THE UNIVERSITY OF NAIROBI

COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES

FACULTY OF AGRICULTURE

FINAL YEAR PROJECT

CHARACTERISATION OF CRUDE PECTIN EXTRACTED FROM BANANA PEELS BY ACID METHOD.

BY

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REG NO: A24/0111/2007

A project report submitted in partial fulfillment of the requirements for the award of the Degree of B.Sc. Food Science and technology..

2011

DECLARATION

I hereby declare that this project is my work only with the guidance of my instructor and to my knowledge it has not been submitted to any other institution of higher learning.

Signature:...

Date:..

Name:...

This project report has been submitted for examination with my approval to:

Signature.......................................

Date..

UNIVERSITY OF NAIROBI

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND TECHNOLOGY

Acknowledgement

I thank God the almighty for seeing me through my undergraduate more so this project.

My acknowledgement goes to my supervisor, Prof J K Imungi of Food Technology and Nutrition Department for dedicating his time, sharing his knowledge, expertise and encouragement throughout my project work.

My sincere appreciation also goes to the departments' technical staff; Mr.M'Thika, Ms.Rosemary and Ms. Jacinta who supported me fully and offered all the necessary assistance.

Lastly I thank The Department of Food Technology and Nutrition for funding this project and making a success.

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CHAPTER 1: INTRODUCTION

1.2: Background information

1.2.1: Pectin

Pectin is a structural heteropolysaccharide contained in the primary cell walls of terrestrial plants. Pectin was first isolated and described in 1825 by Henri Braconnot.

There are two theories about occurrence of pectin in plants:

(i) Attachment to the cell wall through calcium ions
(ii) Occurrence as protopectin which is covalently bonded to other cell wall constituents.(More favoured theory)

Pectin for food use is defined as a polymer containing polygalacturonic acid units (at least 65%). The acid units may either be free(-COOH), combined as a methyl ester(-$COOCH_3$) or as sodium(-$COO\text{-}Na^+$), potassium, calcium or ammonium salts.

Basically, preparations in which half of the carboxyl groups are in the methyl ester form(-$COOCH_3$) are classified as high methoxyl pectins. Preparations in which less than half of the carboxyl groups are in the methyl ester form are called low-methoxyl pectins.

1.2.2: Applications of Pectins

Pectin is one of the most versatile stabilizers available. Its gelling, thickening and stabilizing attributes makes is an essential additive in the production of many food products.

Traditionally, pectin was primarily used in the production of jams and fruit jellies - industrially as well as domestically and in low as well as high sugar products. It secures the desired texture, limits the creation of water/juice on top of the surface as well as an even distribution of fruit in the product. With the change in lifestyle pectin is primarily sold for industrial use. In some European markets it is still sold to the consumers as an integrated component in *gelling sugar*, though.

Product and application development by the major pectin producers has over the years resulted in a large expansion of the opportunities and applicability of pectin. Pectin is a key stabilizer in many food and organic food products as well.

- Fruit applications
  - Jams, jellies, and desserts

- Bakery fillings and toppings
  - Fruit preparations for dairy applications

- Dairy applications
  - Acidified milk and protein drinks
  - Yoghurts (thickening)

- Confectionery
  - Fruit jellies
  - Neutral jellies

- Beverages

- Nutritional and Health Products

- Pharmaceutical and Medical Applications

Over the years the positive public connotation of pectin has proven helpful in its widespread use, and this may be a contributing factor to the growing interest in investigating pectin for possible direct health benefits and thus applications in regulated non-food segment as well as in functional foods and nutraceuticals. Pectins also find medical and pharmaceutical applications.

This wide range of applications explains the need for many different types of commercial pectins, which are sold according to their application, for example:

- Rapid Set pectin - traditionally used for jams and marmalades

- Slow Set Pectin - used for jellies and for some jams and preserves, especially using vacuum cooking at lower temperatures. Also important for higher sugar products like bakery and biscuit jams, sugar confectionery, etc.

- Stabilising Pectins - used for stabilising acidic protein products such as yoghurts, whey and soya drinks against heat processing.

- Low methyl ester and amidated pectins - used in a wide range of lower sugar products, reduced sugar preserves, fruit preparations for yoghurts, dessert gels and toppings, and savoury applications such as sauces and marinades. Can also be used in low acid high sugar products such as preserves containing low acid fruits (figs, bananas) and confectionery.
- bakery and biscuit jams, sugar confectionery, etc.

