EXTRACTION OF PECTIN FROM BANANA AND MANGO PEELS AND ITS APPLICATION

Dissertation submitted to Mahatma Gandhi University in partial fulfilment of the requirements for the award of degree of

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in

FOOD PROCESSING TECHNOLOGY

By

EVELIN PRADEEP (Reg. No. VM20FPT008)

Under the guidance of

Dr. Prabhakumari C.

Principal scientist

Department of Biotechnology

CEPCI- Cashew Export Promotion Council Of India, Kollam

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

DECLARATION

I, EVELIN PRADEEP, hereby declare that the work presented herein entitled **'Extraction of pectin from banana and mango peels and its application'** is a partial fulfilment of the requirement for the M.Voc degree in Food Processing Technology. I also declare that I have independently reviewed the literature, performed all the tests, analysed the results and critically discussed the findings in the presented data.

EVELIN PRADEEP

PLACE: ERNAKULAM
DATE:

M.VOC FOOD PROCESSING TECHNOLOGY
ST. TERESA'S COLLEGE

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With ever regardful memories …

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EVELIN PRADEEP

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ABBREVIATIONS

AOAC - Association of Analytical Chemists

DE - Degree of Esterification

DM - degree of methoxylation

FDA - Food and Drug Administration

GRAS - Generally Recognized as Safe

HGA - homogalacturonan

HM - high methoxy

LM – low methoxy

MeO - Methoxyl

RG- I - rhamnogalacturonan I

TAUA - Total Anhydrouronic Acid Content

TSS- Total Soluble Solids

XGA - xylogalacturonan

ABSTRACT

This study was carried out to investigate the properties of pectin extracted from banana and mango peels that have been discarded as waste. Dried peels were powdered and its physio- chemical characters were studied. Banana peels are good source of dietary fibres (43.2-49.7%), starch (3%), crude protein (6-9%) and crude lipids (3.8-11%). Mango components can be grouped into macronutrients (carbohydrates, proteins, amino acids, lipids, fatty, and organic acids), micronutrients (vitamins and minerals), and phytochemicals (phenolic, polyphenol, pigments, and volatile constituents). Yield was calculated as dried pectin(g/100g) of dried banana and mango peels. Moisture content, Methoxyl content, Equivalent weight, Total Anhydrouronic Acid Content (TAUA), Degree of esterification were also determined.

The study was completed successfully,

INTRODUCTION

1.1 Aim

The aim of this project is to extract commercially useful pectin from banana and mango peels

1.2 Objectives

- Extraction of pectin from dried peels of banana and mango.
- Characterization of extracted pectin.
- Application of extracted pectin under lab scale conditions.

Carbohydrates, together with lipids, proteins and nucleic acids, are one of the four major classes of biologically essential organic molecules found in all living organisms. Carbohydrates, all coming from the process of photosynthesis, represent the major part of organic substance on Earth. They are the most abundant organic components in the major part of fruits, vegetables, legumes and cereal grains, carry out many functions in all living organisms and are the major energy source. Finally, they provide flavour and texture in many processed foods. Carbohydrates, also called Carbs, are defined as aldehydic or ketonic compounds with some number of oxydrilic groups (so polyhydroxy aldehydes or ketones as well). Many of them, but not all, have general formula (CH2O) n (only molecules with n-4 are considered carbohydrates); some, in addition to carbon (C), oxygen (O) and hydrogen (H), include nitrogen or sulphur.

1.1 Functions of Carbohydrates

- They are used as material for energy storage and production. starch and glycogen, respectively in plants and animals, are stored carbohydrates from which glucose can be mobilized for energy production.
- Carbohydrates presence is needed in the lipid metabolism.
- Glucose is indispensable for the maintenance of the integrity of nervous tissue and red blood cells.
- Two sugars, ribose and deoxyribose, are part of the bearing structure, respectively of the RNA and DNA.
- Two homopolysaccharides, cellulose and chitin, serve as structural elements, respectively, in plant cell walls and exoskeletons of arthropods.

- ❖ Heteropolysaccharides provide extracellular support for organisms of all kingdoms: in bacteria, plants and animals.

1.2 Classification of Carbohydrates

On the basis of the number of forming units, three major classes of carbohydrates can be defined: monosaccharides, oligosaccharides and polysaccharides. Monosaccharides are the simplest group of carbohydrates and are referred as simple sugars as they are sweet. The compounds are having free aldehyde or ketone group and two or more hydroxyl (-OH) groups. They cannot be further hydrolysed to simpler compounds. The general formula of the monosaccharide is Cn(H2O)n Examples: Glucose and fructose. Oligosaccharidesare complex sugars, when hydrolysing these sugars yields 2 to 10 molecules of the same or different monosaccharide molecules. They are further classified as disaccharides, trisaccharide, tetra saccharides, etc. based on the number of monosaccharide units. Polysaccharides liberate a large number of monosaccharide molecules on hydrolysis. They are usually amorphous, insoluble in water and tasteless and are called non-sugars. They are again sub-divided into two types. They are homopolysaccharides (e.g. starch, cellulose) and heteropolysaccharides (pectin, heparin etc).

1.3 Pectin

Pectins are high molecular weight complex polysaccharides (heteropolysaccharides) widely spread in the plant kingdom. They can be found as an integral part of the primary cell wall and middle lamella of higher plants. Pectin is a family of galacturonic acid-rich polysaccharides including homogalacturonan, rhamnogalacturonan I, and the substituted galacturonans rhamnogalacturonan II (RG-II), and xylogalacturonan (XGA). Pectin biosynthesis is estimated to require at least 67 transferases including glycosyl-, methyl-, and acetyltransferases (Mohnen et al., 2009). The more commonly used term 'Pectin' designates those pectic substances soluble in water and capable of forming gels under suitable conditions. Pectin varies considerably in composition and structure. Molecular weight can also vary with both botanical origin and maturity of the source materials. Pectin is the most abundant class of macromolecules within this matrix and, in addition, it is also abundant in the middle lamellae between primary cell walls where it functions in regulating intercellular adhesion. Pectin is a major component of primary cell walls of all land plants and it generally thought to account for about one third of all primary cell wall macromolecules (Mohnen, 1999; Smith and Harris, 1999; Willats et al., 2001). The most useful starting biochemical definition of pectin is that it is a group of polysaccharides that are rich in galacturonic acid (GalA). GalA occurs in two major structural features that form the backbone of three polysaccharide domains that are thought to be found in all pectin species: homogalacturonan (HGA), rhamnogalacturonan- I (RG- I) and rhamnogalacturonan- I I (RG- I I) (O'Neill et al., 1990; Albersheim et al. ,1996; Mohnen, 1999).

