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Original Article

Evaluation of the potential of pectin from unripe banana (*musa acuminate* x *balbisiana* var.cardaba) peel for jackfruit (actocarpus heterophyllus lam) marmalade applications

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ABSTRACT

Waste utilization from food processing industries is a highly crucial and challenging task all around the globe. Utilization of the fruit processing co-products into fruit preserves such as marmalade is a favorable venture. However, due to its very low pectin content, it is necessary to fortify the formulation with pectin. This study aimed to evaluate the food application of pectin from banana peel. The pectin was used in the processing of jackfruit marmalade made of jackfruit trimmings and seed coat. Varying levels of pectin (0%, 0.5%, 1%, 1.5%, 2% and 2.5%) were added to the jackfruit marmalade formulation. The sensory attributes, general acceptability, and physico-chemical characteristics of the product were evaluated. The levels of banana peel pectin significantly influenced the color, texture, spread ability, and general acceptability of the product. The pH and total soluble solids also gave significant results. The mean general acceptability for the jackfruit marmalade is 7.59, corresponding to "like moderately'' in the 9-point Hedonic scale. For the consumer preference test, consumers liked and preferred both commercial and extracted pectin for marmalade production. Furthermore, jackfruit marmalade was much preferred by the consumers compared to a commercially available orange marmalade. The cost of producing 500 g of jackfruit marmalade made from jackfruit trimmings, seed coat, and banana peel pectin is Php 265.22.

KEYWORDS: *banana, CRD, jackfruit, marmalade, pectin*

1 INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) processing has been highly encouraged due to several reasons, one of which is that its fruit is rich in Vitamin A, B, and C, potassium, calcium, iron, protein, and carbohydrates (Jagtap et al., 2010; Shanmugapriya et al., 2011, Ranasinghe et al., 2019) besides, jackfruit is also considered as a major crop in Visayas (Galvez & Dizon, 2017). With the development of dehydrated and jackfruit processing in a big bulk of co-products are expected in the coming years.

Jackfruit has a strong natural aroma which is well liked by consumers of all ages. Its aromatic and sweet bulbs constitute about 30% percent of the fruit. Seventy percent of the fruit are co-products which include peel, pith, rags, seed and seed coat (Jagadeesh et al., 2007). These co-products are still aromatic, possessing therefore the potential for product development. Marmalade is a potential product that can be processed from jackfruit co-products. Although jackfruit co-products are still aromatic, they contain significantly lower amount of pectin than that of the bulb. This is pointed out by the report of Ahmmed et al. (2017) wherein pectin content of peel and core or pith is 0.5-1.2% in wet basis and (Begum et al., 2014) with jackfruit bulb containing 1.1-1.6% wet basis. Utilization of the co-products into marmalade is a favorable venture. However, due to its very low pectin content, it is necessary to fortify the formulation with pectin.

Jam, jellies and marmalades are sugar preserved products popular among local and international consumers. They are commonly used as fillers, spreads and frozen dessert toppings. In big hotels and restaurants, whenever bread is served, individually packed marmalade is served. Marmalade is a sugar preserved product wherein fruit bits are suspended in a fruit gel (Merriam-Webster, n.d.). Marmalade is usually made out of fruits rich in pectin. Commercially available marmalade are made of citrus and orange peel and pineapple. Aside from pectin, the natural aroma in fruit is another important consideration in the selection of raw material for marmalade production.

Utilization of banana peel pectin is another promising option. Preliminary experiments have shown that in order to attain good quality pectin from Cardaba (*Musa acuminata* × *balbisiana* var. Cardaba) banana peel, these extraction parameters should be followed:

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100 minutes extraction time, 96.8ºC extraction temperature and 1:30 peel to citric-acid solvent ratio. This extraction process will yield 13.5% (db) of high-methoxyl pectin (Tanaid & Lauzon, 2018). Powdered pectin from banana processing waste may represent potential market development opportunities especially for banana processing plants implementing zero-waste technology.

