

There are 4 samples. Taste the samples and check how much you like or dislike each of the characteristics.

| | Appearance | Aroma | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| Sample 1 | 4 | 5 | 4 | 4 | 4 |
| Sample 2 | 3 | 3 | 3 | 3 | 3 |
| Sample 3 | 4 | 3 | 4 | 3 | 3 |
| Sample 4 | 3 | 4 | 4 | 4 | 4 |

| 5-Point Hedonic Scale | |
|---|---|
| 5 | Like a lot |
| 4 | Like a little |
| 3 | Neither like or Dislike |
| 2 | Dislike a little |
| 1 | Dislike a lot |

Comments: Sample 1 was the best.

Signature: Aswi

## SCORE CARD

## HEDONIC RATING SCALE

Name: Aswathi Anilkumar
Product: ~~Jam~~ Fruit Peel Jam
Date: 13-03-2025

There are 4 samples. Taste the samples and check how much you like or dislike each of the characteristics.

| | Appearance | Aroma | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| Sample 1 | 4·5 | 5 | 5 | 4·5 | 5 |
| Sample 2 | 4 | 4·5 | 4·5 | 4 | 4·5 |
| Sample 3 | 5 | 4·5 | 5 | 5 | 5 |
| Sample 4 | 4·5 | 4 | 4 | 4·5 | 4.5 |

| 5-Point Hedonic Scale | |
|---|---|
| 5 | Like a lot |
| 4 | Like a little |
| 3 | Neither like or Dislike |
| 2 | Dislike a little |
| 1 | Dislike a lot |

Comments: Sample 1 was very good and delicious

Signature:

# APPENDIX II

# RESULT

PVT Merit Biolabs

TC-15392

**TEST REPORT**

| Test report No.: **MB/LT/2024-25/1098/C1** | |
|---|---|
| Customer Name & Address:<br>**ST. TERESA'S COLLEGE**<br>**CONVENT JUNCTION,**<br>**ERNAKULAM**<br>**PH: 9995139117** | Ref No./PO No. :MBL/25/0342<br>Date of Receipt :22/03/2025<br>Date of Analysis :24/03/2025<br>Date of Completion :28/03/2025<br>Date of Issue report :29/03/2025 |
| Sample Name :Fruit Jam<br>Sample Description :Pink Colour semi solid<br>Batch no :NA<br>Sampled By :Customer<br>Sample Ref. No. :MBL/25/0342<br>Sample Condition on Receipt: Good | **ULR-TC1539225100000257F**<br>**DISCIPLINE :CHEMISTRY**<br>**GROUP: Food & Agricultural Products** |

**TEST RESULT**

| Sl.No. | Parameters | Test method | Unit | Result |
|---|---|---|---|---|
| 1. | Total Ash | IS 12711 | % | 0.76 |
| 2. | Moisture | IS 12711 | % | 57.21 |
| 3. | Fat | IS 12711 | g /100g | 0.61 |
| 4. | Protein | IS 7219 | g /100g | 2.46 |
| 5. | Carbohydrate | Food Energy Methods of Analysis and Conversion Factor (FAO) | g/100g | 38.96 |
| 6. | Energy | Food Energy Methods of Analysis and Conversion Factor (FAO) | Kcal/100g | 171.17 |
| 7. | Crude Fiber | AOAC 21(920.86) | % | 9.02 |

***End of Report***

PVT MERIT BIOLABS KOCHI PALARIVATTOM

Joseph K Thenganal
Authorized Signatory (Chemistry)
Pg.1/1

NOTE: This test result relate only to the sample submitted for analysis. Queries shall be made within 7 days of issue of this report. This test report shall not be reproduced except in full without the written approval of the laboratory. Samples shall not be stored beyond 7 days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