DEVELOPMENT OF APPLE WHEY JELLY INCORPORATED WITH HIBISCUS EXTRACT AS A NATURAL COLORING AGENT

Dissertation Submitted to St. Teresa's College. Ernakulam

in Partial Fulfillment of the Requirements for the Award of the Degree of

MASTER OF VOCATIONAL IN FOOD PROCESSING TECHNOLOGY

BY

NEHA BALAKRISHNAN

Register No. VM22FPT018

AT

VERGHESE KURIEN INSTITUTE OF DAIRY AND FOOD TECHNOLOGY. KERALA VETERINARY AND ANIMAL SCIENCES UNIVERSITY

DEPARTMENT OF FOOD PROCESSING TECHNOLOGY

ST. TERESA'S COLLEGE, ERNAKULAM

MAHATMA GANDHI UNIVERSITY

2022-2024

ST. TERESA'S COLLEGE, ERNAKULAM

CERTIFICATE

This is to certify that the dissertation work entitled **" DEVELOPMENT OF APPLE WHEY JELLY INCORPORATED WITH HIBISCUS EXTRACT AS A NATURAL COLORING AGENT**" is a bonafide work done by **Ms. NEHA BALAKRISHNAN (Reg No.VM22FPT018)**, student of ST. TERESA'S COLLEGE, ERNAKULAM, MAHATMA GANDHI UNIVERSITY, in partial fulfillment of the degree of MASTER OF VOCATIONAL IN FOOD PROCESSING TECHNOLOGY. This dissertation work is carried out by her under my supervision and guidance.

SIGNATURE OF EXAMINERS HEAD OF THE DEPARTMENT

1.

2.

KERALA VETERINARY AND ANIMAL SCIENCES UNIVERSITY VERGHESE KURIEN INSTITUTE OF DAIRY AND FOOD TECHNOLOGY

CERTIFICATE

This is to certify that the dissertation work entitled **" DEVELOPMENT OF APPLE WHEY JELLY INCORPORATED WITH HIBISCUS EXTRACT AS A NATURAL COLORING AGENT"** is an authentic project work carried out by **Ms. NEHA BALAKRISHNAN (Reg. No. VM22FPT018)** under the supervision and guidance of **Mrs. RASHMI K.G.,** Dairy Extension Officer (on deputation to KVASU), Department of Dairy Technology, Verghese Kurien Institute of Dairy and Food Technology, Mannuthy, Thrissur, submitted in partial fulfillment of requirements for the award of the degree of Master of Vocational in Food Processing Technology, St. Teresa's College Ernakulam, Mahatma Gandhi University.

Mrs. Rashmi K.G

(Major Advisor)

Mrs. Divya K.B **Dr. Dinker Singh**

DECLARATION

I, NEHA BALAKRISHNAN, do hereby declare that the dissertation **" DEVELOPMENT OF APPLE WHEY JELLY INCORPORATED WITH HIBISCUS EXTRACT AS A NATURAL COLORING AGENT"** is a bonafide record of the project work done by myself in partial fulfillment for the degree of Master of Vocational in Food Processing Technology, St. Teresa's College Ernakulam, Mahathma Gandhi University.

Mannuthy

Date :

NEHA BALAKRISHNAN

VM22FPT018

AKNOWLEDGEMENT

I humbly acknowledge the divine grace that has guided me throughout this academic journey. In the pursuit of knowledge, I recognize the unseen hand that has illuminated my path, granting wisdom, strength, and resilience.

At this moment, I feel deep sense of gratitude to my Major Advisor Mrs. Rashmi K.G,(Dairy Extension Officer) for her inspiring guidance and constant encouragement throughout the study. I admire her expertise in planning the project and immense ability of reasoning, and appreciate her perseverance in tackling research problems. I would like to thank Dr. S N Rajkumar (professor and head of department, department of dairy technology), who granted me permission for doing my project in dairy technology department.

I am very much thankful to the members of my advisory committee Dr.Dinker Singh,(assistant Professor) Mrs Divya K B (Assistant Professor) and Mr Riyaz Muhammed (assistant professor) of dairy technology Department for their advice and cooperation. I take this opportunity to thank my all teachers who laid the foundation by imparting knowledge to me during my work and all the present teachers of verghese Kurien institute of dairy and food technology, who took all pains in imparting knowledge and guiding me once again.

I would like to express my gratitude to Ms. Ambily.M.V , Ms. Gloria Jacob, Ms. Vandhana P.S, Mrs. Jithu Rappai for their assistance and encouragement during my work.

I also want to express my gratitude for all the teaching and non teaching staff of Verghese Kurien Institute of Dairy and Food Technology for their assistance with the project work.

I would like to thank my friends Ms.Anjana, Ms.Aleena ,Ms.Krishnaveni and Ms.Ceona for their support for extending all help and cooperation during this work.

I would like to extend my deepest sense of appreciation and love to my family members. Without their love, moral support, sacrifice and blessings, my dream would not have been a reality. Finally, I would like to express my sincere gratitude to everyone who has supported and assisted me, whether directly or indirectly to complete with this thesis work.

NEHA BALAKRISHNAN

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The study was designed to prepare Apple whey jelly incorporated with Hibiscus extract and thus establish the feasibility of whey based apple jelly confectionary made with natural coloring agent Hibiscus extract. Whey, a major by product obtained during coagulation of milk using acid contain nutritional components such as protein, lactose and minerals in large amount can be effectively utilized to its maximum potential. In order to enhance the nutritional value of jelly, the preliminary trials were conducted by preparing jelly with addition of whey and apple juice at different levels T1(40:60), T2(50:50), T3(60:40), Control(100:00). Based on sensory evaluation T1(40:60) selected and optimized. To this product Hibiscus extract is added at different levels S1(5%), S2 (10%), S3(15%), control (0%). Based on the sesonry evaluation S2 containing 10% hibiscus extract was selected and optimized. The product apple whey jelly incorporated with hibiscus extract were prepared by incorporation of 10% hibiscus extract to whey and apple juice (40 : 60). The prepared jelly has bright red color and acceptable taste. Sensory evaluation of the products are done by using a nine point hedonic scale on the basis of texture,color, flavor and overall acceptability. The physico-chemical and nutritional analysis of apple whey jelly and control jelly was analyzed. The ash, moisture, protein, crude fibre, carbohydrates of apple whey jelly was found to be 0.46,55.78, 0.24 ,0.08, and 43.60% respectively. Total solids was found to be 44.33% while TSS is 42.66º Brix. Acidity and pH of optimized whey jelly was found to be 0.68% and 3.45. Vitamin C content in apple whey jelly incorporated with hibiscus extract was 6.42mg/100g and of control jelly was 1.4mg/100g.

Keywords: Jelly, Whey, Apple juice, Hibiscus Flower extract

1. INTRODUCTION

The dairy sector in India has witnessed remarkable development over the past decade, making it one of the largest producers of milk and value-added milk products globally. With a population of almost 300 million cattle, India produces 198.4 million tonnes of milk. India exported 67,572.99 metric tonnes of dairy products worth $284.65 million during 2022-23. Milk and milk products remain a vital contributor to the nation's economy.

Whey is the liquid component that remains after the separation of solid curds during the production of paneer and cheese. Once whey has been considered as a waste but liquid whey has emerged as a valuable resource due to its nutritional composition and versatile applications. It contains high-quality proteins, such as lactalbumin and lactoglobulin, which are easily digestible and contain all essential amino acids. Whey is also a source of lactose, vitamins, minerals, and bioactive compounds like lactoferrins and immunoglobulins, which offer various health benefits. The utilization of liquid whey presents environmental benefits by reducing waste and resource consumption so instead of disposing of whey, it can be converted into value-added products.

Apple (*Malus domestica)* is a popular fruit for its crisp texture, refreshing taste, and numerous health benefits. Apples are low in calories but high in essential nutrients. They contain vitamin c, potassium, and various antioxidants like flavonoids and polyphenols. The antioxidants and soluble fiber in apples help to lower LDL cholesterol and also promote digestive health. Apple juice is a versatile ingredient used in a variety of food products such as cakes, muffins, jams, jellies, beverages, etc. due to its flavor, nutritional benefits, and functional properties.

Hibiscus flowers, scientifically known as *Hibiscus rosa- sinensis* is a tropical flowering plant native to warm climates. Hibiscus flower extracts are increasingly being used in various food products due to their vibrant color, unique flavor, and potential health benefits. Hibiscus flowers are rich in antioxidants, including flavonoids, polyphenols, and anthocyanins. These compounds help neutralize harmful free radicals in the body, reducing oxidative stress and inflammation. Vitamin C and minerals like calcium, iron, and magnesium play important roles in the immune system, bone health, and energy metabolism. Hibiscus extracts are commonly added to fruit juices, tea beverages, cocktails, and flavored water to enhance both color and flavor. They can be also incorporated into ice creams, jams, jellies, and syrups as it have a slightly tangy flavor and a pop of color.

Jelly is a delightful confection that combines the goodness of fruit with a chewy texture. These colorful and chewy treats are suitable for both children and adults. Apple whey jelly is made by combining apple juice, acidic whey, sugar, a gelling agent and also hibiscus extract. Effective utilization of whey can be done by addition of whey with apple juice turning it into a value added product. The incorporation of hibiscus extract will provide various health benefits and also enhance the colour and appearance of the product. Hence in the present study, an attempt has been made for value addition by improving the nutritional status of jelly by addition of whey and also incorporating hibiscus extract as a natural coloring agent.

