



Pectin Strength of Common Varieties of Plantain Peels Used in the Production of Jam/Marmalade

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Authors' contributions

This work was carried out in collaboration between both authors. Author OMA designed the study, wrote the protocol, supervised and managed the analyses of the study. Author BSC performed the statistical analysis, wrote the first draft of the manuscript and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The pectin strength of peels from four plantain cultivars; Horn Plantain (sample B), French Plantain (sample C), False horn Plantain (sample D), and French Horn Plantain (sample E) and its effect on Jam and Marmalade produced was investigated. Pectin was extracted from the plantain peels with distilled water and EDTA at pH 4.3 and 60°C, precipitated with acidified ethyl alcohol and 0.5N HCl. The pectin strength of peels from the French plantain (sample B) was higher than the others. Peels from False horn and French horn plantain both had medium pectin strength. Jam and marmalade produced were evaluated for proximate composition, chemical properties and acceptability. Jam and Marmalade from sample C were high in moisture content with mean values of 43.19 and 41.33%, respectively. Sample E (in both variants) had significant high crude protein (0.33%) compared to all other samples. Marmalade samples had crude fiber values ranging from 0.75% for sample B to 2.25% for sample E. The ash and carbohydrate content of jam and marmalade produced with pectin from French Plantain, False Horn Plantain and French Horn Plantain were significantly higher than the commercial jam and marmalade. Crude fat ranged from 0.45 to 1.15% for both variants (jam and marmalade). They both recorded low protein contents ranging from 0.14 to 0.32% and 0.16 to 0.33% respectively but high carbohydrate content ranging

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from 50.97 to 67.48% and 52.29 to 69.41% respectively. pH content maintains 3.0-3.10% for all samples. Total sugar content ranged from 55.00 to 63.80% for both Jam and Marmalade. Sample C was most preferred in terms of colour, taste, aroma, appearance, spreadability and overall acceptability, for Jam and Marmalade. All its sensory attributes were compared favorably with the commercial brands. Pectin extracted from plantain peel is strongly recommended for use as gelling agent in Jam and Marmalade production.

Keywords: Pectin strength; plantain peels; jam; marmalade.

1. INTRODUCTION

Plantain, (*Musa paradisiacal*), are banana cultivars in the genus *Musa*, closely related to the common banana (*Musa sapientum*):- Which makes up one-quarter of the total world population of banana (*Musa spp*). Plantain is famously consumed as sweet dishes, or as compliments of cereals like rice or legumes like beans or tubers like yam. Plantain can also be used as food for infants at weaning, by mashing ripe plantain with a pinch of salt. Plantain can also be dried and ground into flour to make plantain meal. Plantain pulp can also be sliced thin and deep-fried in hot oil to produce plantain chips. The peel represents around 35% of the fruit weight (wet basis) [1]. The end-use of plantain peel depends on its chemical composition, which is affected by the fruit's ripeness. Peel from unripe fruit presents (on a dry basis) 6–10% protein, 6–12% ash, 2–6% lipids, 11–39% starch, and 33–43% total dietary fibre (TDF); from the TDF, around 5–13% is soluble dietary fibre (SDF) and 7–36% is insoluble dietary fibre (IDF) [1,2]. Pectin and gums (xanthan, Arabic, guar, etc.) are present in the SDF, whereas cellulose, hemicelluloses, and lignin are included in the IDF.

From the nutritional and health points of view, the type, level and structure of the components in the SDF and IDF, as well as the ratio of both fractions play an important role in the physiological properties in the human body after consumption. [2]. Peel of plantain, presented a higher content of phenolic compounds and antioxidant capacity than the pulp extract [2]. Pectin is a high-value functional food ingredient widely used as a gelling agent particularly in the production of jams and jellies. It is also widely used as fillings, sweets, as a stabilizer in fruit juices and milk drinks and as a source of dietary fiber [3]. The yield and quality of pectin mostly depend upon the source as well as the method employed for the extraction of pectin [4]. The formation of gels by pectin is an interesting aspect of commercial value, in Africa at large.