1.2.3: Sources of pectin

Pectin is present in all plants but the content and composition varies depending on the species, variety, and maturity of the plant, plant part, tissue, and growing condition. The processes used during preparation and subsequent treatments also determine pectin properties. Pectin is higher in legumes and citrus fruits than cereals. Apple, grapefruit, orange and apricot are known to have high levels of pectin. Generally, 60 - 70 percent of the dietary fiber in citrus fruits is pectin. Other sources of pectin include banana, beets, cabbage, and carrots.

Currently Kenya gets its pectin for industrial use from Germany and U.S.A. with conventional sources being citrus fruit peels and apple pomace.

The pectin source identified for this project was banana peels.

Banana peels- These have been identified as a good pectin source according to their composition outlined below;

Lignin	6-12%
Pectin	10-21%
Cellulose	7.6-9.6%
Hemi-celluloses	6.4-9.4%

Table 1.Shows composition of banana peels

1.3: PROBLEM STATEMENT

Pectin is an expensive commodity as it imported into the country.

Citrus fruits and apple pomace are the conventional raw materials used in its production which in turn are not available in sufficient quantities locally. This project seeks to address this problem by utilizing banana peels which can be easily obtained locally at no cost or at no cost to produce pectin. Banana peels mainly end as a waste and this means a valuable material is discarded but could be put to better use by extracting the pectin.

1.4: JUSTIFICATION

Due to the high pectin content (10-21%) and local availability, the pectin harnessed from the banana peels is far much cheaper than the imported one. Moreover, the products that utilize pectin including jams and jellies will be far much affordable to most of the population. Currently these products are quite costly a factor attributed to the expensive commercial pectins used.

It will also be of economic advantage since income can be earned by pectin sales. The by-products can also be used as animal feed.

1.5: MAIN OBJECTIVE

To extract and characterize crude pectin from banana peels.

1.5.1: Sub objectives

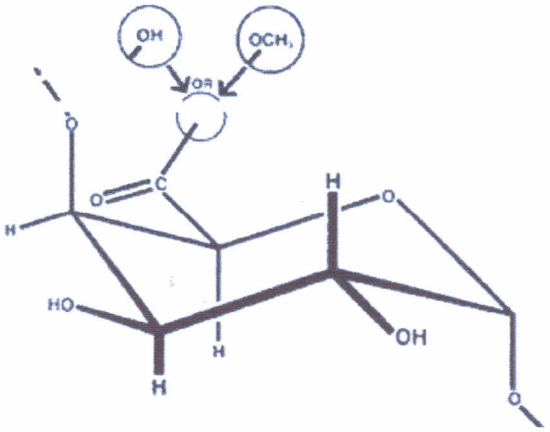
1. Determination of pectin content of banana peel.
2. Determination of yield of pectin from the banana peels.
3. Characterization of pectin by analyzing the degree of methylation, ash content and setting temperature (as either slow or rapid pectin).

1.6: HYPOTHESIS

It is possible to produce quality pectin from banana peels.

CHAPTER 2: LITERATURE REVIEW

Pectin refers to a group of diverse and complex polysaccharides found in the primary cell wall and intercellular space (middle lamella) of plant cells. Pectin is mostly composed of a sugar acid residue called D-galacturonic acid.



Galacturonic acid unit

The neutral sugars are mainly D-galactose, L-arabinose and D-xylose, the types and proportions of neutral sugars vary with the origin of pectin.

Pectin is a linear carbohydrate molecule although some evidence of branching has been reported.

Isolated pectin has a molecular weight of typically 60–130,000 g/mol, varying with origin and extraction conditions.

The pectin in the middle lamella may be easily extracted with water while that in the cell wall has to be extracted with an acidic or alkaline solution. A sequesterant e.g. EDTA may be required to extract the pectin in the plant cell wall.

In nature, around 80% of carboxyl groups of galacturonic acid are esterified with methanol. This proportion is decreased more or less during pectin extraction. The ratio of esterified to non-esterified galacturonic acid determines the behavior of pectin in food applications. This is why pectins are classified as high- vs. low-ester pectins – or in short HM vs. LM-pectins, with more or less than half of all the galacturonic acid esterified.

Suitability of pectin for various uses is determined by its biochemical character via methoxyl content, degree of esterification and anahydrouronic acid content.