It is thought that these three polysaccharide domains can be covalently linked to form pectic network throughout the primary cell wall matrix and middle lamellae. This network has considerable potential for modulation of its structure by the action of cell wall-based enzymes (Willats et al., 2001). HGA is a linear homopolymer of (1→4)-α-linked-D-galacturonic acid and is thought to contain some 100-200 GalA residues (Thibault et al., 1993; Zhan et al., 1998). HGA is an abundant and widespread domain of pectin and appears to be synthesized in the Golgi apparatus and deposited in the cell wall in a form that has 70-80% of GalA residues methyl esterified at the C-6 carboxyl (O'Neill et al., 1990; Mohnen, 1999). The removal of methyl ester groups within the cell wall matrix results in HGA capable of being cross-linked by calcum and the formation of supramolecular assemblies and gels. In addition to HGA, an acidic pectic domain consisting of as many as 100 repeats of the disaccharide (1→2) - α -L-rhamnose-(1→4) - α -D-galacturonic acid has been isolated from a

wide range of plants and is known as RG-I (Albersheim et al., 1996; O'Neill et al., 1990). RG-I is abundant and heterogenous and generally thought to be glycosidically attached to HGA domains. This may indicate a biosynthetic switch from one type of galacturonan backbone to the other. In most cases, 20-80% of rhamnose residues in RG-I are substituted at C-4 with sidechains in which neutral residues predominate and these can vary in size from a single glycosyl residue to 50 or more, resulting in a large and highly variable family of polysaccharides (Albersheim et al., 1996). Common structural features of the sidechains include polymeric (1→4)-β-linked D-galactosyl and (1→5)-α-linked L-arabinosyl residues (Mohnen, 1999). Pectic (1→4)-β-linked D-galactan with non-reducing terminal-arabinose (t-Ara) substituted at the O-3 of some of the Gal units is known as type I arabinogalactan (Carpita and Gibeaut, 1993). A range of other linkages involving these and other sugars, including uronic acids, can also be present (Lerouge et al., 1993; Ros et al., 1996; Mohnen, 1999).

Arabinans can become branched by links through O-2 and O-3. Arabinogalactans of type II with (1→3)-β-and (1→6)-β-linked-D- galactosyl residues also occur on pectic backbones (Guillon and Thibault, 1989; Renard et al.,1991). Type II arabinogalactans also occur in a complex family of proteoglycans known as arabinogalactan-proteins (Nothnagel, 1997). The highly branched nature of RG-I has led to it being known as the hairy region of pectin, in contrast to HGA domains which are known as the smooth region (Schols and Voragen, 1996). Whether GalA residues within RG-I can also be methyl- esterified as in the HGA domain is unknown. A small number of GalA residues in the RG-I backbone of sugarbeet pectins are substituted with single glucuronic acid residues (Renard et al., 1999).

Despite its name, RG-II is not structurally related to RG-I but is a branched pectic domain containing an HGA backbone. RG-I is a highly conserved and widespread domain isolated from cell walls by endopolygalacturonase cleavage indicating covalent attachment to HGA. RG-II has a backbone of around 9 GalA residues that are (1→4)-α-linked and is substituted by 4 heteropolymeric side chains of known and consistent lengths (O'Neill et al., 1996; Vidal et al.,2000). A significant feature of RG-II is that it can dimerize by means of borate ester links through apiosyl residues (Kobayashi et al.,1996; O'Neill et al., 1996; Ishii et al., 1999). RG-II appears to be the only major pectic domain that does not have significant structural diversity or modulation of its fine structure.

According to USDA, fruits contain the greatest number of pectin-all fruits are made up of at least 5-10 % pectin. Peaches, apples, oranges, grape fruits and apricots contain the highest amount of pectin among fruits. For example, one small peach contains 0.91g pectin, while one cup of apple slices contains 0.654g of pectin. Other sources include vegetables and legumes. Typically, the dietary fibre found in them was made up of around 15-20% pectin, according to the USDA (United States Department of Agriculture). Among vegetables, carrots contain one of the highest pectin contents with 0.576g per large carrot. Pectin can be found also in grapes such as cornflakes with 0.75g of pectin per one cup.

1.4 Applications of Pectin

Pectin is used as a jellying and thickening agent in the preparation of jams, jellies and marmalades, as a fat replacer in various food formulations and in the pharmaceutical industry for the treatment of diarrhoea, to reduce blood cholesterol levels and gastrointestinal disorders. It has also been used as a haemostat agent. It is estimated that more than 50 per cent of the world's pectin production is in the making of jellies, jams, marmalades and confectionery products, where the ability of pectin to form gels is the most important property. Although the exact mechanism of gel formation is not clear, significant progress has been made in this direction. Depending on the pectin, coordinate bonding with Ca2+ ions or hydrogen bonding and hydrophobic interactions are involved in gel formation. In low-methoxy pectin, gelation results from ionic linkage via calcium bridges between two carboxyl groups belonging to two different chains in close contact with each other. In high-methoxyl pectin, the cross-linking of pectin molecules involves a combination of hydrogen bonds and hydrophobic interactions between the molecules.

A number of factors—pH, presence of other solutes, molecular size, degree of methoxylation, number and arrangement of side chains, and charge density on the molecule —influence the gelation of pectin. Other applications of pectin include use in edible films, paper substitute, foams and plasticizers, etc. In addition to pectolytic degradation, pectins are susceptible to heat degradation during processing, and the degradation is influenced by the nature of the ions and salts present in the system (Thakur et al., 1997). The manufacture of pectin is an expensive and complicated process involving the preparation of raw materials including deactivation of enzymes, removal of bitter glycosides and crude sugars, conversion of protopectin into soluble pectin, filtration of the extracted pectin, precipitation of the pectin, purification and drying of the pectin. There will be minor variations in the process as

different fruit varieties vary in their pectin content. It varies also at different stages of ripeness and due to different growing conditions.

Even though the current commercial sources of pectin are by-products of the fruit juice industry especially apple and citrus, there is abundance of local fruits that are not consumed as well as waste materials from agricultural practice and other fruit processing industries which can be used to produce pectin. Pectin is widely used in the food industry as a thickener, emulsifier, texturizer and stabilizer. It has also been used as a fat substitute in spreads, ice-cream and salad dressings. Pectin is found to lower blood cholesterol levels and low-density lipoprotein cholesterol fractions, which is beneficial Studies on the extraction and characterization of pectin from peels of different types of citrus fruits 3 for human health (Liu et al., 2006). According to the FAO (1969), pectin is considered to be a safe food additive that can be taken daily without limits (Singthong et al., 2005). Pectin can be extracted through various methods.

Usually, industrial pectin is extracted in a multiple-stage physio-chemical process characterized by an extraction step with hot dilute mineral acid and recovery through alcohol precipitation (Mollea et al., 2008) Pectin helps the water regulation between the cell walls, and keeps them rigid. Pectin is an excellent source of dietary fibre and thus reduces irritable bowel syndrome, acidity and improves digestion. The rich fiber content also prevents the growth of cancerous cells in the body. Pectin is found to be highly effective in controlling blood pressure, prevent heart attacks, increases the density of blood and controls asthma. Regular consumption of Pectin reduces blood cholesterol levels. Pectin is used to treat constipation and diarrhoea as it increases the viscosity and volume of stool. Pectin has the unique property to form soothing layer over inflamed mucous membrane and relieve pain associated with the swelling. Pectin is extensively used in throat lozenges as a demulcent. Pectin facilitates faster wound healing. Thus, it is extensively used in medical adhesives. Pectin is considered as natural remedy for nausea. Pectin has huge detoxification properties. It can be consumed to remove heavy metals and toxins from the human body.

1.5 Pectin production from natural sources

The present work focuses on the extraction of pectin from fruit peels such as that of banana and mango.

Products made from banana and mango has been widely consumed worldwide. It has produced abundant amount of waste, particularly its peel. Mangoes belong to the genus Mangifera of the family Anacardiaceae. The genus Mangifera contains several species that bear edible fruit. Most of the fruit trees that are commonly known as mangos belong to the species Mangifera indica. The other edible Mangifera species generally have lower quality fruit and are commonly referred to as wild mangos. Mango has become naturalized and adapted throughout the tropics and subtropics. Much of the spread and naturalization has occurred in conjunction with the spread of human populations, and as such, the mango plays an important part in the diet and cuisine of many diverse cultures. There are over 1000 named mango varieties throughout the world, which is a testament to their value to humankind.