Waste utilization from food processing industries is a highly indispensable and challenging task all around the globe. At present, new aspects concerning the use of wastes as by-products for further exploitation on the production of food with high value in the food industry have gained increasing interest. Thus, this study focused primarily on evaluating the pectin extracted from Cardaba banana through application in the processing of jackfruit marmalade made of jackfruit trimmings and seed coat. Specific objectives of the study include the determination of the physico-chemical characteristics, assessing consumer preference and determining the cost of producing the best formulation for the marmalade was computed.

2 MATERIALS AND METHODS

Procurement of Materials

Jackfruit trimmings and seed coat were collected at the Department of Food Science and Technology, VSU, Visca, Baybay City, Leyte. Other ingredients such as sugar and calamansi were bought in the local market.

Product Preparation

Pectin produced from the optimized extraction process of Tanaid & Lauzon (2018) from unripe Cardaba banana peel was used as a substitute for commercial pectin for the production of jackfruit marmalade.

Jackfruit pulp trimmings and seed coat (10% w/w) were washed, chopped into small pieces and blended thoroughly. Brown sugar was added in 1:1 (w/w) ratio. The mixture was stirred continuously to avoid scorching. Halfway through the heating process, different levels of pectin were added (Table 1). When the mixture started to thicken, 1 tsp. calamansi juice was added to the mixture. The foam was skimmed off with a spoon and set aside. To test the consistency, a small amount of mixture was scooped and cooled down to room temperature. The marmalade was hot-filled into sterilized glass jars with ¼ headspace, sealed and inverted for 3 minutes.

Experimental Design

The experiment used a single factorial design with different levels of banana peel pectin added to the marmalade mixture. The different levels were determined based on preliminary experiments. Table 1 shows the different treatments with corresponding pectin levels

Table 1. Different treatments for the processing of jackfruit marmalade

TREATMENTS	PECTIN (%w/w)
1	0.0
2	0.5
3	1.0
4	1.5
5	2.0
6	2.5

Sensory Evaluation

The processed product was subjected to sensory evaluation employing 60 panelists composed of students, faculty and staff of the Department of Food Science and Technology. Experimental design for sensory evaluation was arranged based on the Incomplete Block Design by Cochran & Cox (1957) Type I. The sensory attributes of the product such as color, aroma, taste, texture, spreadability and general acceptability were evaluated using a combination of quality description as perceived by the panelists and acceptability using 9-point Hedonic scale.

Physico-Chemical Evaluation

Analysis of the physico-chemical qualities of the product was carried out which included the pH, total soluble solids (TSS) and titratable acidity (TA).

pH

The pH of the fruit marmalade was measured using Qingdao digital pH meter. Fifteen (15) mL sample was placed in a plastic cup and the pH value was obtained by taking the mean of three readings from triplicates.

Total Soluble Solids (TSS)

The total soluble solid was analyzed using the calibrated Atago hand refractometer. One (1) drop from each sample was placed in the refractometer for TSS reading in ºBrix. TSS values were obtained by taking the mean of three readings from triplicates.

Titratable Acidity (% Citric acid)

Five (5) g of the sample was pipetted into an Erlenmeyer flask and added with 20 mL distilled water. About 2-3 drops of 1% phenolphthalein solution was added into the diluted sample. The mixture was titrated against standardized 0.1N NaOH until a faint pink color was achieved.

Computation:

$$\%TA = \frac{V \times N \times M}{W} 100$$

Where:

V= Volume (mL) of NaOH added

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N= Concentration (N) of NaOH
M= milli-equivalent weight of predominant acid

$$W=\frac{\text{wt. of sample}}{\text{wt. of sample+vol. of water added}}\times\text{vol. of aliquot}$$

Consumer Preference Test

To evaluate the acceptability of the best formulation to a larger number of people, consumer testing was employed consisting of one hundred consumers at 4 different age brackets (8-14, 15-22, 23-30 and 30 and above). Consumer testing was used to determine the consumer's acceptability of the jackfruit marmalade with trimmings and seed coat added with banana peel pectin and commercial pectin. The data was subjected to Chi-square test to compare consumer's acceptance of banana peel pectin against commercial pectin and jackfruit marmalade made out of jackfruit seed coat and trimmings against commercial marmalade.