Depending on degree of methylation, methoxyl content of pectin varies. The spreading quality and gel grade of pectin are dependent on their content. The pectin is also divided into low and high pectins which have different conditions for gel formation. There are two types of gels; the low and high solid gels. Low methoxyl pectin can form both types of gels while high methoxyl only form high solid gels. The low methoxyl pectin requires divalent cations for gel formaton.

High solid gels contain more sugar than low solid gels.

Sugarless gels can be made with low pectins. Thus, important in making confectioneries and jellies for diabetics. Moreover, since the setting temperature of gels made with low pectins is low, fruit flavours are also retained. A short heating time is also needed.

Gel grade is the weight of sugar with which 1 part by weight of pectin will under suitable conditions form a satisfactory jelly, Currently it ranges from 8 to 1%.

Anahydrouronic acid content % determines the purity and degree of esterification and evaluation of physical properties.

Acetyl group if present in pectin inhibits jelly formation.

The best source of pectins are fruits. Typical levels of pectin in different fruits

are (fresh weight):

- apples, 1–1.5%
- apricot, 1%
- cherries, 0.4%
- oranges 0.5–3.5%
- carrots approx. 1.4%
- citrus peels, 30%

2.1: Changes in pectin during ripening .

The amount, structure and chemical composition of pectin differs between plants, within a plant over time and in different parts of a plant.

During ripening, pectin is broken down by the enzymes pectinase and pectinesterase; in this process the fruit becomes softer as the middle lamella breaks down and cells become separated from each other.

Pectin occurs in fruits in three forms:

- Protopectin – hard immature fruits like green apples or the peel of citrus fruits.
- Pectin – as the fruit matures protopectin becomes soluble pectin, which is used in making jelly.
- Pectic acid – if fruit becomes over-ripe or a jelly is cooked too long, the pectin converts to pectic acid.

Other pectic substances include pectinates which are salts of pectinic acids and pectates which are salts of pectic acids.

Under ripe fruit contains more pectin than mature fruit.