The objectives of the study are as follows:

1. To optimize the process for preparation of Apple whey jelly incorporated with hibiscus flower extract.
2. To study the physio-chemical, textural and sensory attributes of optimized whey jelly

2. REVIEW OF LITERATURE

2.1. Milk

Milk represents an exceptionally valuable raw material given its relative ease of conversion into a wide variety of products. Bovine milk represents the vast majority of global milk production. Colostrum, the initial mammary secretion following calving, contains elevated protein levels, especially serum proteins. This high protein content is largely attributable to high immunoglobulin concentrations in colostrum. (*Nandan and Kumar, 2022*).The composition of milk differs uniquely across mammalian species, having evolved to meet the specific nutritional needs of each. Specifically, cow's milk protein content ranges from three to four times greater than human milk. Additionally, the mineral content in cow's milk is approximately five to seven times higher than in human milk. These compositional variances reflect the divergent developmental needs of calves versus human infants. (*kumar et al., 2014*)

Milk contains several key components that vary in composition. The four major constituents of milk in terms of quantity are water, fat, protein and lactose. Minor components also found in milk include minerals, enzymes, vitamins, and dissolved gasses. It holds dissolved salts primarily in the form of phosphates, nitrates and chlorides of calcium, magnesium, potassium and sodium. Milk provides particularly high nutritional value owing to the balanced composition of its constituent nutrients. The specific makeup of milk varies between animal species and even among breeds within the same species.(*Guetouache et al.,2014*)

Milk products and their components play a role in regulating body mass through satiety signals. Therefore, whey proteins include physiological milk components for individuals with metabolic syndrome or obesity. High protein milk products containing whey protein may improve insulin sensitivity and reduce fat accumulation. Fermented dairy products can directly impact health or interact with consumed microorganisms through their functional components. Fermentation generates nutrients and microbial metabolites that can also indirectly exert antimicrobial action. Probiotic mechanisms frequently promote health by positively influencing immunity via the impacts of fermentation on the microbial environment.(*Gasmalla et al., 2017)*

2.2. Whey

Whey can be defined as the watery portion of milk that remains after the separation of the curd. This separation occurs as a result of coagulation of milk proteins by acid or proteolytic enzymes. The composition of whey produced at dairy facilities is primarily determined by the processing methods employed to remove casein from liquid milk. Whey contains many important nutrients and its biological components have demonstrated effects in treating various chronic illnesses such as cancer, cardiovascular disease, and HIV. Lactose, as the primary constituent of whey, appears to hold relatively lesser value and presents greater challenges than other components in terms of utilization. **(***Macwan et al., 2016).*Whey poses significant pollution risks due to its extremely high biological oxygen demand (BOD > 35,000) and chemical oxygen demand (COD > 60,000 ppm). The most nutritionally valuable components of whey are the proteins, composed of beta-lacto globulin, alpha-lactalbumin, blood serum albumin, immunoglobulin, and protease-peptone. (*Raghavendra et al., 2017).*

Utilizing whey for the production of food and wellness products proves the most profitable solution to ecological concerns. Protein extracts from whey have long been commonly commercialized and consumed as a dietary supplement due to their demonstrated health benefits. Whey ingredients exhibit outstanding functional qualities like solubility, foaming, emulsification, gelation, and water retention among other properties. *(Kumara, 2020*).

The composition and sensory characteristics of whey can differ based on several factors. These include the type of whey being acid or sweet whey, the source animal producing the milk such as cow or sheep, the feed given to the source animal, the cheese processing method utilized, the time of year, and the lactation stage. *(Tsakali et al., 2010*). Whey constitutes approximately 45-50% of total milk solids. It contains around 70% of milk sugar (lactose), 20% of milk proteins, and 70-90% of minerals originally present in milk. Whey contains all essential amino acids meeting or exceeding FAO standards, including isoleucine, lysine, threonine and tryptophan. (*Baba et al., 2016).*

Whey protein has gained widespread acceptance as a dietary supplement, finding popularity among a diverse range of individuals such as bodybuilders, athletes, and those seeking an additional protein source in their nutrition. Whey is particularly rich in leucine, a branched-chain amino acid renowned for its notable growth-promoting, or anabolic properties. *(Krupa and Ronak, 2033)*

Whey, whey solids, and whey protein concentrates are utilized in the production of dairy, bakery and specialized items. Whey proteins provide diverse roles in foods including gelation, thermal stability, foam generation and emulsification. Dairy whey has various applications in food production and animal feed. It is commonly used to make ricotta, brown cheeses, and other products intended for human consumption. *(Ramji et al., 2016)*

2.2.1. Health benefits of whey

Antimicrobial activity - Components of whey, such as immunoglobulins, lactoferrin and its derivative lactoferricin, lactoperoxidase, glycomacropeptide and sphingolipids, demonstrate antimicrobial properties. Additionally, antimicrobial peptides can be produced from whey protein through proteolysis during gastrointestinal transit. Lactoferrin inhibits several Gram-positive and Gram-negative pathogens like Escherichia coli and can mitigate many microbial infections. Lactoferrin also exhibits meaningful antiviral activity. The antimicrobial role of whey is significant for intestinal function and prevention of gastrointestinal diseases by regulating the intestinal microflora.

Anticancer property- Recent studies have explored the potential anticancer properties of whey. It is believed to be associated with whey's ability to act as an antioxidant as well as detoxify and enhance immunity through its glutathione and lactoferrin content. Accordingly, research has suggested that dietary intake of whey may lower the risk of intestinal, breast, and colorectal cancers.

Bone health- Whey contains minerals that promote bone growth and an active fraction that stimulates proliferation and differentiation of cultured osteoblasts, the cells responsible for bone formation. As such, whey plays an important role in human bone formation as the intestine absorbs these active components. Whey also decreases bone resorption. *(Akideniz,2012)*

Anti-inflammatory property- Whey proteins can impact hypertension through their effects on inflammation and the Renin-Angiotensin System (RAS). Angiotensin-Converting Enzyme (ACE) inhibitors possess anti-inflammatory properties. One study found that consuming whey proteins depleted plasma levels of pro-inflammatory cytokines (IL-1 beta by 59% and IL-6 by 29%) compared to consuming the same amount of casein.

Obesity control- Various research studies have demonstrated that whey proteins can aid in weight management and obesity control. The mechanism involves whey proteins' influence on hormones that regulate appetite and hunger. Research has shown whey proteins to be even more effective than red meat at reducing weight gain while also increasing the body's insulin sensitivity.

Wound healing- Wound healing involves the formation of new skin through the utilization of proteins and their constituent amino acids. The healing process may be impeded when insufficient amounts of protein are present or diets high in poor-quality proteins, such as gelatin, are consumed. Whey proteins contain high-quality proteins and are thus regularly recommended by medical professionals following any surgical or burn treatment procedure. *(Gupta and Prakash, 2017)*

2.3. Hibiscus

The genus Hibiscus includes both annual and perennial herbaceous plants, woody shrubs and small trees.. The plant contains various chemical constituents that are of major pharmacological significance. The stem and leaves contain stigma sterol, β-sitosterol, taraxeryl acetate, and three additional cyclopropane compounds along with their derivatives. Flowers are composed of flavonoids, diglucoside, and vitamins such as thiamine, riboflavin, ascorbic acid and niacin. Quercetin-3-diglucoside, 3,7-diglucoside, cyanidin-3-sophoroside-5-glucoside, and cyaniding-3,5-glucoside have been isolated from the bright yellow flowers of this plant. *(Pearline et al., 2015)*

2.3.1 *Hibiscus rosa- sinensis*

Hibiscus rosa-sinensis, commonly referred to as China rose, is a member of the Malvaceae plant family. The *Hibiscus rosa-sinensis* plant, also known as China rose or "Queen of the tropics," is a popular flowering species commonly found in southeast China as well as some Pacific and Indian Ocean islands. Phytochemical analysis has shown that the plant contains several bioactive compounds believed to contribute to its reported medicinal effects. Specifically, flavonoids, tannins, terpenoids, saponins, and alkaloids were identified as the main groups of compounds present in the plant. (*Missoum, 2018)*. Natural colorants are gaining importance in the food industry due to potential adverse human health effects associated with synthetic colorants. Synthetic dyes used in the food industry may cause behavioral and neurological effects that negatively impact human health. Therefore, anthocyanins can be considered one of the best alternatives for coloring due to their high potential in terms of low cost, vivid coloration and stability. *(Ashitha et al., 2020).*

2.3.2.Anthocyanins

Anthocyanins are widely recognized as the largest and most significant class of water soluble pigments found in nature. According to *Harborne (1998),* they are responsible for the blue, purple, red, and orange hues seen in many fruits and vegetables. The intensity and type of color produced by anthocyanins can be affected by the number of hydroxyl and methoxyl groups present. Under acidic conditions, anthocyanins may appear as a vibrant red or orange shade. *(Miguel, 2011)*. Anthocyanins, a class of flavonoids, are important pigments that produce the vibrant red and blue colors found in flowers and fruits. The plant provides health benefits as a mild laxative, expectorant, and diuretic. *(Priyanka and Nehete, 2022)*. The anthocyanins have been extensively utilized as coloring agents. Specifically, the red anthocyanins present in the calyces of *Roselle Hibiscus sabdariffa L.* have been employed as food colorants. The primary compounds are cyanidin-3-sambubioside and delphinidin-3-sambubioside.*(Weerasingha, 2021).*

The antioxidant activity of the plant extracts was assessed through the estimation of total flavonoid content, total phenolic content, DPPH free radical scavenging activity, and percentage inhibition of linoleic acid oxidation capacity. *(Khan et al., 2014).*

The objective of the study conducted by Baghya in 2022 was to determine the optimum extraction conditions for anthocyanin from fresh and dried hibiscus petals to obtain high antioxidant activity and polyphenol content. Anthocyanin is commonly extracted using aqueous solvents alone or in a mixture with organic solvents such as ethanol, methanol, and acetone. However, anthocyanin is sensitive to temperature, pH, and solvent composition and may degrade or change from its native state when subjected to harsh extraction conditions. *(Baghya et al., 2022)*

The data obtained from the study done by Mandade, indicates that the 80% aqueous-ethanol crude extract of *H. rosasinensis* demonstrated effective antioxidant properties in various in vitro assays, including determination of total antioxidant activity by the ferric thiocyanate method, DPPH radical scavenging, ABTS+ radical cation scavenging, superoxide anion radical scavenging, and hydrogen peroxide scavenging. When compared to standard antioxidant compounds like BHA, BHT, and α-tocopherol, the *H. rosasinensis* extract performed well. *(Mandade et al., 2011)*

2.3.3.Health benefits of hibiscus

Antioxidant property- An ethanolic (95.0%) extract of flowers demonstrated potent scavenging of hydrogen peroxide, inhibiting it by 96 ± 2.35% at a concentration of 50 µg/ml. The standard antioxidant ascorbic acid exhibited 76.33 ± 1.25% radical scavenging activity at a higher concentration of 100 µg/ml. (*Savale & Sonavne, 2022)*

Pharmacological Effects- According to various studies, leaves and flowers of Hibiscus rosa-sinensis have been shown to have a wide range of pharmacological benefits. Extracts from aerial parts of the plant using aqueous ethanol have been reported to help treat constipation and diarrhea. It has also been found to purify the blood and help treat cystitis, which is inflammation of the bladder.

Antimicrobial Effect- The antimicrobial activity of extracts from Hibiscus rosa-sinensis flowers and leaves was studied against select bacterial isolates from clinical samples. The flower extracts of Hibiscus rosa-sinensis demonstrated stronger antimicrobial activity than the leaf extracts. The maximum zone of inhibition (29mm) was observed against Staphylococcus aureus, followed by Proteus vulgaris (25mm), Pseudomonas aeruginosa (24mm) and Citrobacter sp. (24mm); the lowest effect was against Salmonella typhimurium (13mm) at the highest concentration of flower extracts tested (100mg/well). All test bacteria responded to the extracts in a dose-dependent manner.

