ORIGINAL ARTICLE

# The production of guava juice fortified with dietary fiber

**Woranong Thongsombat[1], Anchalee Sirichote[2] and Suganya Chanthachum[3]**

## Abstract

**Thongsombat, W., Sirichote, A. and Chanthachum, S.**

**The production of guava juice fortified with dietary fiber**

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**The production of guava juice fortified with soluble dietary fiber as pectin extracted from guava cake (peel, pulp, seeds) was conducted. The waste guava cake from juice processing plant was used for pectin extraction using sodium hexametaphosphate method followed by pectin precipitation using acidified ethanol method. A yield of 30.50±0.34% crude pectin was achieved. Crude pectin also contained 4.71±0.18% moisture, 0.34±0.21% protein, 0.68±0.00% ash, 20.70±0.16 g (%dwb) soluble dietary fibers. pH of crude pectin was 3.06±0.02. The *L* a**and *b** values were 81.17±0.21, 4.76±0.04 and 15.43±0.07, respectively. Water holding capacity and bulk density were 0.90±0.01 g.water/g.solid and 0.96±0.05 g/ml, respectively. This study found that the optimum conditions for guava juice extraction using pectinase at 45°C were 0.10 % v/v pectinase concentration and 2½ h incubation time. Under these optimum conditions, production of guava juice with different ratios of total soluble solids (°Brix) to acid as citric acid content (%) including, 24.0, 28.0, 32.0, 35.0 and 40.0 °Brix-acid ratio, and product sensory evaluation were also conducted. By the consideration from the greatest perceived scores of all sensory evaluation attributes including color, turbidity, odor, flavor and overall acceptability, the °Brix-acid ratio of 40.0 was selected for guava juice processing. The clarified guava juice was then fortified with pectin powder extracted from previous experiments using various pectin**

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**concentrations: 0, 0.25, 0.50 and 0.75% (w/w). It was found that the perceived scores of the overall acceptability attribute decreased ($p<0.05$) with increasing of pectin concentration. The greatest perceived score of the mouthfeel attribute was observed from the use of 0.25% pectin. Therefore, the optimum concentration of 0.25% soluble dietary fiber as pectin for guava juice fortification is selected for further guava juice processing.**

**Key words :** guava (*Psidium guajava*), dietary fiber, crude pectin, pectinase, °Brix-acid ratio

## บทคัดย่อ

**วรนงค์ ทองสมบัติ อัญชลี ศิริโชติ และ สุกัญญา จันทะชุม**

**การผลิตน้ำฝรั่งพร้อมดื่มเติมใยอาหาร**

**ว. สงขลานครินทร์ วทท. 2550 28(ฉบับพิเศษ 2) : 187-196**

**งานวิจัยนี้ได้ทำการผลิตน้ำฝรั่งเติมใยอาหารในรูปเพกตินซึ่งสกัดจากกากฝรั่ง (เปลือก เนื้อ เมล็ด) กากฝรั่งจากกระบวนการผลิตน้ำฝรั่งนำมาใช้เป็นวัตถุดิบในการสกัดเพกตินด้วยวิธีที่ใช้สารละลายโซเดียมเฮกซะเมตาฟอสเฟตและตกตะกอนด้วยเอธานอลในสภาพเป็นกรด การสกัดที่ได้พบว่าให้ร้อยละของผลผลิตเพกตินเท่ากับ 30.50±0.34 เพกตินยังประกอบด้วยปริมาณความชื้น โปรตีน เถ้า และใยอาหารละลายน้ำ เท่ากับร้อยละ 4.71±0.18 0.34±0.21 0.68±0.00 และ 20.70±0.16 กรัม โดยน้ำหนักแห้ง ตามลำดับ เพกตินมีความเป็นกรดด่างเท่ากับ 3.06±0.02 ค่าสีในรูป *L** *a** และ *b** เท่ากับ 81.17±0.21 4.76±0.04 และ 15.43±0.07 ตามลำดับ ค่า water holding capacity และค่า bulk density เท่ากับ 0.90±0.01 กรัมน้ำ/กรัมของแข็ง และ 0.96±0.05 กรัม/มล. ตามลำดับ เมื่อศึกษาการสกัดน้ำฝรั่งโดยการใช้เอนไซม์เพกติเนสที่อุณหภูมิ 45°C พบว่า สภาวะที่เหมาะสมที่สุดสำหรับการสกัดน้ำฝรั่งคือความเข้มข้นของเอนไซม์เพกติเนสเท่ากับ 0.10% โดยปริมาตร และเวลาในการสกัด 2.50 ชั่วโมง เมื่อทำการผลิตน้ำฝรั่งโดยใช้สภาวะที่เหมาะสมที่สุดนี้ ด้วยน้ำฝรั่งที่มีอัตราส่วนปริมาณของแข็งทั้งหมดที่ละลายน้ำได้ต่อปริมาณกรดทั้งหมดในรูปกรดซิตริก (°Brix-acid ratio) เท่ากับ 24.0 28.0 32.0 35.0 และ 40.0 น้ำฝรั่งที่ได้นำประเมินผลทางประสาทสัมผัสที่พิจารณาคุณลักษณะสี ความขุ่น กลิ่นรส รสชาติและคุณลักษณะโดยรวม พบว่าน้ำฝรั่งที่อัตราส่วนปริมาณของแข็งทั้งหมดที่ละลายน้ำได้ต่อปริมาณกรดทั้งหมด เท่ากับ 40 เป็นอัตราส่วนที่ได้รับผลการประเมินการยอมรับมากที่สุดในทุกคุณลักษณะทางประสาทสัมผัส การผลิตน้ำฝรั่งที่ได้เมื่อเติมเพกตินในปริมาณต่าง ๆ ได้แก่ 0.00%, 0.25%, 0.50% และ 0.75% โดยน้ำหนัก พบว่าคะแนนการยอมรับของผู้ทดสอบชิมในคุณลักษณะโดยรวมจะลดลง ($p<0.05$) ตามปริมาณเพกตินที่เติมเพิ่มขึ้น โดยที่ปริมาณเพกติน 0.25% ได้รับคะแนนการยอมรับในคุณลักษณะเนื้อสัมผัสภายในปาก (mouthfeel) สูงที่สุด งานวิจัยนี้จึงคัดเลือกปริมาณใยอาหารที่ละลายได้ในรูปเพกติน 0.25% เป็นปริมาณที่เหมาะสมสำหรับกระบวนการผลิตน้ำฝรั่งชนิดเติมใยอาหารต่อไป**