Pectin is graded according to its jellifying strength

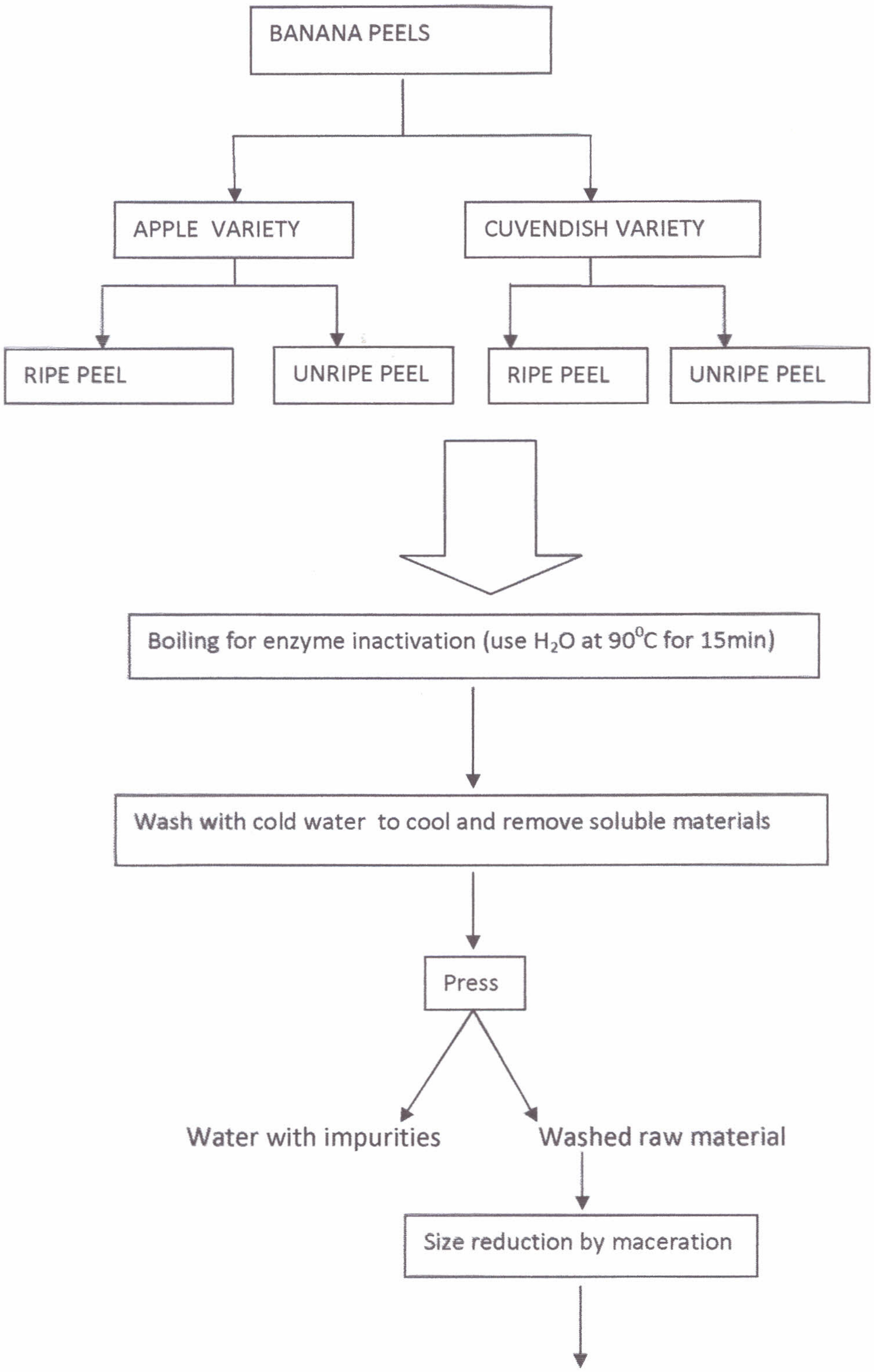
2.2: Banana peels

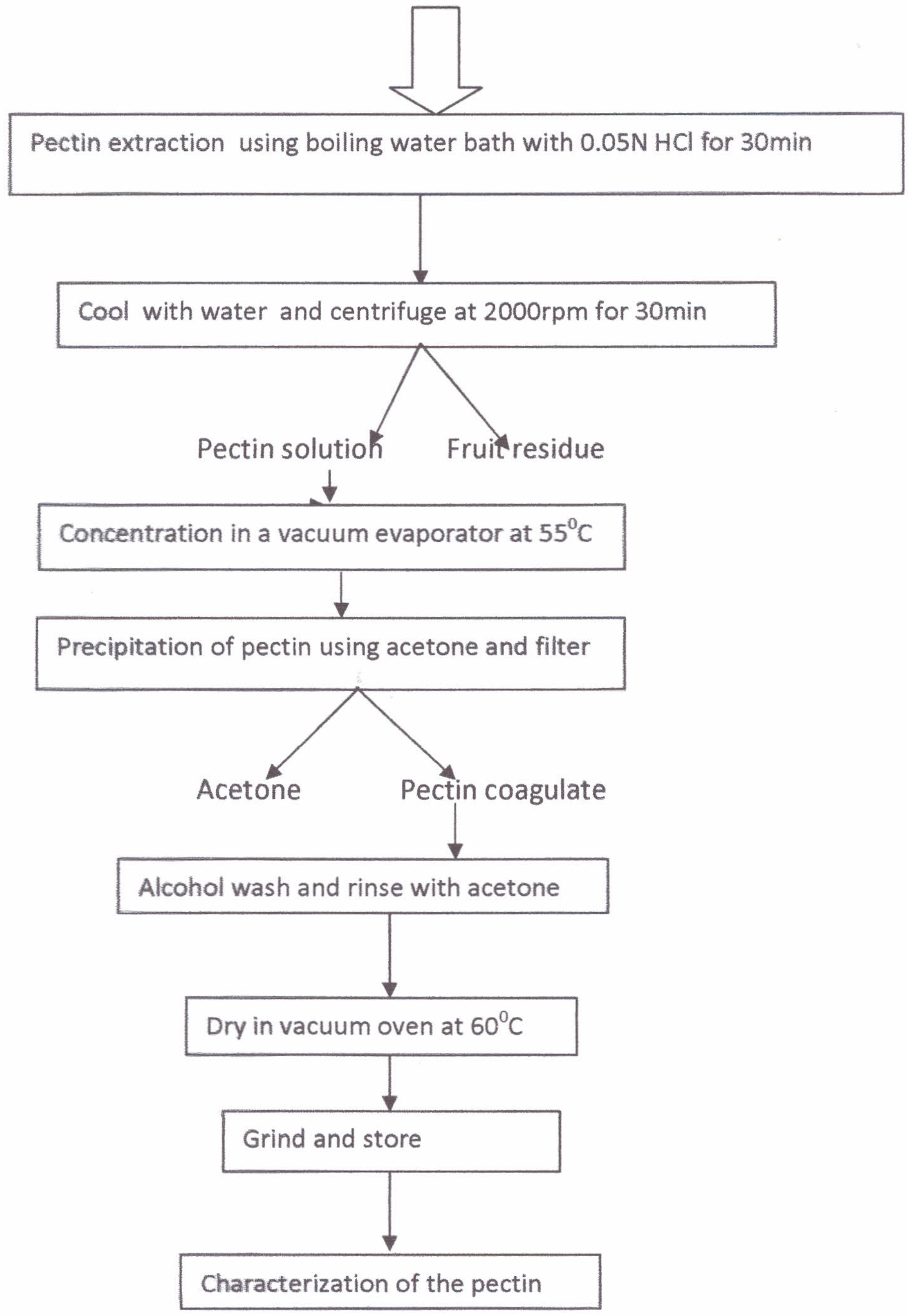
The peel of a banana represent about 40% of the total weight of fresh banana.Besides use of banana peels as base material for pectin production they also form a good feed material for cattle and poultry. They can also be used in wine, ethanol production, as substrate for biogas production.