Antipyretic effect- The researchers investigated the antipyretic effects of a 250mg/kg aqueous root extract of Hibiscus rosa-sinensis in albino Swiss rats using a yeast-induced pyrexia model. After 3.5 hours, the extract reduced the rectal temperature from 39.0 ± to 37.5 ± 0.25°C. For comparison, rats treated with 30mg/kg body weight of paracetamol as a positive control maintained a rectal temperature of 37°C. *(Shandilya & Pathak, 2020).*

Antidiabetic effect- A study was conducted by snafi to evaluate the antidiabetic effect of Hibiscus rosa-sinensis flower powder in patients with type II diabetes. Participants consumed 2 grams per day of Hibiscus rosa-sinensis flower powder for 60 consecutive days. This led to statistically significant reductions in mean fasting blood glucose levels, postprandial blood glucose levels, mean glycosylated hemoglobin levels, mean total cholesterol levels, triglyceride levels, total LDL cholesterol levels, and total VLDL cholesterol levels. *(Al snafi, 2018)*

2.3.4. Confectionary products with hibiscus

Pineapple hibiscus jam was prepared by adding different concentrations of hibiscus and physiochemical properties were analyzed in the study done by Silva in 2019. A study of hibiscus jam formulations found that increasing the concentration of hibiscus significantly impacted the jam's composition. Higher hibiscus concentration reduced total sugar content while increasing ascorbic acid, acidity, total soluble solids, and ash. It also elevated total anthocyanin and flavonoid levels. Among the jams tested, the formulation with 15% hibiscus distinguished itself with high contents of ascorbic acid, flavonoids, and anthocyanins. *(Silva et al., 2019)*

2.4. Apple

The apple (*Malus domestica*) is a pomaceous fruit that belongs to the rose family (Rosaceae) and is a perennial plant. Apple is the most commercially important temperate fruit globally and ranks fourth among the most widely produced fruits worldwide behind bananas, oranges, and grapes. *(Chaudhary et al., 2014)*. There has been growing recognition of the connection between dietary consumption of fruits and vegetables and enhanced human health. The broad and increasing intake of apples, apple juice, and apple products coupled with their abundant phytochemical composition indicate their likely importance in positively impacting the wellness of consuming populations. *(Hyson, 2011).* Carbohydrates represent the primary nutritional value of apples. They include starches, sugars, pectin, cellulose, and hemicellulose. Unripe apples contain a relatively high level of starch (3-4%), however, as the fruit matures the starch is converted to sugars leaving little to no starch. Apples contain a slightly smaller amount of protein (less than 0.3%) compared to various other types of fruit.*(Lee, 2011).* Apples are primarily composed of water (85%) and carbohydrates (14%), including fiber and sugars (mainly fructose). Apples also contain vitamins (particularly vitamin C and vitamin E), minerals (mainly potassium), and polyphenols. Apples contain approximately 2.21 g/100 g of total fiber. Of that, 70% is insoluble fiber such as cellulose and hemicellulose, while 30% is soluble fiber mainly consisting of pectin. Pectin are complex polysaccharide found in the cell walls of higher plants that are not metabolized in the upper digestive tract of humans. (*Bondonno et al., 2017).*Apple polyphenols have been demonstrated to prevent damage to lung tissue from smoking through their antioxidant effects and may decrease the oxidation of low-density lipoprotein (LDL). The main phytochemicals present in apples are polyphenols. Apples contain five primary groups of polyphenols, specifically flavanols (catechins, epicatechin, and procyanidins), flavonols (quercetin glycosides), phenolic acids (chlorogenic, gallic, and coumaric acids), dihydrochalcones (phloretin glycosides), and anthocyanins (cyanidin). (*Marcotte et al., 2022).* Apples were most consistently linked to decreased risk of cancer, heart disease, asthma, and type II diabetes compared to other fruits and vegetables as well as other sources of flavonoids. Apple consumption was also correlated with enhanced lung function and weight loss. *(Boyer and Liu, 2004)*

2.5. Jelly

The terms "gel" and "jellies" derive their origin from the Latin term "gelu" meaning "frost." Gels and jellies find their genesis in the concept of solidifying liquids into a form that does not flow freely while retaining elasticity and certain liquid properties. *(Badola et al., 2021).* Jelly is defined as a semisolid food made from no less than 45 parts by weight of fruit juice ingredient to each 55 parts by weight of sugar. This mixture is concentrated to no less than 65% soluble solids. Jellies are made by cooking fruits (pieces, pulps, and/or juice) with sugars, gelling agents (usually pectin), and edible (usually organic) acids and concentrating the mixture until a characteristic and suitable consistency is obtained. *(Arjun Ringwal, 2019*).

A quality jelly should be transparent and sufficiently firm to maintain its form when removed from its vessel. The jelly should be delicate yet still reflect the angle at which it was cut. The taste of the jelly should be fresh and fruity. The texture should avoid being gummy, tacky, or syrupy. (*Igor et al., 2019).*Fruit pastes and jellies have a relatively lower energy value compared to other confectionery products. Additionally, these products contain gelling agents and fruit raw materials in their composition. Due to these components, fruit pastes and jellies can be classified as diet foods.(*Thakre & Barse, 2018*). Various fruits and combinations of fruits are commonly used for making jellies. Qualitative Assessment of Guava and Wood Apple Blended Jelly Cubes (2022) This study from 2021 evaluated suitable pulp combinations of guava and wood apple juice for developing blended jelly cubes. A randomized block design was implemented with nine treatments testing jelly cubes prepared using various proportions of wood apple and guava fruit juice. *(Ashwini et al.,2022).*

In the study conducted by Ahirrao in 2022, he prepared blended carambola and pineapple jelly cubes using various proportions of carambola and pineapple fruit juices. The study showed an increase in moisture and reducing sugars, with a decrease in total soluble solids, titratable acidity, total sugars, ascorbic acid, and β-carotene in the blended product during the 90-day storage period under ambient conditions. (*Ahirrao et al., 2022*). Textural analysis indicated that gelatin-based jellies containing the sugar substitute sorbitol and xylitol demonstrated higher hardness than gelatin-based jellies containing sucrose. Of all samples tested, jellies containing 1.5% (w/v) carrageenan exhibited higher hardness, cohesiveness, and chewiness than other jellies, irrespective of the sugar substitute used. The pH and Brix levels of carrageenan-based jellies were lower than those of gelatin-based jellies. Carrageenan-based jellies exhibited a lower melting rate compared to gelatin-based jellies. *(Park et al., 2021).*

In the study done by Lucia and Marchellin in 2021, they combined natural pectin and carrageenan to improve the physiochemical properties of jelly candy. As the proportion of carrageenan increases, the chewiness of jelly candy may also rise. When the carrageenan ratio exceeds that of pectin, values for chewiness will tend to augment as well. *(Soedirga & Marchellin, 2021).*

2.5.1 Whey jelly

Wasnik and Changade conducted a study in 2015 and found that paneer whey can be acceptably used to replace up to 100% of the water in certain food products. Specifically, the nutrient levels improved among the treatments as the level of paneer whey increased in substitution of water. *(wasnik and changade, 2015*).

The study of Wasnik was conducted in 2016 to determine the suitable level of whole paneer whey for producing pectin-whey jelly and examine the effects of different levels of paneer whey on the product's physio-chemical and microbial quality. Five different proportions of paneer whey with average total solids (6.36 ± 0.04%), titratable acidity (0.38 ± 0.01%), pH (5.61 ± 0.11), protein (0.35 ± 0.01%), and ash (0.40 ± 0.14%) and corresponding levels of potable water were utilized for testing.*(wasnik, 2016).*

2.6. Carrageenan

Carrageenan is a natural polysaccharide extracted from edible red seaweeds. The name Carrageenan originates from *Chondrus crispus*, a species of seaweed known as Carrageen Moss or Irish Moss in England and Carraigin in Ireland. It is commonly utilized in commercial applications as gelling, thickening, and stabilizing agents. Carrageenan is commonly utilized as an additive in food products where it is designated with the E-number E407 or E407a according to European Union regulations. (*Necas & Bartosikova, 2013).* Carrageenans are a family of water-soluble, linear, sulfated galactans. The backbone of the polysaccharide is comprised of alternating D-galactose units linked by α-(1-3) and β- (1-4) glycosidic bonds. The three principal types of carrageenan of industrial importance are kappa, iota, and lambda. Kappa (k) and iota (i) are gelling polymers, while lambda (λ) is a non-gelling thickening agent.. *(Popescu et al., 2007).*

Kappa-carrageenan is a type of carrageenan that contains one sulfate group per disaccharide. Iota-carrageenan contains two sulfates per disaccharide, whereas lambda-carrageenan contains three sulfates per disaccharide. The three principal types of industrial importance are kappa, iota, and lambda carrageenans. Kappa (k) and iota (i) forms are gelling polymers, while lambda (λ) is a non-gelling, thickening agent. All carrageenans are soluble in hot water. Sodium salts of both kappa and iota carrageenans are soluble in cold water. *(Anggraini & Lo, 2023)*

The initial process in generating gels from mixtures of milk protein and κ-carrageenan involves the adsorption of the carrageenan onto casein micelles. This adsorption occurs in a way that allows most of the carrageenan to participate in gel formation. Milk naturally contains the cations that catalyze the gelation of κ-carrageenan.*(Puvanenthiran et al., 2003).* Kappa carrageenan has the potential for use in producing traditional foods that are oriented toward a hard texture, whereas iota carrageenan can be used in traditional foods requiring better adhesiveness. *(Al-Baarri et al., 2018).* Kappa-carrageenan is commonly utilized as a clarification agent in the wine and beer industries. It is employed in confectionary manufacturing as a substitute for gelatin or to produce low-calorie fruit jelly. Kappa-carrageenan is also applied in the food industry as an edible protective coating or film on pre-cut packaged fruits as it can enhance food preservation primarily by functioning as an oxygen barrier and also helps control discoloration and maintain texture. *(Tasende, & Manríquez, 2016).*

κ-carrageenan forms a strong, rigid gel in the presence of potassium ions and exhibits high syneresis. The interaction between proteins and carrageenan is dependent upon several factors. These include the net charge ratio of the protein to carrageenan as well as the isoelectric point of the protein. The viscosity of carrageenan solutions is impacted by concentration, temperature, and the presence of other solutes and salts. Kappa carrageenan gel forms a turbid structure, while Iota carrageenan produces clear gels. *(Dipali, 2019).*

2.7. Whey Beverage

The production of whey-based beverages originated in the 1970s and since that time a wide variety of whey beverages have been developed. Whey-based beverages encompass a wide range of products created by blending native sweet, diluted, or acidic whey with various additives such as tropical fruits and other fruits like apples, pears, strawberries, or cranberries. Non-alcoholic options include these fruit and plant-based mixtures, while alcoholic varieties contain small amounts of alcohol up to 1.5% or are whey-based versions of beer or wine. Whey beverages appeal to a broad range of consumers from children to older adults. They offer significant nutritional value and beneficial therapeutic properties. *(Irena et al., 2008).*