When sugar is added to pectin, the pectin in fruit or commercial pectin precipitates out and form insoluble fibers. An acid such as citric acid aids in this process. The insoluble fibers produce a mesh-like structure that traps the fruit juice or other liquid (much like a sponge absorbs water) and enables a gel to form. Slightly under ripe fruits contains more pectin than ripe fruits. The pectin in fruit becomes water soluble when it is heated. So for jellying to occur, the fruit must be heated. Commercial pectin can be used with any fruit, even those high in pectin. Too much pectin will give the jelly a tough, rubbers consistency making it difficult to spread.

Historically, jams and marmalade may have originated as an early effort to preserve fruit for consumption in the off-season. As sugar for their manufacture become more affordable, the popularity and availability of these fruit products increased. [5]. Jams and marmalade are primarily distinguished by the form in which their fruit component is incorporated. Jams are made with crushed or ground fruit material, while marmalade is clear jellies in which slices or shreds of citrus peel are suspended. Regardless of their form, all are sugar-acid-pectin gels of low-methoxyl pectin gels. Their structure, appearance and mouth-feel results from a complex interaction between pectin level and functionality in pH, sugar type and content, setting temperature and in the case of low methoxyl pectin gels, calcium content. Pectin extracted from plantain peel could find application as a gelling agent. Its use in the food industry as a gelling agent for producing jams and marmalades. The largest use of pectin is in the manufacture of jellies. About 85% of the commercial pectin in the world is used to make jellies, jams or marmalade and other similar products. Originally, jam or marmalade production relied on the native pectin or incorporated fruit for gel formation. Today other sources have been recommended, including from peels of several varieties of plantain. The pectin gotten from the peels of the plantains are cooked with sugar and acids, and if the proper

balance of sugar level, pH, and pectin content were achieved, a satisfactory jelly was obtained; however modern manufacturing requirement for uniform gel strength and appearance preclude reliance on the plantain peel component pectin's which may vary in content and quality, depending on pulp maturity and variety. In spite of the current availability of other gelling agents, pectin remains the universal choice for jams and jellies, in part because of its presence as a natural fruit ingredient and also because of the characteristics consistency that pectin impacts to a gel. Pectins of known quality and gelling capacity are added to jams and marmalade formulations to achieve the desired gel strength. It is estimated that 80% to 90% of commercial pectin production, which totals 6 to 7 million kg is used in the production of jams and marmalade [6].

In Nigeria, plantain is most widely processed into chips and popular local delicacy called "bole" (which is grilled plantain usually accompanied with sliced yam, potatoes, fish, palm oil and spices) which accounts for 80% of the earnings from processed plantain. Plantain peels therefore

compose a significant quantity of wastes produced from plantain processing which is equivalent to 40% of the total weight of fresh plantain. However, the peel of plantain is often thrown away. The plantain peel wastes, which are perishable give greater concern to the processing industries and environmental sanitation agencies and also the community at large. However, a significant amount of pectin commercially used in the food industry in Nigeria is imported, which acts as a drain on our foreign exchange earnings. Suitable methods have to be adopted to utilize them for conversion into value-added products. Hence the objective of this work was to assess the strength of pectin from common varieties of plantain peels and evaluate its suitability in Jam and Marmalade production.

2. MATERIALS AND METHODS

2.1 Sources of Research Materials

Plantain (*Musa paradisiacal*) and typical banana (*Musa sapientum*). Were purchased from Run-Ndele in Emohua Local Government Area of Rivers State, Nigeria.