Statistical Analysis

The data gathered from the sensory evaluation and physico-chemical tests of pectin's potential use in jackfruit marmalade processing was analyzed using Analysis of Variance (F-test) following the Complete Randomized Design (CRD). For treatments with significant effects, Tukey Honesty Significant Difference Test was used to locate significant means. Consumer's preference was analyzed using Chi-square test. All data analysis were done using SPSS version 17.

Production Cost

The cost of producing the most acceptable formula was determined considering the current market prices of material used. The break-even price was determined by dividing the total cost of production by the total yield.

3 RESULTS AND DISCUSSION

Color

The color of the jackfruit marmalade ranged from yellow to brown (Table 2) with mean acceptability rating of 7.09 which falls under "like moderately" in the 9-point Hedonic scale (Fig.1).

Table 2 suggests that the light brown color of the marmalade without banana peel pectin gave the lowest acceptability score. However, a significant change in color was detected at the highest pectin level, accompanied with a decrease in acceptability score. Treatment 5 with 2% pectin level has the highest acceptability score. The color acceptability of the jackfruit marmalade among treatments was significantly different at $p \leq 0.05$.

Figure 1. Physical appearance of the jackfruit marmalade made from jackfruit seed coat and trimmings as affected by different pectin levels

Table 2. Mean[1] color acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	DESCRIPTION	ACCEPTABILITY	F- VALUE	R^2
1	0	Yellow to Light Brown	6.57[c]	5.40**	0.809
2	0.5	Yellow to Light Brown	7.27[ab]		
3	1.0	Yellow to Light Brown	7.32[a]		
4	1.5	Light brown to Brown	7.15[ab]		
5	2.0	Light brown to Brown	7.43[a]		
6	2.5	Brown to Dark Brown	6.82[bc]		

[ns] not significant ($p>0.05$) *significant ($p\leq 0.05$) **significant ($p\leq 0.01$)
[abcd] Means with the same letter are not significantly different
[1]N=60
[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

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Table 3. Mean[1] aroma acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	DESCRIPTION	ACCEPTABILITY	F-VALUE	R^2
1	0	Slight to moderate jackfruit aroma	7.57	0.42^{ns}	0.856
2	0.5	Slight to moderate jackfruit aroma	7.47		
3	1.0	Slight to moderate jackfruit aroma	7.60		
4	1.5	Slight to moderate jackfruit aroma	7.73		
5	2.0	Slight to strong jackfruit aroma	7.60		
6	2.5	Slight to strong aroma	7.65		

^{ns} not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

Table 4. Mean[1] taste acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMEN	LEVEL OF PECTIN (% w/w)	DESCRIPTION	ACCEPTABILITY	F- VALUE	R^2
1	0	Sweet to very sweet	7.72	0.30^{ns}	0.781
2	0.5	Sweet to very sweet	7.60		
3	1.0	Sweet to very sweet	7.68		
4	1.5	Sweet	7.80		
5	2.0	Sweet	7.65		
6	2.5	Sweet	7.67		

^{ns} not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

The "light brown" to "brown" color is contributed specially by the color of the banana peel pectin which is light to dark brown. The results imply that the banana peel pectin significantly affects the color of the marmalade. Nevertheless, panelists still favored the color of the marmalade with banana peel pectin over the treatment without pectin. Color of pectin is important as it affects the appearance of the gel produced. The brown color could be attributable to the highly colored pectin which may have the presence of polyphenols or other water soluble pigments trapped inside the pectin during precipitation (Shaha et al., 2013).