Peel ash can also be used as fertilizer for plants and alkali source for soap production.Pectin extracted from banana peels contains glucose, galactose, arabinose, rhamnose and xylose.

3. 0: EXPERIMENTAL DESIGN AND METHODOLOGY

For the purpose of this project, peels from two banana varieties were used, ripe and unripe in both sccenarios. See illustration below;





Pectin extraction flow diagram

3.1: Preparation

3.1.1: Size reduction

This is done using a chopper.

Banana peels are fed and reduced to 1cm sized parts.

Wash the reduced peels to remove soluble material.

3.1.2: Enzyme inactivation

Chopped material is transferred into a beaker containing boiling water (90^0C). This done to inactivate pectic enzymes.

Wash to remove some pigments, minerals and acids.

Drain the water using a fruit juice press.

3.1.3: Drying

This is done in a vacuum oven at 60^0C for 16-18 hours

3.3: Extraction

3.3.1: Chemicals and materials needed

- Sodium hexametaphosphate(used as a sequesterant)
- Acetone
- Hydrochloric acid
- Ethanol
- Citric acid
- Vacuum oven at 60^0C
- Round bottomed flasks
- Filter papers
- Fruit juice press

White commercial cane sugar is also necessary for determination of the gelling capacity and setting time.

3.3.2: Conditions for extraction

Dry material was soaked in water at 70-80^{0}C

The temperature was raised to 90^{0}C and held for 30minutes

PH of water was adjusted to 2.0 using 0.05N HCl.

3.3.3: Centrifugation and filtration

The mixture is centrifuged at 2000r.p.m for 15minutes at about 30^{0}C to separate peel residue from pectin solution.

The pectin solution was filtered at a vacuum filter pump on a Buchner glass sintered filter funnel no.2. A filter paper aid was used.

3.3.4: Concentration and drying

A vacuum evaporator was used to concentrate the solution to about 10% weight per volume for 30-40minutes at 60^{0}C.

Acetone was added to the concentrated solution with vigorous stirring to give a mixture of 1:1 pectin solution to acetone. Acetone was then sucked at the vacuum filter pump.

Extracted pectin was washed with a 100Ml of 60% ethyl alcohol which contained 3 Ml of concentrated hydrochloric acid to remove some cations.

The pectin coagulate was then washed with acetone to remove the acid used in extraction and any remaining pigments.

Acetone was then recovered by fractional distillation.

The pectin was dried in an air oven at 60^{0}C for 6-8hours.

3.4: Analysis methodology and characterization of pectin from banana peels

3.4.1: Determination of ash content

A 2gm sample of pectin was incinerated at 400^0C for three hours then ashed at 600^0C for 4-6hours.Direct ashing can prevent complete ashing of pectin.

3.4.2: Determination of the degree of methylation

Degree of methylation is the degree of proportion of the methylated carboxyl groups in the pectin. The free and methylated carboxyl groups are determined according to Deuel method.

3.4.3: Determination of setting temperature (Can be rapid or slow set pectin)

This done by preparing jelly constituents with standard conditions of 65^0Brix, PH 3.2, and a 1.1 pectin to sugar ratio.