Plate 1. False horn plantain



Plate 2. French horn plantain



Plate 3. French plantain



Plate 4. Horn plantain

2.2 Preparation of Pectin from Plantain Peels

The extraction of pectin from plantain peels was produced using the method described by [7]. Five grams of dry grinded plantain peel was weighed into a beaker with 100ml of distilled water and 1 gram of EDTA. It was stirred and allowed to stand for 24 hours at a pH of 4.3; it was then heated for 60°C for 20 min, filtered and cooled, precipitate pectin with acidified ETOH and 0.5N HCL at 1:1 ratio, filtered and dried for 20 minutes.

2.3 Preparation of Jam and Marmalade

The production of jam/marmalade was done using the process described by [8]. Quantities of banana pulp were boiled for jam, while round cuts of ripe banana were boiled for marmalade, with sugar, pectin and citric acid together, until the setting point was reached. More specifically, 30 g of sugar for 50 g of

bananas was added and boiled with 5 g of added pectin and then 1 gm of citric acid was added and stirred continuously till it boiled and reaches the consistency of jam/marmalade expected.

2.4 Evaluation of Pectin Strength

The evaluation of pectin strength was determined using the method described by [9]. Five (5 ml) of the sample extract was put in a sterile test tube. The test tube was then held in a tilted position and 10ml of alcohol poured down to its side till the alcohol made contact with the extract. The test tube and contents were allowed to stand undisturbed for 5 minutes. The test tube was closed with a thumb and again tilted slowly till its contents reached the thumb. During this process, the movement of one large clot in the test tube indicated high pectin strength while the visibility of two small clots and a number of tiny clots indicated medium and weak pectin strength respectively.

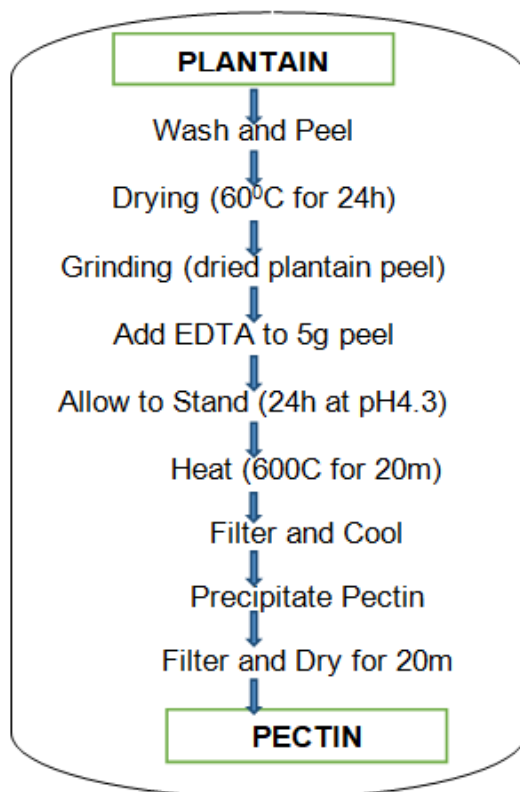


Fig. 1. Flowchart illustrating the extraction of pectin from plantain

2.5 Proximate Composition

The nutrient properties determined were moisture, ash, fat, protein and crude fiber using the method described by the Association of Official Analytical Chemists' [10]. The total carbohydrate content of the samples was calculated by difference (subtracting the sum of percent moisture, crude protein, crude fiber, crude fat, and ash from 100%).

2.6 Chemical Composition

The chemical properties determined were pH and Total sugars, using the procedure of AOAC [10]. While Total titratable acidity (TTA) of the sample was determined following the method of [11]. Three grams each of the sample was weighed into a conical flask and 30 ml of distilled water was added. The suspension was allowed to stand for 30 minutes after which it was titrated with a standard base (0.1 N NaOH) using 3 drops of phenolphthalein as an indicator. Total titratable acidity was estimated according to the formula:

$$\%TTA (w/w) = \frac{N \times V \times Eqwt}{W \times 1000}$$

Where N is the normality of NaOH, V is the volume of 0.1 N NaOH used, Eqwt is the equivalent weight of predominant acid which is lactic acid, W is the weight of sample, and 1000 is the factor relating mg to gram (mg g^{-1}).