Mango is a common garden tree throughout the tropics. Mango components can be grouped into macronutrients (carbohydrates, proteins, amino acids, lipids, fatty, and organic acids), micronutrients (vitamins and minerals), and phytochemicals (phenolic, polyphenol, pigments, and volatile constituents). Mango fruit also contains structural carbohydrates such as pectin's and cellulose. The major amino acids include lysine, leucine, cysteine, valine, arginine, phenylalanine, and methionine.

The lipid composition increases during ripening, particularly the omega-3 and omega-6 fatty acids. The most important pigments of mango fruit include chlorophylls (*a* and *b*) and carotenoids. The most important organic acids include malic and citric acids, and they confer the fruit acidity. The volatile constituents are a heterogeneous group with different chemical functions that contribute to the aromatic profile of the fruit. During development and maturity stages occur important biochemical, physiological, and structural changes affecting mainly the nutritional and phytochemical composition, producing softening, and modifying aroma, flavour, and antioxidant capacity. In addition, postharvest handling practices influence total content of carotenoids, phenolic compounds, vitamin C, antioxidant capacity, and organoleptic properties.

Banana (*Musa* spp.) is an important fruit crop in tropical and subtropical regions of the world. Banana fruit is a good source of energy and minerals which is normally consumed

fresh or processed to make many products such as chips, powder, jam and wine. Banana peels accounts for 40% of the total weight of the fresh fruit. The peel is not used and it is discarded as solid waste at large expense. With the development of the banana processing industry and increased production of processed fruit products, large quantities of banana peel are wasted or cheaply consumed as animal feed. This is both uneconomical and non-environmentally friendly. Therefore, the banana-processing industry has been searching for applications of banana peel as a source of pectin

Banana peel has been found to contain a good amount of pectin which is valuable for food industry (Sitinorazlina and rashid, 2016). The fruit protected by its peel which is discarded as waste after the inner fleshy portion is eaten. Besides being used fresh, banana is used also processed into many products such as juice, jams, chips, pulps, powder, biscuits, etc., Besides, significant quantities of banana peels equivalent to 40% of the total weight fresh banana are generated as a waste product in industries producing banana-based products (Tcehobanoglous etal.,1993).

At present, these peels are not being used for any other purposes and are mostly dumped as solid wastes at large expense. It is thus significant and even essential to find application for these peels as they can contribute to real environment problems (Zhang et al., 2005). Banana peels are a rich source of total dietary fibres (43.2-49.7%), starch (3%), crude protein (6-9%) and crude lipids (3.8-11%). Banana peels dietary fibres are a good source of lignin (6-12%), pectin (10-21%), cellulose (7.6-9.6%), hemicellulose (6.4-9.4%) and galacturonic acid. Banana peels characterised by their polyunsaturated fatty acids (linoleic and α-linolenic acid), essentials amino acids (valine, leucine, phenylalanine and threonine), and minerals such as K, P, Ca and Mg (Emaga et al., 2007 and 2008 a).

Moreover, it is stated that banana peels had good antioxidative components and activity, where the polyphenols of three varieties of banana were in the range of 200-850mg equivalent of tannic acid/100g and free radical scavenging activity (62-90%). From food waste can improve the overall economics of processing units. To reduce the environmental problems, banana peels can be used as base material for pectin extraction (Qiu et al., 2010). Tapping into the trend for alternative source of pectin, Emaga et al., (2008b) reported that pectin extraction from banana peels could find application as a gelling agent. In general, the largest use of pectin is in manufacture of jellies. About 85% of the commercial pectin on the world is to make jelly and similar products (Madhav and Pushpalatha, 2002).

SL NO.	NUTRIENTS	BANANA	MANGO
1.	ENERGY	105Kcal	60Kcal
2.	CARBOHYDRATE	27g	14.98g
3.	PROTEIN	1.3g	0.82g
4.	FIBER	3.1g	1.6g
5.	MAGNESIUM	31.9mg	10mg
6.	PHOSPHOROUS	26mg	14mg
7.	POTASSIUM	422mg	168mg
8.	SELENIUM	1.9mcg	0.7mcg
9.	CHOLINE	11.6mcg	9.4mg
10.			

Nutrient composition of banana and mango

2. REVIEW OF LITERATURE

2.1 Aim

Aim of this project is to extract commercially useful pectin from banana and mango peels

2.2 Objectives

- To extract pectin from banana and mango peels
- Characterization of extracted pectin.
- Application of extracted pectin under lab scale conditions.

Pectin is the key component in fruit responsible for the formation of a gel after heating and addition of sugars. Pectin is generally defined as water-soluble pectinic acids with varying methyl ester contents which are capable of forming gels in addition with sugar and acid when exposed to the correct conditions. Due to its outstanding gelling ability, pectin is a common food ingredient. Pectin is made up of α-(1, 4) inked D-galacturonic acid units linked in a linear fashion. Pectin molecules also contain rhamnogalacturonan, a neutral sugar, which is responsible for splitting andcausingkinks in the galacturonic acid chain (Thakur et al., 1997). Pectin substances are complex colloidal carbohydrate derivatives that occur in plants and contain a large proportion of anhydro-galacturonic acid units. Protopectin is a substance found in plant cell walls from which pectin is created (Monhen 2008). Unlike pectin, protopectin is insoluble in water due to the fact that all of its carboxyl groups are esterified with methanol. Enzyme hydrolysis of protopectin within the plant will yield pectinic acids leading to the softening and ripening of fruits during which protopectin is converted to water soluble pectin (Yamaki et al., 1979). Pectinic acids are polygalacturnonic acid units that contain more than a minimal number of methoxyl groups. Pectinic acids also contains neutral sugars such as arabinose, galactose, rhamnose, and xylose. (Yapo et al 2007).

2.1 Pectin from fruit peels

Fruit peels contain some valuable compounds like pectin. Pectin designates those water soluble pectinic acid (colloidal polygalacturonic acids) of varying methyl ester content and degree of neutralization, which are capable of forming gels with sugar and acids under suitable conditions (GITCO, 1999). In the food industry, pectin has a commercial value as gelling agent in food products. Pectin form gels under certain circumstances, the gelling mechanism is highly dependent on the degree of methoxylation (DM). Conventionally, pectin is divided into high methoxy (HM) pectin with DM > 50% and low methoxy (LM) pectin with DM < 50%. Pectin with DM > 50% forms gels in the presence of high sugar concentration, usually sucrose or fructose and low pH; whereas pectin with DM < 50% forms gels in the presence of divalent ions. The viscoelastic properties of pectins are the base of their broad use as a gelling agent and stabilizer in food products (Urias-Orona, 2010). Characterization of pectin is essential to determine its suitability for various food products.

Researches concerning the extraction methods and characterization of fruit pectin have been reported elsewhere (Fissure *et al*., 2009; Kurita *et al*., 2008; Mollea*et al*., 2008; Yapo*et al*., 2007). The yield and quality of pectin depends mostly upon the source as well as the method employed for extraction of pectin (Rehman *et al.*, 2004). In the present study, saba banana fruit peel waste was utilized as the source of pectin. It aimed to optimize the acid extraction method in terms of extraction time, type of acid and ripeness stage of the peels; and to chemically characterize the extracted pectin. The extracted pectin was also utilized in strawberry jam processing to determine whether it is comparable in terms of sensory characteristics with the commercially used citrus pectin.