Aroma

The aroma of the jackfruit marmalade ranged from slight to moderate jackfruit aroma with mean acceptability of 7.60 which falls under "like moderately" in the 9-point Hedonic scale. This implies that the jackfruit marmalade made from jackfruit trimmings, seed coat and banana peel pectin is well liked by the panelist as reflected by the acceptability score.

Table 3 shows that the highest acceptability is found

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at 1.5% pectin level and lowest at treatment with no added pectin. However, acceptability scores for aroma between treatments are not significantly different with each other. This suggests that the level of pectin did not affect the aroma of the jackfruit marmalade.

Taste

The taste of jackfruit marmalade ranged from sweet to very sweet, which is an evident characteristic of any fruit preserve such as marmalade (Table 4). The mean acceptability for taste is 7.68 which falls under "like moderately" in the 9-point Hedonic scale. The high sugar content of the marmalade act as a preservative. In addition, sugar is very important in the rigidity of the structure of pectin since it competes for water, thus making less water available to associate with the pectin molecules. This reduces the attractive forces between the pectin and water molecules enabling jelly formation (Lara-Espinoza et al., 2018).

Results for taste, as shown in Table 4, shows no evident trend or changes in acceptability at perceived change in sweetness as pectin levels increase. This is also because sugar content of the marmalade was constant in all treatments. There is no significant difference between the treatments implying that different pectin levels did not affect the taste of the marmalade.

Flavor

The flavor of jackfruit marmalade ranged from slightly too moderately perceptible jackfruit. Jackfruit is a very aromatic fruit in which its flavor is easily detected.

The mean acceptability for flavor is 6.86 which falls under "like slightly" in the 9-point Hedonic scale. This suggest that the use of jackfruit co-products, the rags and seed coat, gave a high acceptability scoring and well-liked by the panelists. Different levels of the banana peel pectin did not affect the acceptability score as shown in Table 5. However, at constant jackfruit levels, as pectin increases, sensory panelists have perceived more perceptible jackfruit.

As pectin increases, perceived texture and consistency also changes from free flowing to thick (Table 6). Texture feeling is perceived by the consumer as an assessment of product characteristics such as spreadability, amount and type of sweeteners, gelling agents, and fruit flesh (Basu & Shivrahe 2010; Aprea et al., 2006). Thus, affecting the perceived flavor of the marmalade.

Texture

Pectin gel (liquid dispersed in solid continuous phase) occurs when the pectin molecules interact with each other at specific points. It is not easy to form pectin gels since it requires a delicate balance of pectin, water, sugar, and acid (Vaclavik & Christian, 2008).

Table 5. Mean[1] flavor acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (% w/w)	DESCRIPTION	ACCEPTABILITY	F-VALUE	R^2
1	0	Slight to moderately perceptible jackfruit	6.92	0.14^{ns}	0.703
2	0.5	Slight to moderately perceptible jackfruit	6.82		
3	1.0	Slight to moderately perceptible jackfruit	6.83		
4	1.5	Moderately perceptible jackfruit	6.83		
5	2.0	Moderately perceptible jackfruit	6.85		
6	2.5	Moderately perceptible jackfruit	6.90		

^{ns} not significant ($p>0.05$) *significant ($p\leq 0.05$) **significant ($p\leq 0.01$)

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

The texture of the jackfruit marmalade ranged from watery too thick with mean acceptability of 6.46 which falls under "like slightly" in the 9-point Hedonic scale

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(Table 6). Pectin macromolecules interact with each other through a number of covalent and non-covalent, intra- or intermolecular linkages resulting in the formation of a network (Christiaens et al., 2015). Thus, pectin gelation renders the polymer suitable for use as gelling, thickening, or stabilizing agent (May, 1990 & Voragen et al., 2009) and its application on preserves such as marmalade.