The beverage industry has made considerable advancements in production capabilities over the past several years. Whey drinks provide a light and refreshing option that is less acidic than fruit juices. The medicinal and nutritive benefits of sweet yet mildly acidic whey can be obtained through its combination with fruit juices, fruit purees, and fruit concentrates to develop appealing shelf-stable beverages. The production of whey-based beverages involves mixing suitable fruit juices with minimally processed whey, along with the careful selection of stabilizers and acidulants, in order to develop whey-based fruit beverages that meet acceptable quality standards.*(Pandey et al., 2019).*Acid whey contains components which exhibit biological activity in addition to their high nutritional value, including proteins, mineral salts, and vitamins. Orange beverages containing whey had higher levels of protein, ash, vitamin B2 and lower levels of sucrose compared to orange beverages without whey (*Sady et al., 2016).*

2.7.1 Apple whey beverage

Dairy by-products can be used to enrich fruit juices in order to enhance their therapeutic and nutritional value. A study was conducted by jakhar to develop beverages using apple juice and incorporating whey at various percentage levels and to conduct nutritional analysis. Protein values ranged from 0.72–1.9. Fat content ranged from 0.50–1.10. The ascorbic acid level in the juices ranged from 2.97–0.85 and was found to decrease with increasing amounts of whey. Acidity levels ranged from 0.20–0.34 and increased with higher amounts of whey. Ash content levels also increased, ranging from 0.20–1.50. Apple juice blended with whey protein concentrate demonstrated good nutritional composition and could be recommended to consumers as a healthy drink choice. *(jakhar, 2019).*

2.8. Citric acid

Citric acid (2-hydroxy 2, 3-propanetricarboxylic acid) is the most important organic acid produced through fermentation in terms of volume. It is a tricarboxylic acid and serves as a universal intermediate product across plant and animal metabolism.. Lemon juice remained the primary commercial source for citric acid production until 1919. However, in 1917 Currie discovered that certain strains of the Aspergillus niger fungus produce citric acid through abundant growth in a nutrient medium containing high concentrations of sugar and mineral salts, with an initial medium pH of 2.5–3.5. *(Swain et al., 2011)* Citric acid has a pleasant sour taste with a refreshing entrance and no after-sour taste, making it safe and non-toxic for consumption. It has high solubility in water allowing for direct absorption and metabolism by organisms. Based on these excellent characteristics, citric acid is widely utilized in the food industry. Citric acid represents the largest edible organic acid in global production and consumption.. Citric acid is multifunctional and non-toxic (Generally Recognized as Safe), classified as a safe food additive by the FAO/WHO Expert Committee and referred to as the first edible souring agent. *(Wang et al., 2023)* Citric acid is widely used in food products as it effectively inhibits microbial growth while also providing a clean label profile. It is a relatively mild acid but among the strongest that is entirely edible and demonstrates no harmful effects on humans. For this reason, it is an ideal choice for preserving many types of foods. *(Hossain et al., 2023)* Citric acid is an odorless and colorless compound that is highly soluble in water (62.07% at 25 °C). It exhibits weak hygroscopic properties *(Ciriminna et al., 2017).*

3. MATERIALS AND METHODS

3.1 RAW MATERIALS

Various ingredients and materials used in the preparation of Apple whey Jelly is described below.

3.1.1 Milk

Milk used for the preparation of paneer whey was obtained from dairy plant of KVASU, Mannuthy

3.1.2 Sugar

Fine crystalline sugar obtained from the local market was used in the preparation of jelly.

3.1.3 Kappa carrageenan

Kappa carrageenan of Bake king brand, bought from Thrissur was used as gelling agent in the preparation of jelly.

3.1.4 Citric acid

The citric acid used in the present study was of food-grade quality supplied by brand Ori Professional ingredients was bought from local market, Thrissur.

3.1.5. Apple

The apple procured from local market is used for jelly making. It was taken care that the fruits were not over ripened.

3.1.6. Hibiscus Flowers

Fresh red coloured Hibiscus flowers (*Hibiscus rosa sinesis)* were collected from local market.

3.1.7. Chemicals

Analytical grade chemicals where used for the work

3.2. EQUIPMENTS

The equipments available at the Verghese Kurien Institute of Dairy and Food Technology were used for the present study.

3.3. METHODS OF PREPARATION

3.3.1 Preparation of paneer whey

Paneer whey used for preparation of apple whey jelly was prepared using the method standardized by Bhattacharya, 1971

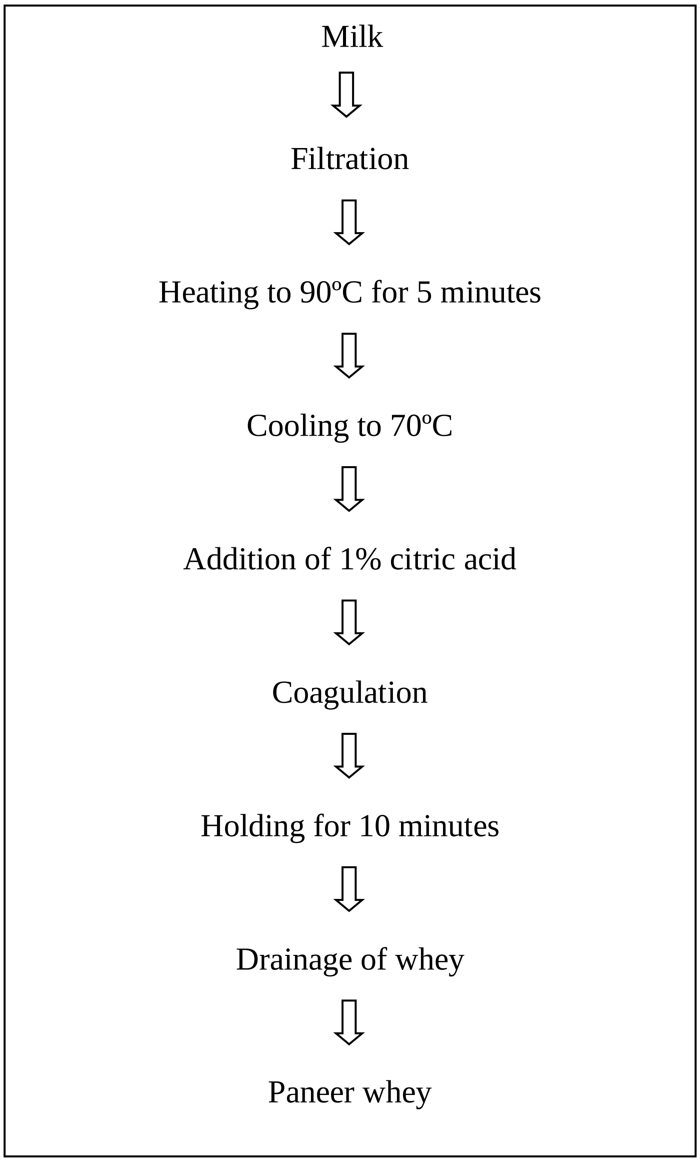

Fig 3.1 Flowchart of preparation of paneer whey

3.3.2. Preparation of Hibiscus extract

The hibiscus extract used for the study was prepared as per the method suggested by Weerasingha, 2021 with slight modifications.

30 g of hibiscus petals were boiled with 100 ml of distilled water and then filtered to obtain clear hibiscus extract

Clear hibiscus extract is obtained

⇩

Take 30g of flower petals

⇩

Boil in 100 ml of distilled water

(2 minutes)

⇩

Filter the extract

⇩

Clear hibiscus extract is obtained

Fig.3.2. Flow chart of preparation of hibiscus extract

3.3.4. Preparation of Apple juice

Apples were cleaned with water thoroughly and the juice was extracted using a semi-automated juicer. Then the apple juice was strained using a muslin cloth to obtain clear juice for the jelly preparation.

Fresh Apples

↓

Cleaning with water

↓

Cutting into small pieces

↓

Juice extraction using jucier

↓

Straining using muslin cloth

↓

Apple juice

Fig.3.3. Flow chart of Prepartion of Apple juice

3.3.5. Preparation of Whey jelly (control)

Whey Jelly was prepared according to the method of wasnik, 2016 with slight modifications whey, sugar, 1.5% of Kappa carrageenan and 0.5 % ciric acid were the ingredients used for preparation. 50g of powdered sugar was added to whey and boiled, followed by the addition 1.5% of kappa carrageenan. Finally 0.5 % of citric acid is added and solution is poured into moulds and allowed to cool for 30 minutes .

3.3.6. Preparation of apple whey jelly

Jelly was prepared as same as control whey jelly by addition of apple juice to whey in different ratios such as 60:40 (S1), 50:50 (S2), 40:60 (S3) and the best combination was selected based on the sensory evaluation.

Table 3.1 Different combination of ingredients for optimizing Apple Whey jelly

SAMPLES	APPLE JUICE (ml)	WHEY (ml)	SUGAR(g)	CITRIC ACID (g)	CARRAGEENAN(g)
Control	0	100	50	0.5	1.5
S1	60	40	50	0.5	1.5
S2	50	50	50	0.5	1.5
S3	40	60	50	0.5	1.5

3.4. OPTIMIZATION OF HIBISCUS EXTRACT IN APPLE WHEY JELLY

Apple whey jelly was prepared with whey and apple juice in a ratio 40:60 as per the method of preparation of jelly mentioned above with addition of hibiscus extract in various levels S1(5ml), S2(10ml), S3 (15ml).The best level was selected on the basis of sensory evaluation .