Heat to boil and cool. Observe when a jelly of satisfactory firmness is formed.

4.0: RESULTS AND DISCUSSION

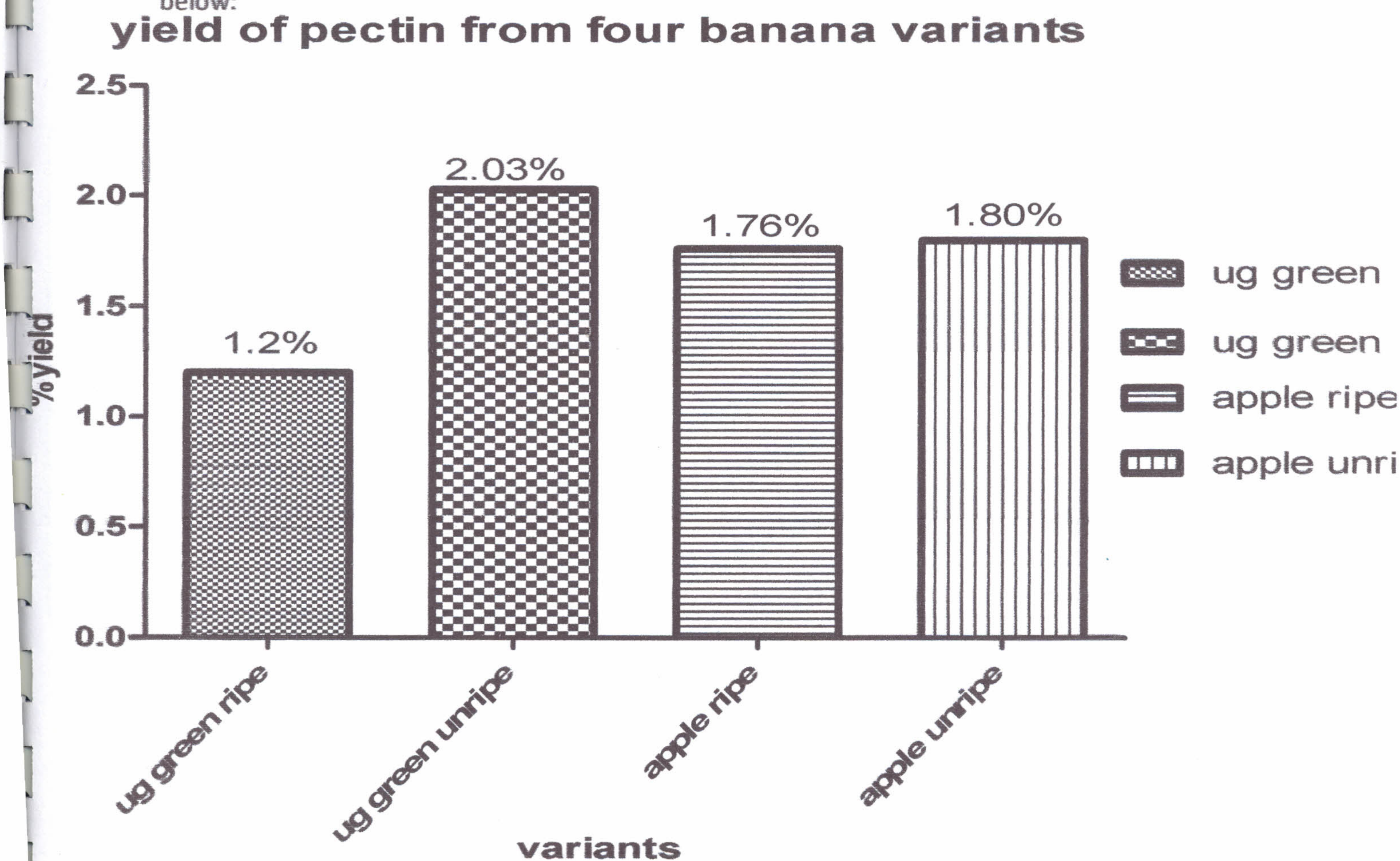
Similar conditions (pH,temperature and time) during extraction were used for all the four banana peel variants. Differences in peel quantity that can be obtained from each banana variety varied basically due to their sizes and peel thickness. Apple banana for instance has a very thin peel layer especially when ripe; Uganda green on the hand has a fairly thick peel layer.