banana peel pectin has good gelling abilities and great influence on the product's texture. T_1 with no pectin added had a 'watery' description had the lowest acceptability score of 5.20 equivalents to neither like nor dislike in the 9-point Hedonic scale. T_3 with 1% pectin had a smooth/silky characteristic and had the highest acceptability score at 7.2 which corresponds to "like moderately'. It could be observed that the pectin levels

Table 6. Mean[1] texture acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	DESCRIPTION	ACCEPTABILITY	F-VALUE	R^2
1	0	Watery to Coarse	5.20[c]	21.69**	0.835
2	0.5	Coarse/grainy	5.63[c]		
3	1.0	Smooth/Silky	7.20[a]		
4	1.5	Coarse to Thick/Not free flowing	7.07[b]		
5	2.0	Coarse to Thick/Not free flowing	7.18[b]		
6	2.5	Coarse to Thick/Not free flowing	6.50[b]		

[ns] not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)

[abcd] Means with the same letter are not significantly different

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

Table 7. Mean[1] spreadability acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	DESCRIPTION	ACCEPTABILITY	F-VALUE	R^2
1	0	Spreadable to moderately spreadable	5.42[d]	20.26 **	0.823
2	0.5	Spreadable to moderately Spreadable to moderately spreadable	6.03[cd]		
3	1.0	Spreadable (viscous)	7.28[ab]		
4	1.5	Spreadable (viscous)	7.28[ab]		
5	2.0	Spreadable (viscous)	7.38[a]		
6	2.5	Spreadable (viscous)	6.62[bc]		

[ns] not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)

[abcd] Means with the same letter are not significantly different

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

The different levels of pectin influenced greatly the textural quality of the jackfruit marmalade as well as its acceptability. Differences between the treatments' textures are highly significant, suggesting that the

have a direct effect on the texture's acceptability up to T_3. Acceptability scores gradually decreased as the pectin levels are increased from 1.5 to 2.5%; wherein the

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marmalade exhibited a thick/not flowing characteristic. As the pectin level reached 2.5%, acceptability scores decreased. This could be attributed to the thickening of the marmalade at the highest level of pectin.

The thickening of the marmalade solution at increased levels of pectin is due to its ability to form gels in the presence of Ca ions or sugar and acid. It is this property of pectin that makes them an important ingredient of many food products (Thakur et al., 1997).

moderately'' in the 9-point Hedonic scale. The highest acceptability was found at 2.0% pectin level. This result suggests that the jackfruit marmalade is very much liked by the sensory panelist despite the use of ingredients from co-products of jackfruit and banana processing. Table 8 shows that addition of pectin significantly ($p \leq 0.01$) affected the general acceptability. General acceptability increased from T1 to T5 (0-2.0% pectin) and decreased at T6 with added 2.5% pectin. Pectin, as a

Table 8. Mean[1] general acceptability ratings[2] of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	DESCRIPTION	ACCEPTABILITY	F- VALUE	R^2
1	0	Like slightly	6.10[d]	37.83**	0.793
2	0.5	Like moderately	7.27[c]		
3	1.0	Like very much	8.12[a]		
4	1.5	Like very much	8.12[a]		
5	2.0	Like very much	8.18[b]		
6	2.5	Like very much	7.75[c]		

[ns] not significant ($p>0.05$) *significant ($p \leq 0.05$) **significant ($p \leq 0.01$)

[abcd] Means with the same letter are not significantly different

[1]N=60

[2]Range of acceptability score: 9- like extremely, 8- like very much, 7- like moderately, 6- like slightly, 5- neither like nor dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1- dislike extremely

Spreadability

The spreadability of jackfruit marmalade ranged from moderately spreadable to spreadable. The mean acceptability of the product is 6.70 which corresponds to "like slightly'' in the 9-point Hedonic scale. Acceptability for pectin is high at 2.0% pectin and decreased when it reached 2.5%. The highest percentage for pectin may have caused the marmalade to be too rigid, though still spreadable, in which the panelists did not find acceptable (Table 7).