Table 3.2 Different combination of ingredients for optimizing Apple whey jelly with hibiscus extract

SAMPLES	APPLE JUICE: WHEY (ml)	HIBISCUS EXTRACT(ml)	SUGAR(g)	CITRIC ACID(g)	CARRAGEENAN(g)
control	00:100	0	50	0.5	1.5
S1	60:40	5	50	0.5	1.5
S2	60:40	10	50	0.5	1.5
S3	60:40	15	50	0.5	1.5

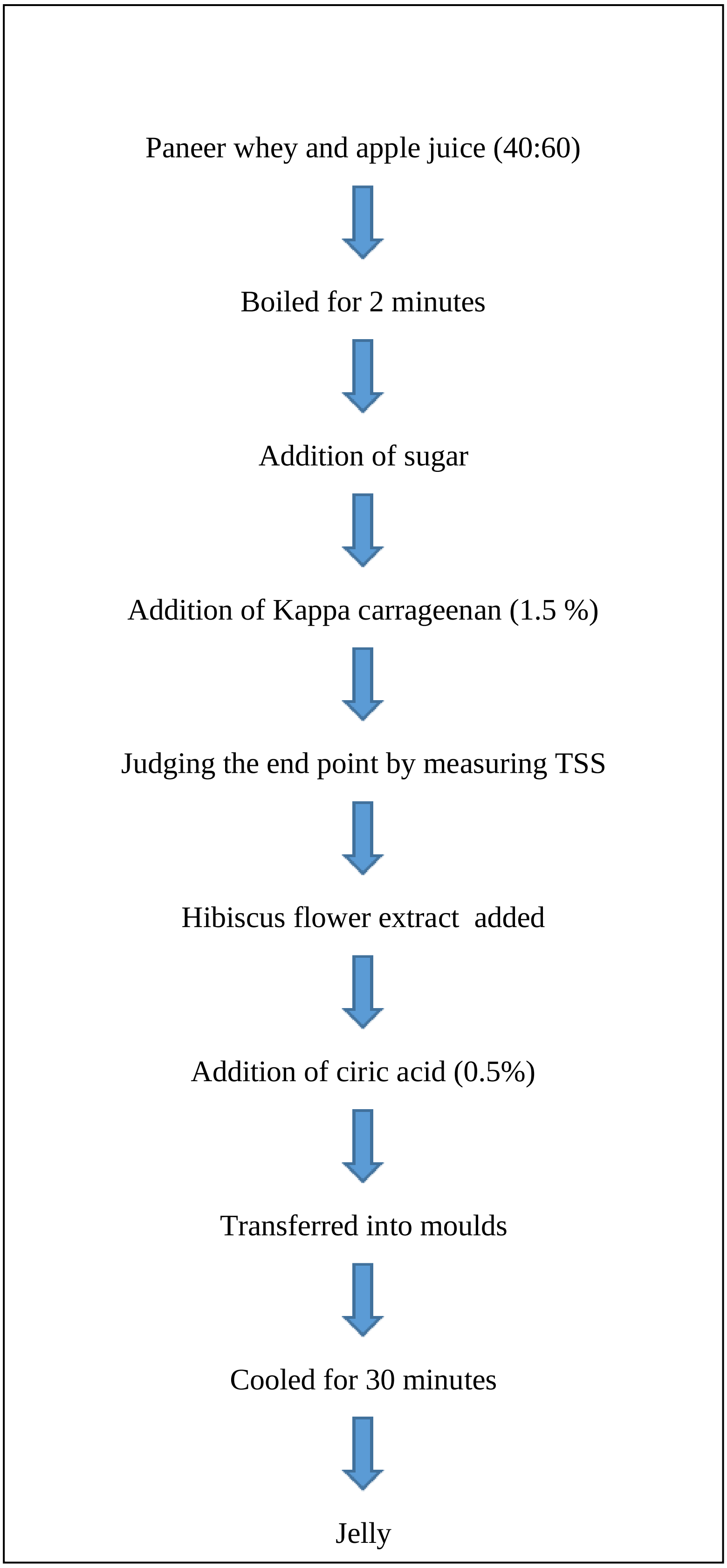

Fig.3.4. Flowchart of preparation of apple whey hibiscus jelly

3.5. PROXIMATE COMPOSITION AND PHYSICO-CHEMICAL ANALYSIS OF JELLY

3.5.1. Moisture

The moisture content of jelly samples was estimated following the procedure outlined by Ranganna (2012). A flat bottom metal dish was dried in an oven at 110 degrees Celsius for 1 hour, removed and weighed. Then 10 grams of jelly was uniformly spread in the dish. The sample was dried in a hot air oven under atmospheric pressure, maintaining a temperature of 100 degrees Celsius. After drying, the sample was cooled in a desiccator and reweighed. The sample was subsequently reheated and reweighed until consecutive measurements varied by no more than 1 milligram. The percentage moisture content in the sample was then calculated using the specified formula.

$$Moisture\ per\ cent = \frac{w_1 - w_2}{w_1} \times 100$$

Where,

W1= weight of sample before drying

W2=weight of sample after drying

Fig.3.5. Hot air oven

3.5.2. Total solids

The total solid content is expressed as ratio of weights obtained before and after drying. The total solids in the sample were calculated using the expression given below.

$$\text{Total solids\%} = 100 - moisture\%$$

3.5.3. Total soluble solids (TSS)

TSS of jelly samples were determined by using Hand Refractometer of range 28º - 62º Brix.

3.5.4. Protein

Total nitrogen content of jelly samples was determined using a modified macro Kjeldahl method based on Ranganna (2012). 3 grams of each sample were accurately weighed into digestion tubes. Then, 2.4 grams of digestion mixture was added to each tube along with 25 ml of nitrogen-free concentrated sulfuric acid. The tubes were transferred to a digestion block and heated to 350°C for approximately 30 minutes until the digests were clear or pale blue. The cooled digests were loaded into a Kjel-plus distillation unit which automatically added 60-70 ml of 50% sodium hydroxide for neutralization. The samples were distilled for 9 minutes with the liberated ammonia condensed and collected in 50 ml of saturated boric acid solution containing a mixed indicator. The distillates were then titrated against 0.1 N sulfuric acid. A reagent blank was run simultaneously. Total nitrogen content was calculated using the specified formula.

$$\% \text{ Nitrogen} = \frac{(V_1 - V_2) \text{ x normality of } H_2SO_4 \text{ x } 14 \text{ x } 100}{W_1 \text{ x } 1000}$$

Where, W_1= Weight of sample,

V1 = Volume of 0.1 N H_2SO_4 used in titrating the sample,

V2 = Volume of 0.1 N H_2SO_4 used in blank titration.

The per cent total protein was calculated by multiplying nitrogen with a factor of 6.25

Fig.3.6. Kjeldahl apparatus

3.5.5. Ash

The Ash content of control and Apple whey hibiscus jelly was estimated by procedure described in Ranganna (2012). 15g jelly sample was weighted into silica dish (7-8 cm dia). Silica dish was used for ashing. The contents were ignited on a bunsen burner. Then material was ashed at not more than 525° C for 10 hour in a muffle furnace. The dishes were cooled in a desiccators and weighed. The total ash content in per cent was calculated as follows:

$$\text{Total ash (\% by weight)} = \frac{100 \times (W_3 - W_1)}{(W_2 - W_1)}$$

Where, W1 = Weight in gram of the empty crucible

W2 = Weight in gram of the crucible with sample

W3 = Weight in g of the crucible with ash

Fig.3.7. Muffle Furnace

3.5.6. Crude fibre

The crude fiber content of jelly was determined using the method described in AOAC (2016). Approximately 2 grams of sample was accurately weighed and transferred to a hard filter paper supported on a filter cone in a 60 degree funnel. The sample was then extracted with three 25 mL portions of ether and a vacuum was applied until drying was complete. The extracted sample was then quantitatively transferred to a 600 mL beaker of the fiber digestion apparatus. 20mL of well-mixed ceramic fiber suspension was added along with 200 mL of boiling 1.25% sulfuric acid solution, and one drop of diluted antifoam agent. The beaker was then placed on a preadjusted heating apparatus and boiled for exactly 30 minutes, with periodic rotation to prevent solids from adhering to the sides.

The beaker was removed and the contents filtered through a funnel precoated with approximately 0.75 grams of ceramic fiber - dry weight. The beaker was then rinsed with 50-75 mL of boiling water and washed through the funnel. This was repeated with three 50 mL portions of water, and suction was applied until drying was complete. The fiber mat and residue were returned to the beaker by blowing back through the funnel. 200 mL of boiling 1.25% sodium hydroxide solution was then added and returned to the heater for boiling for exactly 30 minutes. The beaker was then removed and filtered as before, and washed with 25 mL of boiling 1.25% sulfuric acid solution, three 50 mL portions of water, and 25 mL of alcohol. The mat and residue were then removed and transferred to a silica dish. The fiber mat and residue were dried at 130 ± 2 °C for 2 hours. After cooling in a desiccator, the sample was weighed. It was then ignited in a muffle furnace at 550 ± 15 °C until a constant weight was achieved (usually 30 minutes). After cooling in a desiccator, the sample was weighed. The fiber content was determined using the specified formula.

$$\text{Crude fibre} = \frac{W_1 - W_2}{W_S} \times 100$$

where,

Ws= weight of sample

W1= initial weight of crucible

W2= weight of crucible with ash

Fig.3.8. Crude Fiber Apparatus

3.5.7.Titratable acidity

A 10 gram sample of jelly was dissolved in distilled water and heated in a water bath to fully dissolve the sample. It was then cooled and diluted to a final volume of 50 ml. The solution was then titrated with 0.1 N sodium hydroxide solution using a few drops of 1% phenolphthalein indicator. The titration endpoint was recorded and used to calculate the percentage of anhydrous citric acid present, per the method outlined by Ranganna in 2012.

Equivalent weight of acid = 64

$$\text{Titrability acid (\% citric acid)} = \frac{E.W.Of\ acid \times titre\ value \times Normality\ of\ NaoH \times Volume\ made\ up \times 100}{1000 \times aliquot\ taken \times weight\ of\ sample}$$

3.5.8. pH

The pH values of jelly samples were determined using a digital pH meter after mixing the samples with equal quantity of distilled water (Ranganna, 2012).

Fig.3.9. pH Meter

3.5.9. Vitamin C

a) Standardization of dye (2, 6 - Dichlorophenol indophenols)

Vitamin C content of jelly samples were analyzed using the method outlined by Ranganna in 2012. 5ml of the standard ascorbic acid solution (with one milliliter equivalent to 0.1 milligrams of ascorbic acid) were added to 5ml of a 3% HPO_3 solution. This was then titrated with 2,6-Dichlorophenol indophenol dye until a pink color persisted for 15 seconds.

$$\text{Dye factor} = \frac{0.5}{\text{titre value}}$$

b) Analysis of sample

c) Ten grams of jelly samples were blended with 3 % phosphoric acid and the volume was made up to 100 ml with phosphoric acid. An aliquot of 2-10 ml of the filtered phosphoric acid extract of the jelly was titrated with a standard dye solution to a pink endpoint that persisted for at least 15 seconds. The ascorbic acid content was calculated using the provided formula.

$$\text{Ascorbic acid (mg / 100 g)} = \frac{\text{titre value} \times \text{dye factor}}{\text{aliquot of extract taken for estimation}} \times \frac{\text{volume made up}}{\text{weight or volume of sample taken for estimation}} \times 100$$

3.6. PHYSICAL PROPERTIES

3.6.1 Color characterstics

The colour characteristics of Apple whey jelly was measured in terms of L*, a* and b* values were determined using Hunter Lab Colorimeter (model D25L.9 Hunter Associates Lab, Inc.). The jelly samples were scanned at three different locations and the hunter values were recorded. A low number (0-50) of L * value indicates dark and a high number (51-100) of L* indicates light colour. A negative number of a* indicates green colour positive number of a* value indicates red colour. Similarly, a negative number of b* value indicates blue colour and positive number of b* value indicates yellow.