2.7 Sensory Evaluation of Jam and Marmalade

Sensory evaluation of Jam and Marmalade samples was carried out through evaluating colour, taste, aroma, texture, appearance and overall acceptability as described by [12]. The samples were served to 20 semi trained panelists from the students and staff of the department of Food Science and Technology, Rivers State University. Score card and description sheet were designated to describe the excellent criteria of each of the jams/Marmalade quality characteristics. Panelists were asked to give numerical values for the jam/marmalade characteristics, using a 9-point hedonic scale.

2.8 Statistical Analysis

The data obtained for proximate composition, chemical and sensory properties were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Science (SPSS) version 20.0

software 2011. All the analyses were conducted in triplicate and means separated using Duncan multiple range test.

3. RESULTS AND DISCUSSION

3.1 Pectin Strength of Plantain Peels

The result of pectin strength as shown in Table1, reveal that, the pectin strength of French plantain (sample B) was higher than others while False horn and French horn plantain both had medium pectin strength, this could be attributed to the fact that these two varieties belong to the same genomic group, whereas, pectin strength of horn plantain was slightly lower. This agreed with the reported of earlier researchers [13,14]. The difference in the strength of the plantain varieties might be due to age of the plantain as well as agronomic and environmental factor.

Table 1. Pectin strength of plantain peels

Samples	Pectin strength
A	Weak
B	High
C	Medium
D	Medium

Key: Sample A = Horn Plantain peel, Sample B = French Plantain peel, Sample C = False horn Plantain peel, Sample D = French horn Plantain peel

3.2 Proximate Analysis of Jam

Result of the proximate analysis of jam made with pectin extracted from the varieties of plantain peels, as given in Table 2, showed moisture content ranging from 43.19% – 25.65%, jam with false horn plantain peel's pectin (sample D) being the lowest while jam with French plantain peel's pectin (sample C) was the highest. Moisture has a great impact on the shelf life of food products [15,16]. Processing of jam resulted in water removal and thus concentrates its food nutrients. Moisture and dry matter levels of any food material is a measure of the shelf life of the food [17,18]. There was no significant difference ($P>0.05$) in the ash values for samples C and E. Sample B had the least ash content of 2.24% while sample D gave the highest ash content of 4.40%. The ash content was lower compared to the data obtained for prickly pear jam [19]. Ash content gives an indication of minerals composition of food sample and is very important in many biochemical reactions which aid physiological functioning of major metabolic processes in the body [17]. Fat content of the samples ranged from 0.45 – 1.15% and there

were significant differences amongst the values with samples B and E being the lowest and highest, respectively. Jam produced with French Horn Plantain peel pectin (Sample E) had significant high crude protein value compared to all other samples. Jam samples had crude fibre values ranging from 0.55% for sample B to 1.75% for sample E. There was no significant difference ($P<0.05$) between sample B and D in their carbohydrate value while sample C had the lowest carbohydrate value of 50.97%.

Result for nutrient composition of marmalade is shown in Table 3. Moisture content ranged from 23.25% – 41.56% with sample D being the lowest while sample C compared favorably with the commercial marmalade. There was significant difference amongst the ash content of the samples with sample B being the lowest and sample D being the highest. Fat content of the samples ranged from 0.45% – 1.15% and there were significant differences amongst the values with samples B and E being the lowest and highest, respectively. Sample E (0.33%) had significant high crude protein value compared to all other samples. Marmalade samples had crude fibre values ranging from 0.75% for sample B to 2.25% for sample E. There was no significant difference ($P<0.05$) between sample B and D in

their carbohydrate value while sample C had the lowest carbohydrate value of 50.97%. The high carbohydrate content observed, might be attributed to the high carbohydrate content in banana used as raw material for the production of Jam and Marmalade.