	Weight Of whole bananas(g)	**Weight of peel (g)**	**% peel quantity**	**Weight of dry peel(g)**
Ripe U. Green	3806	1526	40.09	319.2
Unripe U. Green	1655	1085	42.2	209.7
Ripe Apple	4505	1200	26.63	212.9
Unripe Apple	2085	886	31.7	186.7

Table 2.Raw material l(banana peel) yield from the various bananas used.

4.1.1 Pectin yields

Yields of pectin obtained were highest in unripe uganda green variant at 2.03g while the least was from the ripe Uganda Green which gave 1.14g. Various yields are shown by the graph below:



4.1.2: Extractability

Extractability in commercial apple pomace is 15%. All peels had an extractability that exceeded this figure with unripe Uganda green having highest extractability.

	EXTRACTION RATE-6%	RAW MATERIAL USED(g)	QUANTITY PECTIN ATTAINED(g)	EXTRACTABILITY (%)
UG. Green ripe	0.6	90	1.14	21
" unripe	0.6	100	2.03	37.5
Apple ripe	0.6	100	1.76	32.6
Apple unripe	0.6	100	1.80	33.3

Table 3.showing extractability of various banana peels both in ripe and unripe conditions

4.1.3: Degree of methylation of unripe uganda green and ripe apple variants were 47.05% and 43.75% respectively.

4.1.4: Ash content

Unripe Uganda green had an ash content of 0.8g while apple had 0.6g respectively

4.1.5: Setting temperature.

A jelly prepared under conditions of 65^{o}brix, 1% pectin and a PH 3.2 was cooked and on cooling, a gel formed at 45^{o}C.

4.2: DISCUSSION

Locally, Uganda green bananas are consumed green. The main waste is therefore the unripe peel. Apple bananas on the other hand are only consumed ripe and thus it is also unlikely to find unripe peels as a waste. My analysis was therefore based on unripe Uganda Green pectin and Ripe apple pectin'

4.2.1: Pectin yield

The method used was efficient since high yields of pectin were attained. Unripe Uganda green pectin gave the highest yields while ripe apple pectin gave the least. Commercially used apple pomace gives a 1.21% pectin yield. This indicates that banana peels can be utilized to source pectin given the yields.

4.2.2: Extractability

Results attained were similar to those in the yields attained with unripe Uganda green having the highest extractability. Commonly used apple pomace extractability can be as low as 15%. This means the peels can be profitably used as sources of pectin.

4.2.3: Degree of methylation

Pectin occurs in nature with a degree of methylation of about 65%. This may slightly fall after fruits harvest to 60%.

Basing on degree of methylation, pectins are categorised as either low methoxy (55% or less DM) or high methoxy pectin (above 55% DM). In this case unripe Uganda green pectin had a DM of 47.05% while ripe apple had 43%. Therefore banana peel pectin obtained was low methoxy pectin in both cases. Low methoxy pectins are applied in stabilizing dairy products such as yoghurt as well as acting as thickeners. They can also be used in manufacture of low sugar products.

A high methoxy pectin can be obtained from low methoxy pectin by further processing so as to increase the methoxy groups and degree of methylation for that matter.

4.2.4: Ash content

Ash is an indicator of calcium ions present and is important factor in manufacture of dietetic jams. Uganda green and apple pectins gave an ash content of 0.60% and 0.45% respectively. This was low compared to commercial pectins which lie between 1.0 and 0.8%. The low ash content can be attributed to washing with acidic 60% alcohol which removed most of the mineral content.

4.2.5: Setting temperature

Pectin is categorised based on setting temperature as either rapid set or slow set pectin with rapid set forming a gel at 88°C while slow set forms a gel at or below 55°C. Banana peel pectin formed a gel at 45°C therefore it was slow set pectin.

Slow set pectins are utilized in manufacture of jellies and some jams, preserves Also for high sugar products like bakery and biscuit jams

5.0: CONCLUSION

- Characteristics of the pectins obtained did not vary much in regards to degree of methoxylation (both were low methoxy pectins)
- An appreciable quantity of pectin can be obtained from unripe uganda green, it gave the highest yield and extractability. Commercialization targets at profitability and of the 2 varieties it(>30% extractability).

6.0: RECOMMENDATION

- Other banana varieties need to be tried among others and assess for pectin extractability.
- Drying of extracted pectin should be carried out in a vacuum oven as opposed to an air oven. This is because of high risk of oxidation and polymerisation which leads to colour change of pectin: This can also interfere with pectin characteristics

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