2.2 Fruit sources of pectin:

Pectin is a carbohydrate found in fruits, and is particularly rich in the rind of citrus fruits and in apples. It is a gelling agent and contributes to the solidification of jams. A formulation of pectin called Sango stop was introduced as a haemostatic agent in 1935, and it was claimed that it could reduce bleeding in a variety of conditions. The active component consisted of colloidal polygalacturonic acid esters from apple pectin. It was given in a variety of ways: locally, orally, by subcutaneous or intravenous injection, or per rectum. The solution for local and oral use contained 5% pectin (3% for the preparation for intravenous administration). Several published reports from the 1930s claimed that pectin had a

haemostatic effect, but these were based purely on subjective clinical judgement. Randomized controlled trials, with quantification of blood loss, have never been carried out.

It is clear that pectin, which has been given to a large number of patients in the past, rarely causes adverse reactions, although the toxicological investigations which would now be required by regulatory authorities have not been conducted. The largest study involved the use of Sango stop in more than 400 patients undergoing surgery. Pectin was subsequently shown to have antifibrinolytic activity in vitro, which could explain its haemostatic effect.

2.3 Uses of Pectin

Pectin extracted from banana skin could find application as a gelling agent.)tʒs use in food industry as a gelling agent for example by producing jellies, jam, marmalades, confectionary jelly products, and other food applications. The larges used of pectin is in the manufacture of jellies. About 85% of the commercial pectin in the world is used to make jelly and similar products. Pectins are widely used in the food science, nutrition, cosmetics and pharmaceutical (BeMiller,1986). The yield and DE of a pectin source need to be determined prior mass production of pectin. An extraction process is the most important operation to obtain pectin from banana peel. Pectin extraction is a multiple-stage physical–chemical process in which hydrolysis and extraction of pectin macromolecules from plant tissue and their solubilisation take place under the influence of different factors, mainly temperature, pH and time. The yield and quality of pectin depends mostly upon the source as well as the method employed for extraction of pectin (Rehman et al., 2004). In the present study, unripe banana peel waste was utilized as the source of pectin. It aimed to optimize the conventional extraction method in terms of extraction time, and to chemically characterize the extracted pectin.

2.4 Extraction of Pectin from Fruit Peels

S.Yeoh et. al (2008): Microwave and conventional methods have been used to extract pectin from orange peels, with different extraction periods, different solvent pHs and different types of solvent systems. For microwave extraction, the greatest total amount of pectin yield was found to be 5.27% on a dry basis for 15 min of extraction, although the greatest amount of material per unit time (%/min) was obtained after 5 min, which was the same amount as that extracted using Soxhlet extraction for 3 h. The relative extraction rate between microwave and Soxhlet extraction was similar to that in previous work. Microwave

treatment was further investigated at pHs of 1.5, 2.0, 5.5 and 10.0 for 15-min extraction periods, with the greatest amount of pectin being extracted at the most strongly acidic condition of pH 1.5. Fifteen-minute extraction periods and a pH of 1.5 were also studied with solvent systems containing ethanol and EDTA (ethylenediamine tetra acetic acid); giving approximately double the amount of pectin extracted using distilled water.

Shan et. Al (2014): The influence of pH and extraction time on pectin yield and composition was studied in a citric acid extraction process. The pectin yield and degree of esterification (DE) of the extracted pectin ranged from 2.25 to 14.60% and 41.67 to 67.31% respectively. It was found that extraction pH was the most important parameter influencing yield. DE was significantly affected by extraction time. Morphological analysis performed using scanning electron microscopy suggested that the dried passion fruit pectin has a smooth surface with little mound-shaped pellets on it.

Alok et. Al (2017): The orange peels are sun dried till their moisture content is negligible. They are then crushed and 16, 32 and 60 mesh screens are used to separate the powdered peels accordingly. 80 gm of powdered peel of 16 mesh size is taken and fed to the Soxhlet apparatus with 1000mL of petroleum ether (taken as solvent). The setup is maintained at 400C (B.P. of Petroleum ether) for 6 hours, 9 hours and 12 hours respectively. The oil collects at the bottom in the solvent which can be separated by simple distillation. Further, the powdered peels are collected separately after the solvent extraction is complete. Citric acid solutions of pH 1.0, 1.5, 2.0 and 2.5 are prepared. 5gms of powdered peels collected are heated with the pH solutions prepared for 30 minutes (optimum time) at temperature 650C with continuous stirring. After cooling the solution, it was filtered with muslin cloth. The filtrate was added to double amount of ethanol and allowed to precipitate. The jelly-like precipitate formed is nothing but pectin which was subsequently washed with ethanol two times. Pectin was then dried in a hot air oven at 400C for 20 minutes. The process was repeated for 32 and 60 mesh size.

Abdel et al: Total pectin was determined as g/100 g on fresh weight basis sample. Orange and lemon were peeled and dried for four days and powdered. Orange powder (500 g) and from lemon powder (500 g) were used. Then 5 litre distilled water and 50 ml HCL were added for each blend and then mixed and left for 24 hours, then filtered in separation device. One litre of filtrate was added to 1 litre ethanol (95%), the mixture was put into centrifugation apparatus. Ten left one hour and filtered through Buchner funnel. Acidified ethanol was added to residues. The filtrate was washed with 250 ml acetone for drying and

filtrate was dried at room temperature for 24 hours. The product was ground into fine powder and sieved by 40 mesh sieves to separate pectin from fiber. The pectin powder was then collected, weighed and packed in plastic container pending jam production.

Elizabeth Devi et. Al (2014): The extraction procedure was based on method given by Kratchanova M. Et al, considering several variables. 5g of the peel powder was weighed and put into a 250ml conical flask, added 150 ml distilled water. Acid was added for maintaining different pH medium as reagents. For maintaining 1.5,2.0 and 2.5 pH medium, required 45g,14g and 10g citric acid (99.9% conc.) respectively. Likewise for maintaining the above three pH medium, added 0.8ml,0.4ml and 0.2ml nitric acid (70% conc.) respectively. Extraction was done by hot water bath procedure. Thereafter, the mixture was heated for each different pH medium of extraction while stirred at 60,70 and 80°C for each different time 30,45 and 60min. The hot acid extract was filtered through muslin cloth. For each acid, three different pH medium of extraction at three different range of time and temperature, extraction was carried out and collected the extract separately for further experiments. The filtrate was cooled to room temperature.

3. MATERIALS AND METHODS

3.1 Sample collection

Fruit wastes such as peels of banana and papaya were collected from different locations like houses, fruit stalls, etc. Collected fruit wastes were first washed and cut into pieces for easy drying. Sample drying was done in a hot air oven at 60◦C for 24 hours in trays to eliminate moisture content and to obtain easily crushable material. The samples were ground to powder and kept separately in air-tight moisture free bags for extraction purposes.

Banana Peels

Mango Peels

Banana Peel Powder

Mango Peel Powder

3.2 Extraction of Pectin from Fruit Peel

5g of peel powder (banana and mango respectively) was added to 250 ml of distilled water and mixed vigorously. 1N HCl was added so as to adjust the pH to an acidic condition. The mixture was heated to 70◦C for 45 minutes in a hot water bath. Then the solution was filtered through muslin cloth and then cooled. The filtrate obtained was precipitated with 96% ethanol (alcohol precipitation) and it was kept overnight. The solution was again filtered via centrifugation for the separation of coagulated pectin. The solution was centrifuged at a speed of 10,000 rpm for 15minutes. The pellet obtained via centrifugation was collected and then kept for drying in an oven. The dried pectin was obtained and stored in a cool dry place until further analysis.

The pectin extraction was done for banana and mango peel separately.