3.3 Chemical Properties of Jam and Marmalade

The pH, TTA and total sugar value of the jam and marmalade samples are presented in Figs. 2 and 3, respectively. pH values of the jam samples were significantly ($P<0.05$) higher than that of the control (commercial jam), while the pH of marmalade samples was same with that of the commercial marmalade as shown in Figure 3. In both cases, pH was slightly lower than that of jackfruit [15] and pineapple jam [20]. The pH of jam and marmalade is an important factor to obtain optimum gel condition. The acidity value of the jam and marmalade ranged from 0.2385 - 0.3545% and 0.2385 - 0.3495%, respectively. These agreed with the report of earlier researcher [21]. The total sugar value of the sample ranged from 55.00 – 63.80%, in both cases. Jam and marmalade with sugar content above 61% is usually of very good quality [22].

Table 2. Proximate composition of jam

Samples	Moisture %	Ash %	Fat %	Protein %	Fiber %	Carbohydrate %
A	41.23±0.10 ^b	2.91±0.01 ^c	0.78±0.10 ^b	0.19±0.10 ^c	1.40±0.05 ^b	53.49±0.01 ^c
B	29.20±0.15 ^c	2.24±0.05 ^d	0.45±0.05 ^c	0.23±0.00 ^b	0.55±0.05 ^c	67.34±0.10 ^a
C	43.19±0.32 ^a	3.46±0.21 ^b	0.75±0.05 ^b	0.14±0.00 ^d	1.50±0.10 ^{ab}	50.97±0.04 ^d
D	25.65±0.16 ^d	4.40±0.11 ^a	0.95±0.05 ^{ab}	0.23±0.00 ^b	1.30±0.00 ^b	67.48±0.31 ^a
E	28.48±0.17 ^c	3.77±0.03 ^b	1.15±0.05 ^a	0.32±0.01 ^a	1.75±0.05 ^a	64.55±0.25 ^b

Values are means ± standard deviation of triplicate samples

Mean values bearing different superscript in the same column are significantly different ($P<0.05$)

Key: Sample A = Control (commercial marmalade), Sample B = marmalade produced with Horn Plantain peel pectin, Sample C = marmalade produced with French Plantain peel pectin,

Sample D = marmalade produced with False Horn Plantain peel pectin, Sample E = marmalade produced with French Horn Plantain peel pectin

Table 3. Proximate composition of marmalade

Samples	Moisture %	Ash %	Fat %	Protein %	Fiber %	Carbohydrate %
A	41.56±0.05 ^a	3.32±0.01 ^d	0.76±0.10 ^b	0.16±0.02 ^c	1.71±0.00 ^b	52.49±0.01 ^d
B	27.43±0.18 ^b	2.54±0.03 ^e	0.45±0.05 ^c	0.24±0.00 ^b	0.75±0.05 ^c	68.61±0.10 ^b
C	41.33±0.18 ^a	3.64±0.15 ^c	0.75±0.05 ^b	0.16±0.01 ^c	1.85±0.05 ^b	52.29±0.43 ^d
D	23.15±0.05 ^d	4.66±0.06 ^a	0.95±0.05 ^{ab}	0.23±0.01 ^b	1.60±0.00 ^b	69.41±0.03 ^a
E	25.96±0.06 ^c	4.00±0.04 ^b	1.15±0.05 ^a	0.33±0.02 ^a	2.25±0.05 ^a	66.33±0.19 ^c

Values are means ± standard deviation of triplicate samples

Mean values bearing different superscript in the same column are significantly different ($P<0.05$)

Key: Sample A = Control (commercial marmalade), Sample B = marmalade produced with Horn Plantain peel pectin, Sample C = marmalade produced with French Plantain peel pectin,

Sample D = marmalade produced with False Horn Plantain peel pectin, Sample E = marmalade produced with French Horn Plantain peel pectin