3.6.2 Textural characterstics

Various textural characteristics such as hardness, cohesiveness, springiness, gumminess & chewiness were measured by texture profile analyzer (TA-X T2 texture analyzer - stable microsystem). The equipment was set in the back extrusion mode with the following settings:

- Pretest speed: 1.00mm/sec, Test speed: 5.00mm/sec, Post test speed: 5 mm/sec, Distance: 10mm, Trigger force: 5.0g.
- Probe with a diameter of 75 mm was used the test.
- The mode was set to measure the force in compression.
- Run the equipment and note the readings.

Fig.3.10. Texture profile analyzer

3.7 SENSORY EVALUATION

The sample was evaluated on a 9 point hedonic scale, for their sensory attributes of flavor, color and appearance, body and texure, and overall acceptability.

Liked extremely - 9

Liked very much - 8

Liked moderately -7

Liked slightly - 6

Neither liked nor disliked - 5

Disliked slightly - 4

Disliked moderately - 3

Disliked very much - 2

Disliked extremely - 1

Table 3.3 Score card for sensory evaluation of apple whey jelly incorporated with hibiscus extract

Name of judge : Date :

ATTRIBUTES					
Flavour					
Color					
Body and Texture					
Overall Aceptability					

Remarks: Signature :

5.RESULTS AND DISCUSSION

The goal of the current study is to produce jelly-like confections using paneer whey. Two phases made up the entire study. The study's initial phase focused on standardizing the procedure for using paneer whey and apple juice to make jelly-like confection. The standardized product's chemical makeup, physico-chemical characteristics, textural attributes, and sensory aspects were assessed in the second phase. This chapter presents the research findings in detail along with a discussion.

4.1 EFFECT OF LEVEL OF ADDITION OF APPLE JUICE AND HIBISCUS EXTRACT ON THE SENSORY SCORE OF APPLE WHEY JELLY

Apple whey jelly was prepared by standard method. In order to optimize the extent of addition, trials were done by adding apple juice and hibiscus extract at different levels. Levels of apple juice and whey were optimized in the preliminary trials and added with hibiscus extract at different levels to the optimized product. The flavor, body and texture, color and appearance & overall acceptability of jelly having various composition of apple juice and hibiscus extract were analyzed by sensory evaluation. The optimized product was evaluated for its physico-chemical and textural attributes.

The preliminary trials were done addition of three different proportion of whey and apple juice viz, T1 (40:60), T2 (50:50), T3 (60:40) and control (100:0) The organoleptic quality of product was determined with the help of a panel of judges using 9-point hedonic scale. The results are depicted in Table below.

Table 4.1 Sensory scores of apple whey jelly prepared by the addition of whey and apple juice at different proportions

SAMPLE	ATTRIBUTES*			OVERALL ACCEPABILITY
	FLAVOUR	COLOR & APPEARANCE	BODY & TEXTURE	
T_1	8.01±0.23	7.6±0.08	7.8±0.26	8.0±0.25
T_2	7.7±0.75	7.4±0.36	6.8±0.31	7.3±0.40
T_3	7.4±0.68	7.2±0.52	7.5±0.33	7.2±0.52
Control	7.6±0.35	7.5±0.30	7.6±0.56	7.6±0.30

*All values are mean +/- standard error of 3 independent replications

T1 – 40:60 (whey :apple juice)

T2 - 50:50 (whey : apple juice)

T3 – 60:40 (whey : apple juice)

Control – 100:00 (whey : apple juice)

Fig 4.1.Apple whey jelly

Effect on Flavor : Here T_1 whey and apple juice 40:60 proportion imparts a good flavor to the product when compared to the control and other samples. The attribute was found to decrease as the concentration of whey increased.

Effect on Color and appearance **:** The mean sensory scores for color and appearance of apple whey jelly are presented in table. The mean highest sensory score is obtained for T1 (having whey and apple juice in 40:60 proportion)

Effect on Body and texture**:** Body and texture scores advocated significant effect. It was noticed that maximum score was obtained for T1.

***Effect on Overall acceptability*:** It is based on multiple organoleptic quality parameters like color, flavor, texture etc and shows accumulative perception and acceptance by the panelists. So based on that maximum score was awarded for T_2 having whey and apple juice in 40:60 proportion.

From the results of sensory evaluation of preliminary trials done to standardize the combination and levels of whey and apple juice best scores were observed for sample T1 containing whey and apple juice in 40: 60 proportion.

The second trials were done to standardize the level of hibiscus extract to the apple whey jelly. Different levels of hibiscus extract (5ml, 10ml, 15ml) were added to the T1 sample having 40: 60 proportion of whey and apple juice. The organoleptic quality of product was determined with the help of a panel of judges using 9-point hedonic scale.

Table 4.2 Sensory scores of apple whey jelly incorporated with hibiscus extract prepared by the addition of hibiscus extract in different levels

SAMPLE	**ATTRIBUTES***			**OVERALL ACCEPABILITY**
	FLAVOUR	**COLOR & APPEARANCE**	**BODY & TEXTURE**	
S_1	7.8±0.34	7.2±0.11	7.8±0.2	7.6±0.41
S_2	8.2±0.30	8.4±0.30	8.3±0.11	8.1±0.28
S_3	8.0±0.23	8.3±0.11	8.3±0.11	7.9±0.26
Control	7.5±0.32	7.2±0.30	7.6±0.57	7.6±0.36

*All values are mean +/- standard error of 3 independent replications

S1 –5 ml of hibiscus extract is added

S2 – 10 ml of hibiscus extract is added

S3- 15 ml of hibiscus extract is added

Fig.4.2 Control jelly

Fig.4.3 Sample jelly

Effect on Flavor

Here S_2 imparts a good flavor to the product when compared to the control. The attribute was found to decrease as the concentration of the extract was decreased.

Effect on Color and appearance

The mean sensory scores for color and appearance of apple whey jelly are presented in table. The mean highest sensory score is obtained for S2 (having 10 ml of hibiscus extract). S2 have more bright colour compared to that of S1 and control while S3.

Effect on Body and texture

Body and texture scores advocated significant effect. It was noticed that maximum score was obtained for S2 and S3.

Effect on Overall acceptability

It is based on multiple organoleptic quality parameters like color, flavor, texture etc and shows accumulative perception and acceptance by the panelists. So based on that maximum score was awarded for S_2. Such that the product with 10 ml of hibiscus extract were selected as the best product.

4.2.PHYSICO-CHEMICAL ANALYSIS

The optimized product was taken for further analysis along with the control.

Table 4.3 proximate analysis of optimized jelly and control jelly

PROXIMATE ANALYSIS	**APPLE WHEY JELLY SAMPLE**	**CONTROL***
ASH	0.46±0.02%	0.62±0.06%
MOISTURE	55.78±0.45%	54.49±0.26%
PROTEIN	0.24±0.01%	0.22±0.01%
CRUDE FIBRE	0.08±0.005%	0.06±0.005%
TOTAL SOLIDS	44.33±0.57	45.24±0.57
TOTAL SOLUBLE SOLIDS	42.66±0.57º	41.66±0.57º
pH	3.45±0.06	3.74±0.08
TITRABLE ACDITY	0.68±0.05	0.84±0.07
VITAMIN C	6.42±1.54	1.42±0.02

4.2.1.Ash

Ash is the inorganic residue remaining after water and inorganic matter have been removed by heating. The ash in apple jelly was 0.46% and control was 0.62%

In similar studies done by wasnik et al,2016 found that ash content in whey jelly prepared by complete replacement of water with whey is to be 0.4%.

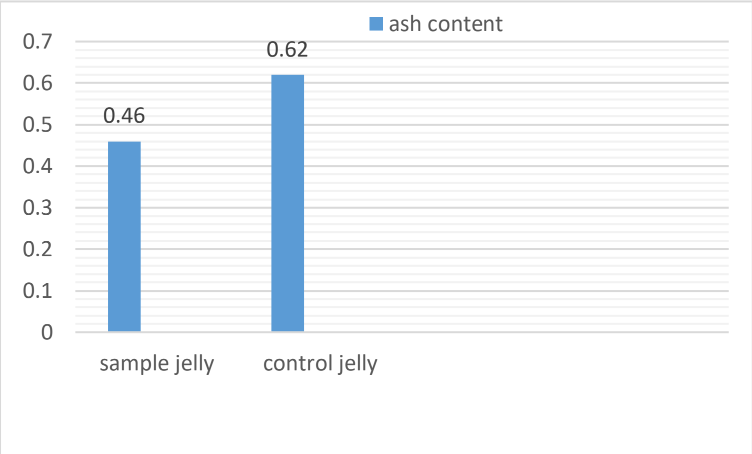

Fig 4.4 Graphical representation of ash content

4.2.2. Moisture

Moisture content influence taste, texture, weight appearance shelf life of food products. Moisture content is one of the most commonly measured property of food materials its control greatly influences physical property & product quality of nearly all substance & materials at all stages of processing & final product existence. The moisture percentage calculated in apple whey jelly was 55.78% and in control is 54.49%. Similar studies conducted by mondhe et al., in 2018, have moisture content 50 % in jelly produced with blending guava and pomogranate.

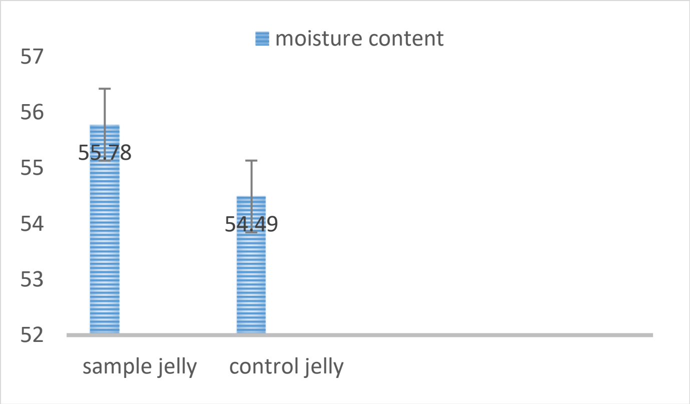

Fig 4.5 Graphical representation of moisture content

4.2.3.Protein

Protein is crucial for maintaining good health and supporting various bodily functions. Body needs protein for growth and maintenance of tissues. Insufficient protein can weaken immunity. The protein percentage was calculated by micro kjeldhalmethod. The protein percentage in apple whey jelly was 0.24% and that of control was 0.22%. In study conducted by wasnik and changade in 2015 observed 0.35% protein in their whey jelly.