3.3Physicochemical Characterization of Pectin

3.3.1 Pectin Yield:

The yield of the pectin extracted from both banana and papaya peels were calculated using the following formula

$$\text{Pectin (g/100g)} = \frac{\text{Weight (g) of dried pectin} \times 100}{\text{Weight (g) dried peel powder taken for extraction}}$$

3.3.2 Moisture Content:

Moisture content was determined according to the Association of Analytical Chemists (AOAC)method (AOAC, 1990). The moisture content was determined by oven drying method. 5g sample was taken in a pre –weighed Petri dish. Then, the sample was placed into an oven at 130ºC for 2 hours. Lastly, the sample was allowed to cool down in desiccators and weighed again to get the dry sample weight.

3.3.3 Equivalent Weight:

Equivalent weight was determined by the standard methods of Owens et al., (1952). Equivalent weight was done by weighing 0.5g pectin (moisture free) in a 250 ml conical flask, moistened with 5ml ethanol, added 1g of sodium chloride to sharpen the end points, added 100ml of deionised water and 6 drops of phenol red. The pectin substances were stirred rapidly to dissolve, and then titrated slowly with 0.1N NaOH until the colour of the indicator changed (pH 7.5) and persisted for at least 30seconds. The neutralised solution was saved for methoxyl determination.

$$\text{Equivalent weight} = \frac{\text{Weight of sample} \times 1000}{\text{Volume of alkali} \times \text{Normality of alkali}}$$

3.3.4 Methoxyl Content:

Methoxyl (MeO) content was determined by adding 25ml of 0.25N NaOH to the neutral solution, mixing thoroughly, and allowed to stand for 30 minutes at room temperature in a stopper flask. 25ml of 0.25N HCl was then added and titrated with 0.1N NaOH to the same endpoint as before.

$$\text{Methoxyl content (\%)} = \frac{\text{ml of alkali} \times \text{Normality of alkali} \times 3.1}{\text{Weight of sample}}$$

3.3.5 Total Anhydrouronic Acid Content (TAUA):

TAUA is essential to determine the purity and degree of esterification, and to evaluate the physical properties. By using the values of the equivalent weight and the methoxyl content, theAnhydrouronic acid content is calculated by the expression given below. Total AUA of pectin is obtained by the following formula (Mohamed and Hasan, 1995).

$$\text{TAUA (\%)} = \frac{(176\times 0.1z\times 100)}{W\times 1000} + \frac{(176\times 0.1y\times 100)}{W\times 1000}$$

where molecular unit of AUA (1 unit) = 176g,
z = ml (titre) of NaOH from equivalent weight determination,
y = ml (titre) of NaOH from methoxyl content determination,
W = weight of sample.

3.3.6 Degree of Esterification (DE):

DE of extracted pectin was calculated from methoxyl and anhydrouronic acid content using the following expression

$$\text{DE} = \frac{176\times \text{methoxylcontent (\%)} \times 100}{31\times \text{AUA (\%)}}$$

3.4 UTILIZATIONOF PECTIN IN THE PREPARATION OF PINEAPPLE JAM

An attempt was made to prepare jam from the pulp of pineapple used in the present investigation using pectin extracted from the peel of citrus fruits.

3.4.1 Preparation of Jam

Jam is a product made by boiling fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. Apply sapota, papaya, plums, mango, grapes, jack, pineapple, banana, guava and pears are usedfor preparation of jam. It can be prepared from one kind of fruit or from two or more kinds. In its preparation about 45 (%) of fruit pulp should be used for every 55 (%) of sugar. The specification of jam is 68.5 (%) TSS, 45 (%) of fruit pulp and 0.5-0.6 (%) of acid (citric acid) per 100 gm of the prepared product.

a) Selection and preparation of fruit

Good quality of ripened pineapple fruits was selected. The fruits were washed well using cold water and peeled to get ready to eat edible fruit. Peeled fruits were cut into small pieces with a stainless-steel knife. Pineapple pulp was prepared using mixer.

b) Addition of sugar and acid

100g of pineapple pulp and 75 gm of sugar powder was taken is a stainless-steel vessel, 2-3 drops of lemon juice were added and mixed thoroughly.

c) Cooking

The mixture was slowly cooked for 15-20min with occasional stirring.

d) Sheet (or) Flake Test

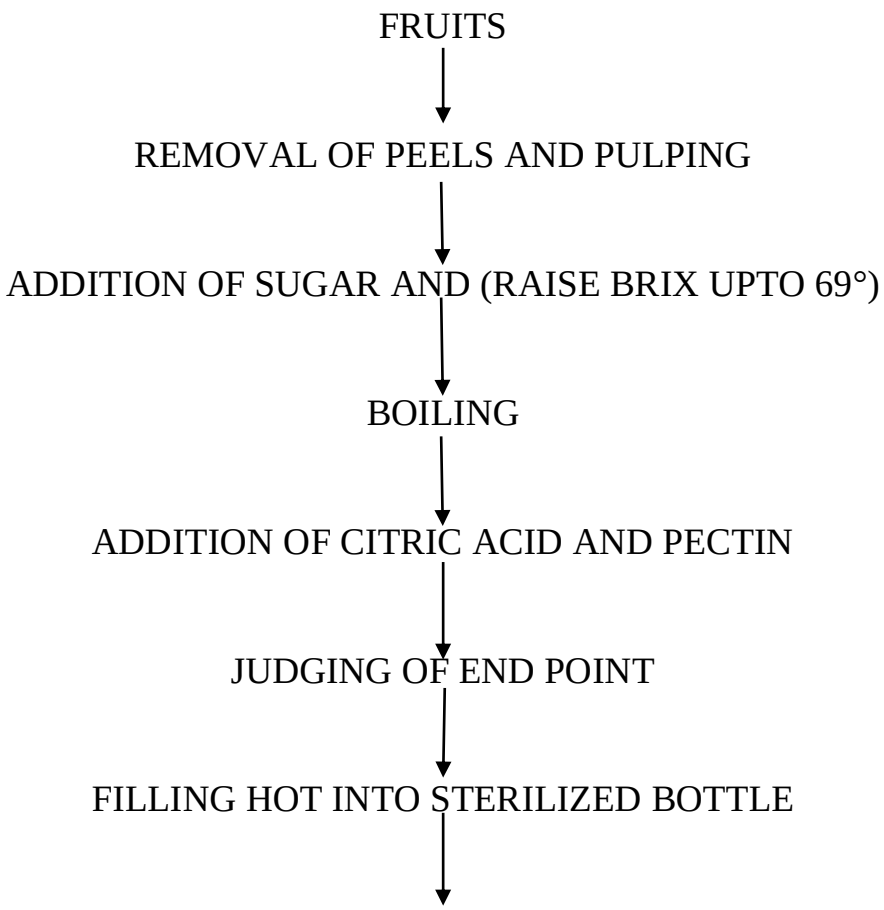
A small portion of jam was taken out during boiling in a spoon and cooled slightly. It was then allowed to drop. The product fell off in the form of a sheet (or) flakes instead of flowing in a continuous stream (or) syrup. This means that the end point has been reached and the product is ready.

e) Packaging

The processed hot jam was transferred to clean dry sterilized jars, cooled and sealed with sterilized lid.

Pineapple pulp

Pineapple jam made using pectin



(Flow chart of preparation of jam)

4. RESULTS

The present study was taken up to extract pectin from fruits peels of banana and mango and to study their characteristics. The fruit peels were obtained from the fruit stalls and houses in Kollam for research. They were subjected to overnight oven drying at 60 ºC. The dried peel was ground to powder and stored in air tight container for the study. The peel powder from each fruit was estimated for their pectin content and the optimal conditions for the maximum extraction of pectin were found out. The ones with high pectin content were selected for evaluation of their quality like moisture content, equivalent weight, degree of esterification etc.