Result of the sensory evaluation show that the spreadability between treatments are highly significant at $p \leq 0.01$, which suggests the high influence of pectin levels for this characteristic. Pectin being a cementing material on plants is used industrially not just for its jelly forming ability but also as thickener and stabilizer. In a gel, pectin forms a long polymer chain called junction zones that are able to entrap water. Hence, a gel is formed, with water trapped in the pockets of the three-dimensional pectin network (Vaclavik & Christian, 2008).

General Acceptability

The mean general acceptability for the jackfruit marmalade made from jackfruit co-products (trimmings & seed coat) is 7.56 which corresponds to "like

thickener and stabilizer, tends to thicken the marmalade if added at very high amount making the product too rigid or thick. The decrease in general acceptability of treatment 6 (with 2.5% pectin concentration) could be attributed to its dark color (Figure 1) and its thick/not free flowing texture (Table 6) which are important sensory attributes for a marmalade.

Results of Physico-chemical Analysis

pH

The pH of the jackfruit marmalade ranged from pH 3.6 to 4.0. pH of the treatments having different pectin levels showed significant results ($p \leq 0.01$). Banana peel pectin which was extracted through citric acid solvent may have contributed to these changes in pH. Normal jam and marmalade pH ranges from 3.5 to 4.0 (Williams & Philips, 2003) (Table 10).

The acidity of marmalades helps prevent the growth of molds and yeast that are able to grow at high acid foods. Also, growth of microorganisms are prevented from spoiling jams by ensuring that the sugar content of the preserve is at least 60-68% (Vaclavik & Christian, 2008).

The acidity of marmalades helps prevent the growth of molds and yeast that are able to grow at high acid

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Table 10. Mean[1] pH of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	pH	F- VALUE	R^2
1	0	3.83[abc]	7.69**	0.862195
2	0.5	3.77[bc]		
3	1.0	3.90[ab]		
4	1.5	4.03[a]		
5	2.0	3.63[c]		
6	2.5	3.90[ab]		

[ns] not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)
[abcd] Means with the same letter are not significantly different
[1]N=3

Table 11. Mean[1] TSS of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN %w/w	TSS (°BRIX)	F- VALUE	R^2
1	0	62.50[c]	103.78**	0.977
2	0.5	64.10[b]		
3	1.0	65.27[a]		
4	1.5	60.09[d]		
5	2.0	62.17[c]		
6	2.5	63.94[b]		

[ns] not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)
[abcd] Means with the same letter are not significantly different
[1]N=3

Table 12. Mean[1] TA of jackfruit marmalade as affected by different levels of banana peel pectin

TREATMENTS	LEVEL OF PECTIN (%w/w)	TA	F- VALUE	R^2
1	0	0.48	1.67[ns]	0.911
2	0.5	0.56		
3	1.0	0.51		
4	1.5	0.56		
5	2.0	0.51		
6	2.5	0.56		

[ns] not significant (p>0.05) *significant (p≤ 0.05) **significant (p≤ 0.01)
[abcd] Means with the same letter are not significantly different
[1]N=3

foods. Also, growth of microorganisms are prevented from spoiling jams by ensuring that the sugar content of the preserve is at least 60-68% (Vaclavik & Christian, 2008).

Total Soluble Solids (TSS)

The TSS of the jackfruit marmalade ranged 62-65 °Brix. The TSS is primarily represented by sugar present in the product. According to the Codex Alimentarius standard (CODEX STAN, 2009), normal fruit conserves or preserves must contain ≥60% soluble solids.

TSS value of the different treatments showed significant results. However, there was no association

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(either linear or quadratic) found on the levels of pectin to the TSS value (Table 11). This could be true since a constant amount of sugar was added in all treatments. Furthermore this is in agreement with the result of the taste parameter which is not significant.