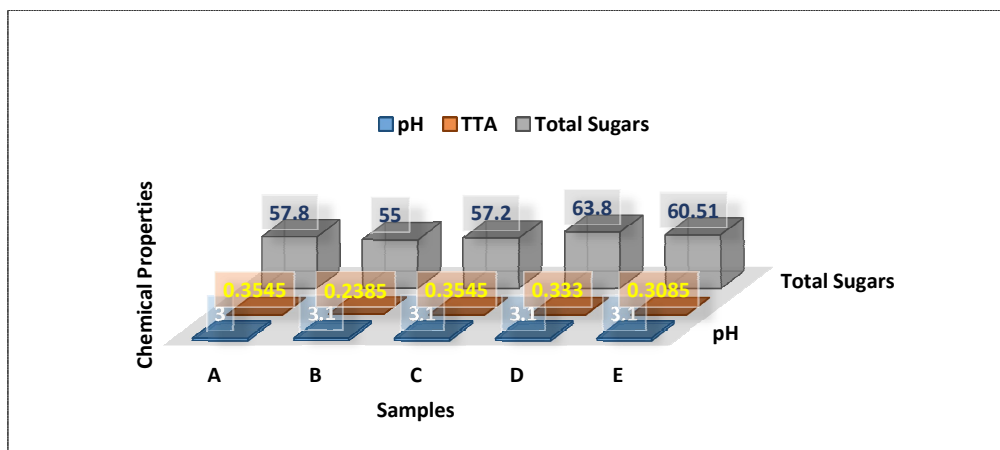


Fig. 2. Chemical properties of jam

Key Sample A = Control (commercial jam), Sample B =jam produced with Horn Plantain peel pectin, Sample C = jam produced with French Plantain peel pectin, Sample D = jam produced with False Horn Plantain peel pectin, Sample E = jam produced with French Horn Plantain peel pectin

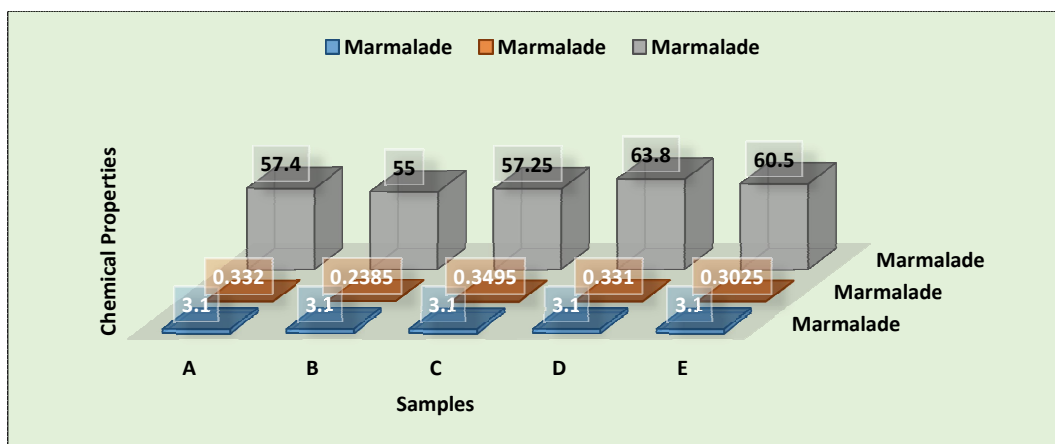


Fig. 3. Chemical properties of marmalade

Key Sample A = Control (commercial marmalade), Sample B =marmalade produced with Horn Plantain peel pectin, Sample C = marmalade produced with French Plantain peel pectin, Sample D = marmalade produced with False Horn Plantain peel pectin, Sample E = marmalade produced with French Horn Plantain peel pectin

3.4 Sensory Properties of Jam and Marmalade

Results for sensory evaluation of jam and marmalade produced with pectin from peels of different varieties of plantain are shown in Tables 4 and 5. Scores for Colour ranged from 3.30 – 6.80 and 3.30 – 7.60 for jam and marmalade respectively. while aroma ranged from 3.00 – 6.80 and 4.50 – 7.60, respectively, with Horn plantain (sample B) having the lowest in both cases. Colour is an important sensory attribute on which the consumer preference depends [23].