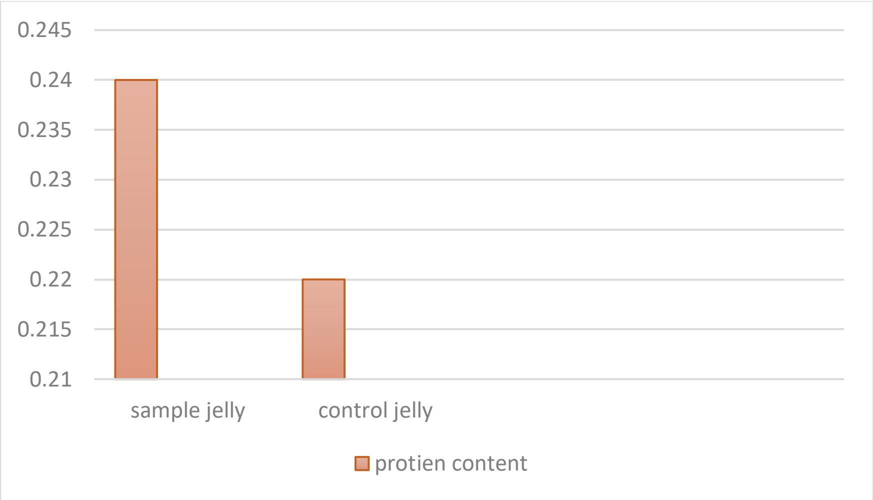

Fig 4.6. Graphical representation of protein content

4.2.4.Crude fiber

Fiber content is the complex mixture of different components and may or may not include fibrous structure ,crude fiber on the other hand ,is a term used to describe residue that is left after it has been dissolved in laboratory with certain harsh chemical solvents. The crude fiber percentage in apple whey jelly was 0.08 % and in control was 0.06% which is slightly lesser than the sample.

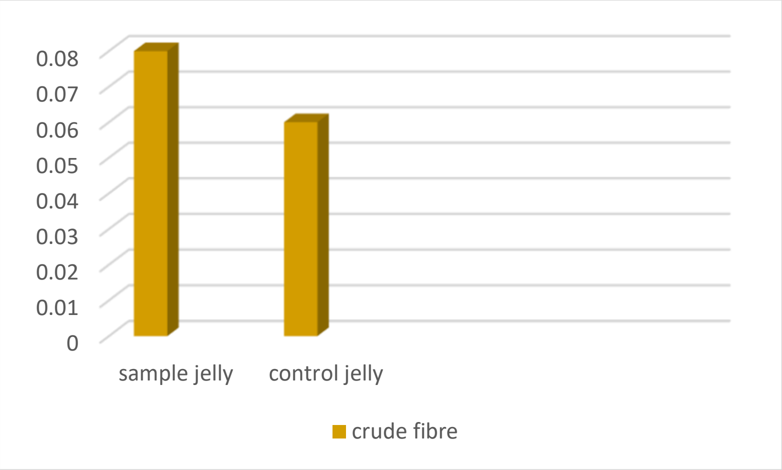

Fig 4.7. Graphical representation of crude fiber content

4.2.5.Total solids

Total solids refer to the portion of a liquid (such as milk) that remains after removing the water content. Total solids of the optimized jelly product is found to be 44.33% and 45.24% in control. In a similar study done by Lukin et al., 2019 found that total solids in orange whey jelly is to 41.5%.

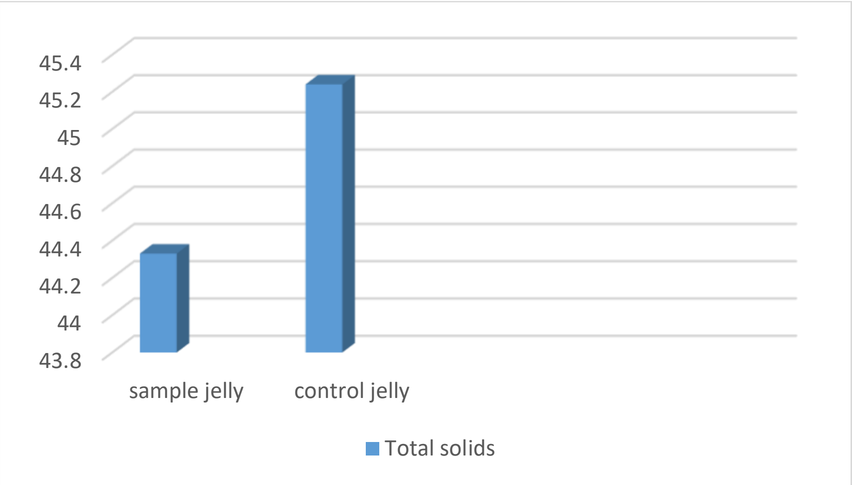

Fig 4.8. Graphical representation of total solids

4.2.6. Total soluble solids

Total soluble solids refer to the sum of all dissolved components in a liquid or solution. TSS of apple whey jelly was determined with hand refractometer and noted as 42.66º brix and 41.66º brix in control jelly.

4.2.7. pH and Titrable aAcidity

pH of optimized jelly product was observed as 3.45 and 3.74 in the control sample with the help of a digital pH meter. Titratable acidity is a better predictor of how organic acid in food sample impact flavor. It measures the total acid ion determined by titration of intrinsic acid with standard base.The apple whey jelly having acidity of 0.68% and 0.84% for the control. As per the results obtained by the study done by manasiya, 2016 pH of whey jelly like confection observed is 3.29 and titrable acidity of 0.76%.

4.2.8. Vitamin c

Vitamin C, also known as ascorbic acid, is a water-soluble nutrient found in various foods. Vitamin C in sample jelly is found to be 6.42 mg while the control jelly have 1.4mg which is very lesser than that of the sample jelly. This may be due to the addition of apple juice aand hibiscus extract to the control which have a significant amount of vitamin C in it. In the study done by sharma et al., 2019 founded 10.57mg/100ml ascorbic acid in apple whey beverage.

4.3. COLOR CHARACTERISTICS

The color of food is one of the major attributes which affect consumer perception & its quality. This change in color characteristics of herbal paneer spread was measured instrumentally in terms of L* (lightness), a* & b* (color opponent dimension) values by using Hunter's lab

Table 4.4. colour characteristics of sample jelly and control jelly

COLOUR CHARACTERISTICS	SAMPLE JELLY	CONTROL JELLY
L^*	35.94±0.49	54.86±2.80
a^*	28.43±1.41	-1.54±0.03
b^*	17.92±0.88	2.49±1.01

Color characteristics values of Apple whey jelly and control.

L* value ranges from 0 to 100 in which 0 indicates black & near to 100 represents whiteness. And the a* represents redness if it has positive value and 0 indicates grey and if it has negative value, it represents greenness and its value ranges from -60 to +60.And the b* is the degree of yellowness if it has positive value and 0 is the indication of grey and blueness if it has negative value and its value ranges from -60 to +60.These are the value representation of international color system

4.5. TEXTURE PROFILE ANALYSIS

It is known that various properties (texture, functionality and appearance) of foods were greatly affected by their structure. The textural attribute of apple whey jelly sample was analysed by using Texture Profile Analyzer. Textural attributes of sample were compared with that of control. The observation on rheological attributes of sample and control represented in table:

Table 4.5. Textural characteristics of apple whey jelly and control

TEXTURAL ATTRIBUTE	SAMPLE	CONTROL
HARDNESS (g)	981.37	1170.52
SPRINGINESS (mm)	0.413	0.418
COHESIVENESS	0.119	0.111
GUMMINESS (Kgf)	116.80	129.477
CHEWINESS (Kgf.mm)	48.28	54.162

By texture wise, Apple whey jelly is similar to the study done on dragonfruit jelly candy by lucia et al., 2022.

5.SUMMARY AND CONCLUSION

Jellies are semi solid products prepared using strained solution containing fruit extract , free from pulp along with sugar,acid and a gelling agent. It should be of attractive colour with a texture neither though nor rubbery. Attractive colour, fruity taste along with sweetness and soft texture makes it more acceptable to consumers especially children. This project was designed to develop apple whey jelly by incorporation of hibiscus extract as a natural coloring agent. The added apple juice improves the taste and flavor of whey jelly while hibiscus extract replaces artificial coloring agents by imparting bright color along with other health benefits.

A preliminary study was conducted to standardize the concentration of whey and apple juice to be used in apple whey jelly. 40% of whey and 60% of apple juice found to be most accepted concentration of whey and apple juice with high sensory attributes like flavor, appearance, colour, body, texture and overall acceptability, which was comparable to control and selected for further studies. Second study was carried out to standardize the concentration of hibiscus extract and jelly made with addition of 10% hibiscus extract found to be most accepted as per the results of sensory evaluation.

Physiochemical analysis of optimized jelly was done and compared with the control sample. The ash, moisture, protein, crude fibre, of apple whey jelly was found to be 0.46,55.78, 0.24 ,0.08 respectively. Total solids is found to be 44.33% while TSS is 42.66º Brix. Acidity and pH of optimized whey jelly was found to be 0.68% and 3.45. Vitamin C content in apple whey jelly incorporated with hibiscus extract is 6.42mg/100g which is higher than that of control jelly. There is slight difference in the values of ash, moisture, protein, crude fibre, carbohydrates, total solids, TSS, Acidity and pH.

From the result of present investigation it may be concluded that whey, apple juice and hibiscus extract could be successfully utilized for preparation of jelly confection. Addition of apple juice and hibiscus extract improved nutritional quality, sensory quality and acceptability of the product.

REFERENCES

1. Ahirrao, P. P., Relekar, P. P., & Kadam, S. K. (2022). Development of Carambola (Averrhoa carambola L.)-pineapple (Ananas comosus L.) Blended jelly cubes.
2. Al-Baarri, A. N., Legowo, A. M., Rizqiati, H., Septianingrum, A., Sabrina, H. N., Arganis, L. M., ... & Mochtar, R. C. (2018). Application of iota and kappa carrageenans to traditional several food using modified cassava flour. In *IOP Conference Series: Earth and Environmental Science* (Vol. 102, No. 1, p. 012056). IOP Publishing.
3. Al-Snafi, A. E. (2018). Chemical constituents, pharmacological effects and therapeutic importance of Hibiscus rosa-sinensis-A review. *IOSR Journal of Pharmacy*, *8*(7), 101-119.
4. Anggraini, J., & Lo, D. (2023, April). Health impact of carrageenan and its application in food industry: a review. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1169, No. 1, p. 012098). IOP Publishing.
5. Arjun Ringwal, (2019), Preparation and Comparitive Studies of Orange-Aloevera-Gourd Based Jelly, *International Journal of Recent Scientific Research*
6. Ashitha, G. N., Prince, M. V., & Sanjay, P. (2020). Microwave assisted extraction of anthocyanin from Hibiscus rosa-sinensis. *Journal of Pharmacognosy and Phytochemistry*, *9*(2), 1418-1424.
7. Ashwini, N., Sanjana, G., Lakshmi, K. V., & Dashrath, W. S. (2022). Qualitative Assessment of Guava and Wood Apple Blended Jelly Cubes. *International Journal of Agriculture, Environment and Biotechnology*, *15*(3), 727-732.
8. Baba, W. N., Din, S., Punoo, H. A., Wani, T. A., Ahmad, M., & Masoodi, F. A. (2016). Comparison of cheese and paneer whey for production of a functional pineapple beverage: Nutraceutical properties and Shelf life. *Journal of Food Science and Technology*, *53*, 2558-2568
9. Badola, A., Goyal, M., & Baluni, S. (2021). Gels And Jellies A Recent Technology In Semisolids: A. *World J. Pharm. Res*, *10*, 461-475.
10. Bagal-Kestwal, D. R., Pan, M. H., & Chiang, B. H. (2019). Properties and applications of gelatin, pectin, and carrageenan gels. *Bio monomers for green polymeric composite materials*, 117-140.