Required quantities of pectin were extracted from each type of fruit peel under optimal reaction conditions and were studied for their characteristic properties. The suitability of pectin for different purposes is determined by their characters viz., moisture content, equivalent weight anhydrouronic acid content, methoxy content and degree of esterification. Hence, it is an unavoidable aspect that every pectin should be described properly for its biochemical characters. The biochemical characters were analysed using standard procedures (Ranganna, 2005). The results of analysis are given below:

4.1 Moisture content

The moisture content was determined for the pectin that was obtained under optimised conditions. In the case of banana, the moisture content determined was 4.61%. While, for mango, it was 6.80%.

4.2Equivalent weight

Equivalent weight for the pectin obtained from banana was 103.89g and from papaya were 207.46g

4.3Methoxyl content (%)

The methoxyl content is an important factor in controlling the setting time of pectins, the sensitivity to polyvalent cations, and their usefulness in the preparation of low solid gels, films, and fibers. It is determined by the saponification of the pectin and titration of the liberated carboxyl group. The Methoxyl content of the pectin from banana and mango was 29.837% and 8.841% respectively.

4.4 Total anhydrouronic acid content (TAUA)

Pectin, which is a partly esterified polygalacturonide, contains 10% or more of organic material composed of arabinose, galactose and other sugars. Estimation of anhydrouronic acid content is essential to determine the purity, degree of esterification, and in evaluating the physical properties of pectin. Making use of the equivalent weight, methoxyl content and the alkalinity of the ash data, anhydrouronic acid was calculated. Total anhydrouronic acid content was determined and was 338.8% for banana and 102.38% for mango.

4.5 Degree of esterification

Degree of esterification value for banana and mango was determined to be 50%. It is clear from the results that both banana and mango peel pectins are low methoxyl pectins. Anhydrouronicacid content which is a measure of purity of the pectin indicates that AUA is in the range of 45-65% with the mango peel having low AUA, 102.38(%), and banana peel with highest AUA,338.8%, Values of degree of esterification of the both the fruit peel pectin was found to be 50%which indicates its low gelling grade.

SL NO.	Pectin source	Moisture content	Equivalent weight	Methoxyl content	TAUA (%)	DE (%)
1.	Banana	4.61%	103.89	29.837	338.8	49.99
2.	Mango	6.80%	207.46	8.841	102.38	36.432

Characterization of the Extracted Pectin

Colour change in the Titration involved in evaluating the Equivalent Weight of the Extracted Pectin

5. DISCUSSION

Peel, also known as rind or skin, is the outer protective layer of a fruit or vegetable which can be peeled off. Depending on the thickness and taste, fruit peel is sometimes eaten as part of the fruit, such as with apples. In some the peel is inedible, where it is removed and discarded, such as with bananas or papayas. The peel of some fruits like citrus is used in cooking, to garnish cocktails or to make marmalade or fruit soup. The peel can also be candied, or dried to produce a seasoning. The outer skins of fruit like citrus, apple, bananas, mangoes, papayas etc. are filled with flavour and vitamins.

Bananas, the largest herbaceous flowering plants, are native to tropical Indomalaya and Australia, and are likely to have been first domesticated in Papua New Guinea. Bananas are rich in potassium and fiber and help to prevent asthma, cancer, high blood pressure, diabetes, cardiovascular disease, and digestive problems. Banana peel may have capability to extract heavy metal contamination from river water. Bananas are also a good source of pectin especially before getting to ripen or soft. mango is an edible stone fruit produced by the tropical tree *Mangifera indica* which is believed to have originated from the region between north-western Myanmar, Bangladesh, and north-eastern India. *M. indica* has been cultivated in South and Southeast Asia since ancient times resulting in two distinct types of modern mango cultivars: the "Indian type" and the "Southeast Asian type". Other species in the genus *Mangifera* also produce edible fruits that are also called "mangoes", the majority of which are found in the Malesian ecoregion.

Pectin is an important polysaccharide with applications in foods, Pharmaceuticals, and a number of other industries. Its importance in the food sector lies in its ability to form gel in the presence of Cations or a solute at low pH. In food industry, pectin is used in jams, jellies, frozen foods, and more recently in low-calorie foods as a fat and/or sugar replacer. Pilgim et al. (1991). It is used to reduced blood cholesterol and gastrointestinal disorders. Pectin is also used in various applications such as edible films, paper substitute, foams and plasticizers, etc. Pectins are heat sensitive, so temperature is monitored strictly during extraction in order to obtain the highest quality product. Pectins are most widely present in apple pomace and orange peel which are commercially extracted. It is used in low-sugar and low-fat applications. It has been used as a carrier for drug delivery to the gastrointestinal tract

in the form of matrix tablets, gel beads, film-coated dose form. From a culinary perspective, pectin is widely used in enhancing the flavour properties in food.

Petin is a methylated polymer of galacturonic acid. Fruit tissues are rich in pectin's about 40% of the total cell wall polysaccharides. Homogalacturonan is the most abundant pectic polysaccharides. Pectin's are deposited in the cell walls, with high degree of esterification. These methyl ethyl esters decrease during ripening. Pectin substances include protopectin, pectin and pectic acid. Pectin substances acts as cementing substances and bind cells together. As fruit ripens, some demethylation and hydrolysis occur along with the protopectin molecules due to the enzyme (pectin-esterase). The transition takes place from a methylated water insoluble polymer protopectin to a shorter methylated compound capable of dispersing easily in water pectin. Pectin forms gel on heating with acid and sugar. As the degradation of pectin continues the molecules gradually become shorter and lose all of their methoxy groups. These shorter polymers of galacturonic acid are designated as pectic acid. Pectic acid is found in over ripe.

Pectin can be extracted from the cell walls of plants, especially the leaves, roots and fruits. In general, pectin is broken down by enzymes as fruit ripens and becomes softer. Pectin consumption impacts blood cholesterol levels and it help regulates blood glucose levels. It also helps remove toxins such as lead and mercury from your body. Citrus fruits and apples are particularly rich sources of pectin. A number of other fruits are very good sources of pectin when eaten along with their skin. Commercially, it's used to make jams and jellies because it turns into a sticky gel-like compound when combined with water. Banana and mango peels have a relatively high amount of pectin, which can be used commercially used. Juices extracted from fruits are used in processing industries, but the peel and other waste materials are often thrown away. This not only creates environmental hazard, but also incurs cost of its disposal. Interestingly, if fruit wastes are used properly, they could serve in establishing other related industries. With this background in the present investigation "studies on the extraction and characterization of pectin from banana and papaya fruit peels", efforts were made to evaluate the extraction, yield and characterization of pectin from the peels of banana and mango fruit wastes and are discussed herein.

5.1 Extraction of pectin

Fresh banana and mango peels were collected from fruit stalls and houses. The peels were washed to remove adhered particles and excess flesh and then dried in hot air oven at 65°C to remove moisture. The dried peels were finely grounded for extraction of pectin.

5g of peel powder (banana and papaya respectively) was added to 250 ml of distilled water and mixed vigorously. 1N HCl was added so as to adjust the pH to an acidic condition. The mixture was heated to 70◦C for 45 minutes in a hot water bath. Then the solution was filtered through muslin cloth and then cooled. The filtrate obtained was precipitated with 96% ethanol (alcohol precipitation) and it was kept overnight. The solution was again filtered via centrifugation for the separation of coagulated pectin. The solution was centrifuged at a speed of 10,000 rpm for 15minutes. The pellet obtained via centrifugation was collected and then kept for drying in an oven. The dried pectin was obtained and stored in a cool dry place until further analysis.