Titratable Acidity (TA)

Titratable acidity of the marmalades is not affected by different levels of pectin. Result of the ANOVA (Table 12) also showed no correlation between pectin levels and TA. This is due to the constant amount of jackfruit co-products added to the marmalade. The values obtained also coincides with the normal TA values for fruit jams and marmalade which is 0.39 - 1.1 % citric acid (Awolu et al., 2018) but may differ depending on the type of fruit used.

Consumer Preference Test

The extracted banana peel pectin and commercial pectin were subjected to consumer evaluation by producing a jackfruit marmalade using jackfruit co-products and pectin to test the acceptability of the product and to evaluate the preference between the two in the market. The level of pectin used for the production of marmalade was at 1.5% w/w (T_5) since it showed the highest acceptability among majority of the sensory attributes (color, spreadability & general acceptability). At age bracket 15-22, there is a significant result in the preference of the consumers, however, at all other age brackets (8-14, 23-30 & 30 & above), results were found not significant (Table 13). The reasons for the preference for the marmalade using extracted pectin include color and a spreadable consistency. The jackfruit marmalade with commercial pectin and with banana peel pectin was subjected to consumer evaluation to determine consumer's reaction to the product. On the other hand, marmalade using commercial pectin was also preferred because of its taste and firmer or spreadable consistency.

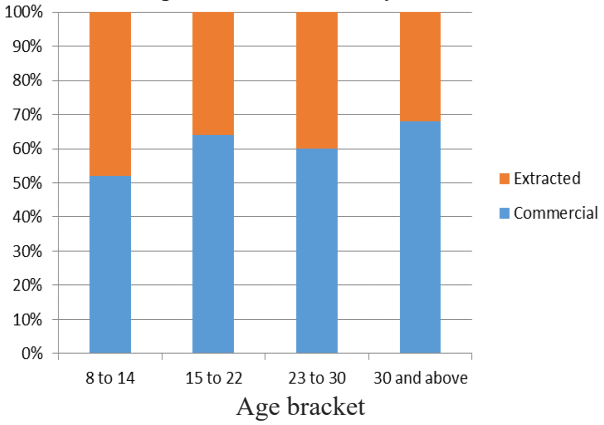
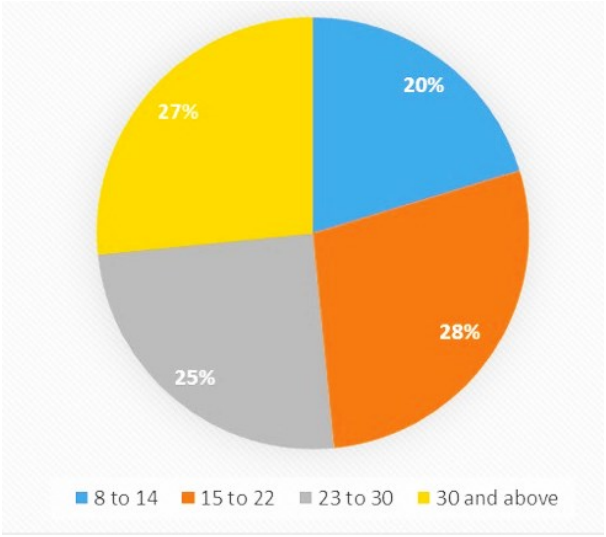


Figure 2. Comparison between consumer preference of extracted pectin and commercial pectin used in jackfruit marmalade at different age brackets.

A.



B.