11. Baghya Nisha Radhakrishnan, Rita Narayanan, Baskaran Dharmar, Palani Dorai R, Valli C[5]. (2022). Optimization of extraction conditions for anthocyanin from *Hibiscus rosasinensis* and its characterisation by Chromatography techniques . The Journal of Phytopharmacology 2022; 11(2):128-132
12. Barukčić, I., Božanić, R., & Tratnik, L. (2008). Whey-based beverages-a new generation of diary products. *Journal MLJEKARSTVO*, *58*(3), 257-274.
13. Bondonno, N. P., Bondonno, C. P., Ward, N. C., Hodgson, J. M., & Croft, K. D. (2017). The cardiovascular health benefits of apples: Whole fruit vs. isolated compounds. *Trends in Food Science & Technology*, *69*, 243-256.
14. Boyer, J., & Liu, R. H. (2004). Apple phytochemicals and their health benefits. *Nutrition journal*, *3*, 1-15.
15. Chaudhary, D. A., Chaudhary, M. R., & Judal, A. L. (2014). Apple: Varieties and its health benefits. *Research Journal of Animal Husbandry & Dairy Science*, 35-38.
16. Ciriminna, R., Meneguzzo, F., Delisi, R., & Pagliaro, M. (2017). Citric acid: emerging applications of key biotechnology industrial product. *Chemistry Central Journal*, *11*(1), 1-9.
17. de Vilela Silva, E. T., Moura, H. V., de Figueiredo, R. M. F., de Melo Queiroz, A. J., & dos Santos Moreira, I. (2019). Production and characterization of mixed pineapple and hibiscus jam. *Revista agro@ mbiente on-line*, *13*, 155-163.
18. Gasmalla, M. A. A., Tessema, H. A., Salaheldin, A., Alahmad, K., Hassanin, H. A. M., & Aboshora, W. (2017). Health benefits of milk and functional dairy products. *MOJ Food Process Technol*, *4*(4), 108-111.
19. Guetouache, M., Guessas, B., & Medjekal, S. (2014). Composition and nutritional value of raw milk. *J Issues Biol Sci Pharm Res*, *2350*, 1588.
20. Gupta, C., & Prakash, D. (2017). Therapeutic potential of milk whey. *Beverages*, *3*(3), 31.
21. Hossain, M. R., Ahmed, M., Sarker, M. S. H., & Roy, J. (2023). Effect of citric acid concentration on physico-chemical properties, bio-active compounds and sensory attributes of dried jackfruit bulb slices during storage. *Food Research*, *7*(2), 356-364.
22. Hyson, D. A. (2011). A comprehensive review of apples and apple components and their relationship to human health. *Advances in nutrition*, *2*(5), 408-420.
23. Igor, N., Marina, N., Nadezhda, A., & Andrey, K. (2019). Comprehensive assessment of fruit jelly with an improved carbohydrate profile based on unconventional plant raw materials. *Foods and Raw materials*, *7*(1), 26-34.

24. Jakhar, M. (2019). Development of whey with apple juice and appraisal of their nutritional qualities. *Asian Journal of Dairy and Food Research*, *38*(2), 163-166.
25. Khan, Z. A., Naqvi, S. A., Mukhtar, A., Hussain, Z., Shahzad, S. A., Mansha, A., ... & Yar, M. (2014). Antioxidant and antibacterial activities of Hibiscus Rosa-sinensis Linn flower extracts. *Pak J Pharm Sci*, *27*(3), 469-474.
26. Krupa Ramani and Ronak A Patel (2023) significance of whey as a biofunctional asset in dairy industry. *International Journal of Research Publication and Reviews*, Vol 4
27. Kumar, S., Kumar, K., Suman, S., & Kumar, P. (2014). Cow milk and human health-a review. *Res Rev J Dairy Sci Technology*.
28. Kumari, S. Formulation of nutritional food products by utilizing Indian paneer whey.(2020), *indian food industry magazine.*
29. Lee, C. Y. (2012). Common nutrients and nutraceutical quality of apples. *New york fruit quarterly*, *20*(3), 1-8.
30. Macwan, S. R., Dabhi, B. K., Parmar, S. C., & Aparnathi, K. D. (2016). Whey and its utilization. *International Journal of Current Microbiology and Applied Sciences*, *5*(8), 134-155.
31. Mandade, R., Sreenivas, S. A., Sakarkar, D. M., & Choudhury, A. (2011). Radical scavenging and antioxidant activity of Hibiscus rosasinensis extract. *African Journal of Pharmacy and Pharmacology*, *5*(17), 2027-2034.
32. Miguel, M. G. (2011). Anthocyanins: Antioxidant and/or anti-inflammatory activities. *Journal of Applied Pharmaceutical Science*, (Issue), 07-15.
33. Missoum, A. (2018). An update review on Hibiscus rosa sinensis phytochemistry and medicinal uses. *Journal of Ayurvedic and Herbal Medicine*, *4*(3), 135-146.
34. Nandan, D., & Kumar, P. (2022). An Overview on Properties and Constituents of Cow's Milk. *International Journal of Innovative Research in Engineering & Management*, *9*(1), 380-383**.**
35. Necas, J., & Bartosikova, L. (2013). Carrageenan: a review. *Veterinarni medicina*, *58*(4), 187-205.
36. Pandey, A., Mishra, A. A., Shukla, R. N., Dubey, P. K., & Vasant, R. K. (2019). Development of the process for whey based pineapple beverage. *Int J Curr Microbiol App Sci*, *8*(6), 3212-3228.

37. Park, J. J., Olawuyi, I. F., Park, G. D., & Lee, W. Y. (2021). Effects of gelling agents and sugar substitutes on the quality characteristics of carrot jelly. *Korean Journal of Food Preservation*, *28*(4), 469-479.
38. Pearline, D., Kamat, N., & Thiagarajan, P. (2015). Rosa sinensis (Hibiscus)-a versatile Indian origin plant. *J. Chem. Pharm. Sci*, *8*(4), 970-974.
39. Popescu, C., Iordan, M., & Cristian, B. (2007). Structure and properties of carrageenan. *The Annals Valahia University of Tărgovişte*, 27-32.
40. Priyanka V. Dalod and Nehete J. Y (2022). A review on hibiscus rosa sinesis flowers. *International journal of recent scientific research*.
41. Puvanenthiran, A., Goddard, S. J., McKinnon, I. R., & Augustin, M. A. (2003). Milk-based gels made with κ-carrageenan. *Journal of food science*, *68*(1), 137-141.
42. Raghavendra, S., Veena, N., Nath, B. S., & Amaladhas, P. H. (2017). Utilization of concentrated paneer whey in the preparation of dahi. *Indian J Dairy Sci*, *70*(6), 720-725.
43. Ramji, L., Yadav, M. P. S., Chauhan, A. S., & Upadhyay, P. K. (2016). Micro-biological qualities of whey based mango beverage by using sugar and essence. *Journal of Experimental Zoology, India*, *19*(1), 373-376.
44. Sady, M., Jaworska, G., Grega, T., Bernas, E., & Domagala, J. (2013). Application of acid whey in orange drink production. *Food Technology and Biotechnology*, *51*(2), 266.
45. Savale, A. R., & Sonavne, I. K. The Review on Medicinal Uses of Hibiscus Flower. *IJFMR-International Journal For Multidisciplinary Research*, *4*(5).
46. Shandilya, S., & Pathak, V. (2020). *Chemical constituents & pharmacological effects of hibiscus rosa-sinensis* (CHINA ROSE)–A REVIEW.
47. *Shivangi Srivastava, Dr. Priyanka Shankar(2023).*formulation and sensory evaluvation of mango jelly enriched with extract of periwinkle flower**.** *International Journal of Research Publication and Reviews*, Vol 4, no 6.
48. Soedirga, L. C., & Marchellin, M. (2021). Physicochemical properties of jelly candy made with pectin from red dragon fruit peel in combination with carrageenan. *Caraka Tani: Journal of Sustainable Agriculture*, *37*(1), 1-14.
49. Swain, M. R., Ray, R. C., & Patra, J. K. (2011). Citric acid: microbial production and applications in food and pharmaceutical industries. *Citric Acid: Synthesis, Properties and Applications, Edition*, *1*, 97-118.

50. Tasende, M. G., & Manríquez-Hernández, J. A. (2016). Carrageenan properties and applications: A review. *Carrageenans—Sources and Extraction Methods, Molecular Structure, Bioactive Properties and Health Effects*, 17-49.
51. Thakre, G., & Barse, A. (2018). Development of herbal jelly (with Hibiscus Rosa sinensis and Rose petals). *J. Med. Plants Stud*, *6*, 30-32.
52. Tsakali, E., Petrotos, K., D'Allessandro, A., & Goulas, P. (2010, June). A review on whey composition and the methods used for its utilization for food and pharmaceutical products. In *Proc. 6th Int. Conf. Simul. Modelling Food Bioind* (pp. 195-201).
53. Vallée Marcotte, B., Verheyde, M., Pomerleau, S., Doyen, A., & Couillard, C. (2022). Health benefits of apple juice consumption: A review of interventional trials on humans. *Nutrients*, *14*(4), 821.
54. WANG, B., ZHONG, Z., HOU, Y., Zhao, X., ZHANG, P., WEI, J., ... & QIU, L. (2023). Biomanufacturing of food-grade citric acid and comprehensive utilization of its production wastewater. *Food Science and Technology, 43*.
55. Wasnik, P. K. (2016). A study on physico-chemical and microbial quality of pectin-paneer whey jelly. *International Journal of Tropical Agriculture*, *34*(2), 283-287.
56. Wasnik, P. K., & Changade, S. P. (2015). Studies on shelf-life of paneer whey based jelly confection. *Asian Journal of Dairy and Food Research*, *34*(3), 187-192.
57. Weerasingha, W. M. R. K. S., Chandrasiri, M. H. T. K., Hewawitharana, K2023 H. I. K., & Sampath, J. K. H. (2021). Evaluation of anthocyanin extracted from Hibiscus Rosa Synesis as a natural food colorant.