Yield was calculated as dried pectin(g/100g) of dried banana and mango peels. Moisture content, Methoxyl content, Equivalent weight, Total Anhydrouronic Acid Content (TAUA), Degree of esterification were also determined.

5.2 Characterization of Pectin:

Pectin was extracted from the peels of banana and papaya using optimum conditions identified in this investigation and characterized by the properties like methoxyl content, degree ofesterification, equivalent weight, total anhydrouronic acid content (TAUA%) as these properties determines the suitability of pectin for different purposes.

Moisture content is determined by the oven drying method. Methoxyl content or degree of esterification is an important factor in controlling the setting time of pectin, the sensitivity to polyvalent cations, and their usefulness in the preparation of low solid gels, films and fibres. It is determined by saponification of the pectin and titration of the liberated carboxyl groups. It is clear from the experiment results that pectin from banana and mango peel are very low methoxyl pectins with 29.836% and 8.841% respectively. Equivalent weight of pectin was found out by the standard methods of Owens et al (1952). Equivalent weight of banana and mango pectin was found to be 103.89g and 207.46g respectively. Equivalent weight is used for calculating the anhydrouronic acid content and degree of esterification. TAUA is essential to determine the purity and degree of esterification, and to

evaluate the physical properties, it is obtained by the following formula (Mohamed and Hasan, 1995). Anhydrouronic acid content of pectin from mango peel is least with 102.38% to highest, 338.8% in pectin obtained from banana peel and degree of esterification was found to be 50% and 36.432% for both banana and mango.

Good quality of pectin based on the high degree of esterification and intrinsic viscosity with lowacetyl content. Degree of methylation is related to the rate of gel formation. High methoxylpectins (HMP) gel in the presence of sugar gel but low methoxyl pectin (LMP) gel in thepresence of calcium. Gel strength depends on the length of molecule. At very low molecular weight, pectin is unable to form gels under conditions (Pagan et al., 1999).

LM pectins can gel in the presence of divalent cations, usually calcium. In these systems gelationis due to the formation of intermolecular junction zones between homogalacturonan smooth regions of different chains. The structure of such a junction zone is generally ascribed to the so-called ‘egg box’ binding process. Initial strong association of two polymers into a dimer is followed by the formation of weak interdimer aggregation, mainly governed by electrostatic interactions. The gel forming ability of LM pectins increases with decreasing degree of methylation. LM pectins with a block wise distribution of free carboxyl groups are very sensitive to low calcium levels. The presence of acetyl groups prevents gel formation with calcium ions but gives the pectin emulsion stabilising properties.

HM Pectins have the ability to form gels with sugar and acid, so-called low water activity gels or sugar-acid-pectin gels. Such a gel is considered a 2-dimensional network of pectin molecules in which the solvent (water) with the co-solutes sugar and acid are immobilised. This results in a system resisting deformation and showing a stress-strain relationship for small deformation. The build-up of the 3-d network is based on the formation of junction zones in which there are chain associations stabilised by hydrogen bonding between undissociated carboxyl and secondary alcohol groups and by hydrophobic interaction between methyl esters. The gelation mechanism of pectins is mainly governed by their degree of esterification (DE). For the low methoxyl pectins, denoted LMP (DE 50%), gelation results from specific non-covalent ionic interactions between blocks of galacturonic acid residues of the pectin backbone and with divalent ions such as calcium. The affinity of pectin chains towards calcium is known to increase with decreasing degree of esterification

or ionic strength, and with increasing polymer concentration. Besides the influence of the charge density of the polygalacturonate chain, the distribution pattern of free and esterified carboxyl groups has an important effect on the strength of calcium binding. Depending upon the degree of esterification, pectins are divided in two categories: high-ester pectin with DE higher than 50% and low-ester pectin, with DE lower than 50% (Thakur et al.,1997). In HMP, the gel is formed by 11 building a junction zone resulting from the cross-linking of homogalacturan through hydrogen bond and the hydrophobic interaction between methoxyl groups. In low-ester pectin, junction zones are formed by calcium cross-linking between free carboxyl groups (Willats et al., 2006). Pectin is also used in fillings, sweets, as a stabilizer in fruit juices and as a source of dietary fiber. In nature, around 80% of carboxyl groups of galacturonic acids are esterified with methanol. This proportion is although reported to decrease more or less during pectin extraction. The ratio of esterified to non-esterified galacturonic acid determines the behaviour of pectin in food applications (Srivasatva & Malviya, 2011).

5.3 Applications of Extracted Pectin:

The main use for pectin is as a gelling agent, thickening agent and stabilizer in food. The classical application is giving the jelly-like consistency to jams or marmalades, which otherwise be sweet juices. Pectin can also be used to stabilize acidic protein drinks, such as drinking yoghurt, and as a fat substitute in baked goods. Pectin is used in dairy field to prevent the aggregation of casein on heating at pH values, below 4.3. A low level of pectin can be used to improve the texture of low-calorie soft drinks and also to replace some of the textures due to fruit pulp in low juice formations. In water ices, it can be used to control ice crystal size in both sorbets and ice pops. It has a number of applications in pharmaceutical fields like maintain the viscosity of syrups etc.

Madhav and Pushpalatha (2002) studied on the pectin extraction and preparation of jelly from different fruit wastes, jackfruit rind, nutmeg rind, passion fruit rind, mangosteen rind, pumeloes, mango peel, pineapple peel, citrus peel, banana peel and cocoa pod husk. Most of the jellies made using pectin from fruit wastes were found to have good quality. Masmoudi et al. (2010) studied on the preparation of jelly using date juice which was enriched with pectin and lumiflavins with reducing sugar content. Their results showed that the prepared jellies averaged4.17–5.47 and 4.59–5.67 for taste and firmness, respectively. It is clear from the results that pectin extracted from papaya and banana was low methoxyl

pectins. Low methoxyl content pectin works best with the pH 2.8 to 6.5 and it sets at 50 to 70 °C.

Calcium induced gelation is predominant in low methoxy pectin gels. Gelation is due to the formation of intermolecular junction zones between the smooth HG regions of separate polymers. The nature of the interaction, although known to be electrostatic to some extent, is still debated. Gel forming ability decreases with degree of methoxylation and some blockwide distributions of carboxyl groups are very sensitive to calcium presence. The effect of calcium is decreased by the acetylation of the pectin. Amidation, conversely, improves the gelling ability of LM pectins and are less prone to precipitation by high calcium levels. The modification of the hydrogen bonding nature of the polymer by the addition of amide or acetyl moieties indicates that 'egg box' mechanism of gelation may not apply for all situations of calcium induced low methoxy pectin gelation. Gelation in marmalades can be achieved by adding an amidated low methoxyl pectin which is capable of gelling at high pH. Spoon able yoghurts is thickened by adding low level of amidated low methoxyl pectin before culturing.

6. SUMMARY AND CONCLUSION

Pectin is a high-molecular-weight carbohydrate polymer which is present in virtually all plants where it contributes to the cell structure. The term pectin covers a number of polymers which vary according to their molecular weight, chemical configuration, and content of neutral sugars, and different plant types produce pectin with different functional properties. The word 'pectin 'comes from the Greek word '*pektos'* which means firm and hard, reflecting pectin's ability to form gels. The gelling properties of pectin have been known for centuries, but the isolation of commercial pectin only started at the beginning of the twentieth century. In the present work, the extraction of characterization of the pectin was done from two different substrates i.e., peels of banana and papaya. The peels were dried, powder and then pectin was extracted via alcohol precipitation method. The reaction parameters such as pH, Temperature and Incubation period were optimized. The characterization of the extracted pectin reveals the low methoxyl content in the pectin. Good quality of pectin based on the high degree of esterification and intrinsic viscosity with low acetyl content. Degree of methylation is related to the rate of gel formation. High methoxyl pectins (HMP) gel in the presence of sugar gel but low methoxylpectin (LMP)gel in the presence of calcium. Gel strength depends on the length of molecule. At very low molecular weight, pectin is unable to form gels under conditions (Pagan et al., 1999). LM pectin scan gel in the presence of divalent cations, usually calcium. Hence the extracted LM Pectin was tested for its gelling grade and the gelling grade was found to be less. Such LM pectin can find its use in bakery and confectionary industries.