Taste ranged from 2.90 – 6.50 and 4.70 – 7.00 for jam and marmalade, respectively. All the sensory attributes of sample C (in jam and marmalade) compared favorably with the commercial samples (sample A). Jam produced with pectin from peels of French horn plantain (sample E) recorded the least acceptability in terms of appearance taste and overall acceptability. Jam and marmalade produced with pectin from French Plantain peel (Sample C) were most preferred in terms of colour, taste, aroma, appearance, spreadability and overall acceptability.

Table 4. Sensory properties of jam

Samples	Colour	Appearance	Aroma	Taste	Texture	Spreadability	Overall acceptability
A	5.30 ^{ab}	6.00 ^a	6.20 ^a	6.30 ^{ab}	6.40 ^a	6.70 ^{ab}	7.00 ^{ab}
B	3.30 ^b	3.30 ^{bc}	3.00 ^b	4.40 ^{bc}	3.10 ^b	5.40 ^{bc}	5.10 ^{cd}
C	5.60 ^{ab}	6.60 ^a	5.80 ^a	6.50 ^a	6.60 ^a	7.20 ^a	7.40 ^a
D	6.80 ^a	5.00 ^{ab}	4.90 ^{ab}	5.20 ^{ab}	5.70 ^a	5.30 ^c	5.70 ^{bc}
E	4.60 ^{ab}	2.90 ^c	3.80 ^b	2.90 ^c	5.20 ^a	5.30 ^c	3.80 ^d

Table 5. Sensory properties of marmalade

Samples	Colour	Appearance	Aroma	Taste	Texture	Spreadability	Overall acceptability
A	7.60 ^a	6.50 ^a	7.50 ^a	6.90 ^a	6.50 ^a	7.30 ^a	7.20 ^{ab}
B	3.30 ^c	3.60 ^b	6.40 ^{ab}	6.00 ^{ab}	5.70 ^a	6.50 ^{ab}	6.30 ^{bc}
C	7.10 ^a	5.90 ^a	7.60 ^a	7.00 ^a	6.80 ^a	7.20 ^a	7.50 ^a
D	5.20 ^b	3.60 ^b	5.80 ^{bc}	4.70 ^b	5.50 ^a	5.10 ^c	5.80 ^c
E	3.80 ^{bc}	5.70 ^a	4.50 ^c	4.70 ^b	6.30 ^a	6.00 ^{bc}	5.50 ^c

Values are mean scores of twenty responses

Mean values bearing different superscript in the same column and significantly different (P<0.05)

Key Sample A = Control (commercial marmalade), Sample B = marmalade produced with Horn Plantain peel pectin, Sample C = marmalade produced with French Plantain peel pectin,

Sample D = marmalade produced with False Horn Plantain peel pectin, Sample E = marmalade produced with French Horn Plantain peel pectin

4. CONCLUSION

From the result, pectin strength of peels from French plantain (sample B) was higher than others. while peels from False horn and French horn plantain both had medium pectin strength. The ash and carbohydrate content of jam and marmalade produced with pectin from French Plantain, False Horn Plantain and French Horn Plantain were significantly higher than the commercial jam and marmalade, while the fat and fibre content compared favorably with the commercial jam and marmalade. The pH of marmalade containing plantain peel pectin compared favorably with that of the commercial marmalade. Samples E and D gave appreciable high sugar content of 60.5% and 63.8%, respectively. Jam and marmalade produced with pectin from French Plantain peel (Sample C) were most preferred in terms of colour, taste, aroma, appearance, spreadability and overall acceptability. Pectin extracted from plantain peel is strongly recommended for use as gelling agent in Jam and Marmalade production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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