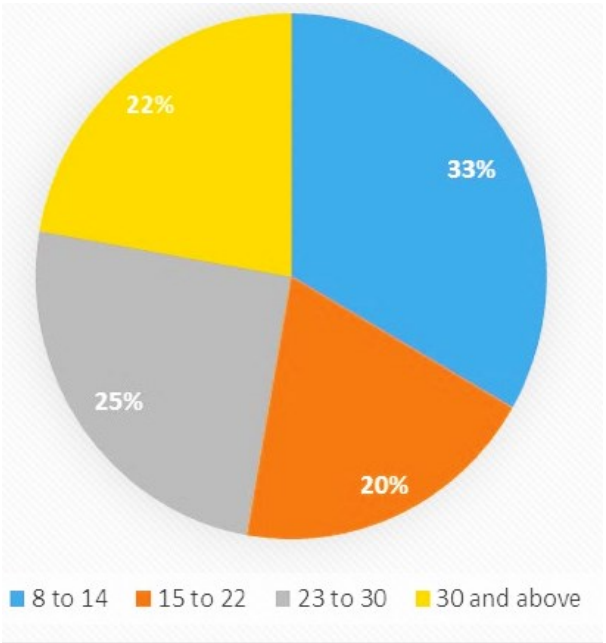


Figure 3. Consumer preference share of different age brackets between (a) commercial pectin and (b) extracted pectin used in jackfruit marmalade.

The jackfruit-co product marmalade using both commercial and extracted pectin was also subjected to consumer preference test against commercial orange peel marmalade. Table 13 shows that there is a significant result in the preference of jackfruit marmalade over commercial orange marmalade.

On the other hand, the preference for jackfruit marmalade produced using extracted pectin was not significantly different with that of commercial marmalade. These results suggest that the marmalade produced from jackfruit co-products and pectin has a

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high chance of consumer once introduced into the market.

physico-chemical values (pH, TSS and TA) were within the standard values for marmalade.

Table 13. Consumer preference test for commercial marmalade vs. jackfruit marmalade.

	PREFERENCE	CHI-SQUARE		PREFERENCE	CHI-SQUARE
Jackfruit marmalade (commercial pectin)	43	7.562500**	Jackfruit marmalade (extracted pectin)	16	0.444^{ns}
Orange marmalade	21		Orange marmalade	20	

^{ns} not significant ($p>0.05$) *significant ($p\leq 0.05$) **significant ($p\leq 0.01$)

Cost of Production

The break-even price for the marmalade was determined by dividing the total cost of production by the total yield.

Break Even Price = (Total Cost of Production)/Yield

The cost of producing 500 g of the best formulation of marmalade (T5) using 1.5% banana peel pectin is Php 265.22. This is relatively the same with that of the other marmalades found in the market. Utilization of co-products into high value food products add economic value to the peels.

For the consumer preference test, consumers liked and preferred both marmalades with commercial and extracted pectin. This suggests that the marmalade produced from jackfruit co-products and pectin has high chance of consumer acceptance once introduced into the market.

It is recommended to conduct packaging and storage studies for the product to determine the appropriate conditions for the storage of the jackfruit marmalade. It is also suggested that other fruit processing by-product could be explored for possible marmalade and fruit spread production.

4 CONLUSIONS AND RECOMMENDATION

This study was conducted with the general objective of evaluating the potential of banana peel pectin as pectin enhancer in the processing of jackfruit marmalade made of jackfruit trimmings and seed coat. Specific objectives of the study are to determine the sensory quality, pH, TSS and TA of the produced marmalade, consumer preference test for the marmalade and determining the cost of production. In order to achieve this, a single factorial design with varying levels of pectin (0%, 0.5%, 1%, 1.5%, 2% & 2.5%) was added to the jackfruit marmalade. The sensory attributes were evaluated to determine the best pectin level for marmalade production.

Sensory attributes such as color, texture, spreadability and general acceptability and the physico-chemical attributes of the marmalade were significantly influenced by the different pectin levels. The mean general acceptability for the jackfruit marmalade is 7.59 which corresponds to "like moderately'' in the 9-point Hedonic scale. Treatment 5 with 1.5% w/w pectin is the best formulation since it showed the highest acceptability among majority of the sensory attributes (color, spreadability & general acceptability). All

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