Pectin is primarily used in food production and home cooking as a thickener. In food industry, pectin is listed as Generally Recognized As Safe (GRAS) by the Food and Drug Administration and is used as gelling, stabilizing, or thickening agent in food products such as jams, yoghurt drinks, fruity milk drinks, and ice cream. For home kitchen use, pectin is sold as a white or light-brown powder or a colourless liquid. Pectin is also used as a soluble fibre supplement, which is often sold in capsule form. Soluble fibre may help relieve constipation, lower cholesterol and triglyceride levels, improve blood sugars, and promote a healthy weight. Finally, this fibre is a key component of time-release coatings used in some medications. Pectin may improve blood sugar and blood fat levels, kill cancer cells, promote a healthy weight, and improve digestion. However, more research in humans is needed. Pectin supplements may cause gas or bloating in some people. If you are allergic to apples or

citrus, avoid these supplements. Eating more fruits and vegetables or taking a supplement are good ways to boost your pectin intake. Jams and jellies should be eaten in moderation, as they are high in sugar and calories. Due to its biodegradability, biocompatibility, edibility, and versatile chemical and physical properties (such as gelation, selective gas permeability, etc), pectin is a suitable polymeric matrix for the elaboration of edible films intended as active food packaging. Active packaging is a packaging system which possesses attributes beyond basic barrier properties that are achieved by adding active ingredients in the packaging material and/or using functionally active polymers. When the packaging system has antimicrobial activity, the packaging limits or prevents the microbial growth by extending the lag period and reducing the growth rate of microorganisms.

7. REFERENCE

Aina, V.O., Barau, M.M., Mamman, O.A., Zakari, A., Haruna, H., Hauwa Umar, M.S. and Abba, Y. B. 2012. Extraction and characterization of pectin from peels of lemon (Citrus limon), grape fruit (Citrus paradise) and sweet orange (Citrus sinensis). British Journal of Pharmacology and Toxicology 3(6):259-262.

Attri, B.L. and Maini, S.B. 1996. Extraction of pectin from Galgal (Citrus pseudolimn Tan) peel. Indian Food Packer 50 (2): 5-12.

Emaga, H.T., Adrianaivo, R.H., Wathelet, B., Tchangco, J.T. and Paquot, M. 2007. Effect of the stage of maturation and varieties on the chemical composition of banana and plantain peels. Food Chemistry 103 (2):590-600.

Fissure, E.N., N.M. Ponce, E.A. Wider, C.A. Stortz, L.N. Gerschenson and A.M. Rojas, 2009. Commercial cell wall hydrolytic enzymes for producing pectin-enriched products from betternut (Cucurbita moschata, Duchesne ex Poiret). Journal of Food Engineering 93: 293-301.

Food Chemical Codex. 1996. IV monographs. Washington Table 2. Sensory evaluation using Triangle test of strawberry jam with pectin from saba banana peels and commercial citrus pectin. 195 Castillo-Israel et al./IFRJ 22(1): 190-195 DC: National Academy Press. pp 283.

Gee, M., McComb, E.A. and McReady, R.M. 1958. A method for the characterization of pectic substances in some fruit and sugar-beet marcs. Journal of Food Science 23(1): 72-75.

GITCO, 1999. Twenty-five prospective food processing projects. Vol. 2. Gujarat Industrial and Technical Consultancy Organization Limited. GITCO House, Ahamedabad.p.52.

Hwang, J., Roshdy, T.H., Kontominas, M. and Kokini, J.L. 1992. Comparison of dialysis and metal precipitation effects on apple pectin. Journal Food Science 57:1180- 1184.

J.K. Aronson MA, DPhil, MBChB, FRCP, HonFBPhS, HonFFPM, in Meyler's Side Effects of Drugs, 2016

Johnson, C.M. 1945. Determination of water in dry food materials: application of the Fischer volumetric method. Indian Engineering and Chemical Analysis Education 17:312-316.

Kurita, O., Fujiwara, T., & Yamazaki, E. (2008). Characterization of the pectin Madhav, A, and Pushpalatha, PM. 2002. Characterization of pectin from different fruit wastes. Journal of Tropical Agriculture (40): 53-55.

Molina, A.B. and Roa, V.N. eds. 2000. Advancing banana and plantain R and D in Asia and the Pacific. National Research, Development and Extension Agenda for Banana. p.93.

Mollea, C., Chiamp, F. and Conti, R. 2008. Extraction and characterization of pectin cocoa husks: A preliminary study. Food Chemistry 107(3): 1353-1356.

Muhmadzadeh, J., Sadeghi-Mahoonak, A.R., Yaghbani, M. and Aalami, M. 2010. Extraction of pectin from sunflower head residues of selected Iranian cultivars. World Applied Sciences Journal 8:21-24.

Naggarajaiah, S.B. and Prakash, J. 2011. Chemical composition and antioxidant potential of peels from three varieties of banana. Asian Journal of Food and Agro-Industry 4(01):31-46.

Norazelina, S.M. and Nazarrudin, R. 2011. Extraction and characterization of pectin from dragonfruit (Hylocereuspolyrrhizus) using various extraction conditions. Malaysia: Sains Malaysiana 41(1): 41-45.

Owens, H.S., McCready, R.M., Shepherd, A.D., Schultz, S.H., Pippen, E.L., Swenson, H.A., Miers, J.C., Erlandsen, R.F. and Maclay, W.D. 1952. Methods used at Western Regional Research Laboratory for extraction and analysis of pectic materials. AIC-340, Western Regional Research Laboratory, Albany, California.

Ranganna, S. 1986. Handbook of analysis and quality control for fruit and vegetable products. Tata Mc Graw-Hill Publishing Company. New Delhi. 1112p.

Rehman, Z.U., Salariya, A.M., Habib, F. and Shah, W.H. 2004. Utilization of mango peels as source of pectin. Journal of the Chemical Society of Pakistan 26: 725– 730.

Rouse, A.H., Atkins, C.D. and Moore, E.L. 1962. The occurrence and evaluation of pectin in component parts of Valencia oranges during maturation. Proceedings of the Florida State Horticultural Society 75: 307-311.

Shaha, R.K., Nayagi, Y., Punichelvana, A. and Afandi A., 2013. Optimized extraction condition and characterization of pectin from Kaffir lime (Citrus hystrix). Malaysia: Research Journal of Agriculture and Forestry Sciences 1(2):1-11.

Urias-Orona, V., Rascon-Chu, A., Lizardi-Mendoza, J., Caravajal-Millan, E., Gardea, AA. and RamirezWong, B. 2010. A novel pectin material: extraction, characterization and gelling properties. International Journal of Molecular Science. 11:3686-3695; doi:10.3390/ijms11103686.

Vaclavik, V.A. and E.W. Christian. 2008. Essentials in food science. 3rd ed. USA: Springer Science+Business.

Yapo, B.M., Robert, C., Etienne, I., Wathelet, B. and Paquot, M. 2007. Effect of extraction condition on the yield, purity and surface properties of sugar beet pulp pectin extracts. Food Chemistry 100: 1356-1364.