**ภาควิชาเทคโนโลยีอาหาร คณะอุตสาหกรรมเกษตร มหาวิทยาลัยสงขลานครินทร์ อำเภอหาดใหญ่ จังหวัดสงขลา 90112**

Guava (*Psidium guajava* L.), which belongs to the Myrtaceae family, is a native of tropical America and is widespread throughout the tropical and subtropical areas (Chopda and Barrett, 2001). Guava is consumed fresh or made into processed products such as juice, nectar, puree, jam and jelly (Kashyap *et al*., 2001). Guava fruit not only has exotic flavor but also is a rich source of relatively low methoxylated pectin (50%) amounting to more than 10% of the dry weight. Therefore, guava juice has special characteristics in its flavor and viscosity, which is popular in many tropical countries (Yen and Lin, 1998).

Commercial guava juice processing normally involves the use of pectinase enzymes to increase juice yield from pressed guava peel and pulp

(Alkorta *et al*., 1998). Guava cake (peel, pulp and seeds) a by-product from juice production, accounts for 30% of the guava fruit weight and is commonly used as animal feed or fertilizer. However, very recent investigations indicate that guava peel and pulp can also be used as a new source of dietary fiber (DF) and antioxidant phenolic compounds (Jimenez-Escrig *et al*., 2001).

The DF includes plant substances that resist the action of human digestive enzymes. Total DF is divided into two major fractions: water-soluble (pectin, gum) and water-insoluble (cellulose, lignin, some of the hemicellulose). The latter is mainly credited for regulating bowl movement whereas the soluble fraction is chiefly involved in lowering blood cholesterol and glucose adsorption (Grigelmo-Miguel and Martin-Belloso, 1999)

Therefore, guava cake may be a valuable food ingredient, especially as a supplement in guava product itself. The objectives of this study were: (a) to study the extraction method and chemical and physical properties of crude pectin from guava cake; (b) to study the optimum enzyme concentration and incubation time to increase the yield of guava juice; (c) to formulate the optimum °Brix to acid ratio for guava juice processing; and (d) to determine an acceptable concentration of crude pectin for the fortification of guava juice.

## Materials and methods

### 1. Extraction and characterization of pectin

#### 1.1 Preparation of dried guava cake

Dried guava cake was prepared by the method of Satra (1999). Guava cake (peel, pulp and seeds) was obtained directly from a commercial guava juice processing plant. The guava cake was washed with water three times, wrapped in cheesecloth and pressed to remove liquid and dried in an air dryer at 60°C for 6-8 h to obtain dried press cake with 8% moisture content. The dried sample was ground using a blender at speed 1 (National, Tokyo, Japan). The guava cake powder was immediately packed in a nylon-bag, vacuum sealed with a vacuum sealer (Henkovac, Germany) and stored at 4°C before use.

#### 1.2 The extraction of pectin

Pectin was extracted from guava cake powder by the method of Iglesias and Lozano (2004) with a slight modification. The powder was washed with hot water (50 g powder: 1 L hot water) at 75°C for 15 min to remove pigments, then filtered through cheesecloth. A solution of 0.75% sodium hexametaphosphate (Ajax-Finechem, NSW, Australia) was prepared and mixed with the washed powder at the ratio of 50 g powder to 1 L solution. The pH of slurry was adjusted to 3.5 with 6 N hydrochloric acid then incubated in a water bath (Model WB/OB7-45, Memmert, Schwabach, Germany) at a constant temperature of 75°C for 1 h. During incubation period, the slurry was stirred with a spatula every 15 min.

After the incubation, the solution was filtered through a Buchner funnel with a Whatman No.4 filter paper and diatomaceous earth pre-coat. The filtrate was concentrated in a Rotary vacuum evaporator (Model-1000, Eyela, Japan) at 55°C to a volume of 500 ml. The concentrated filtrate was precipitated with acidified ethanol (Concentrated filtrate : 1 N HCl : 95% ethanol = 4:1:3), allowed to stand overnight at 4°C, then centrifuged at 3,500 xg for 15 min at 4°C with a refrigerated centrifuge (Model RC-5B plus, Sorvall, U.S.A.). The crude pectin slurry was washed with 70% ethanol to remove HCl and dried in a hot air oven at 50°C for 24 h. The dried crude pectin was ground to powder. The % yield of the extraction was calculated as Y = (weight of pectin after extraction/weight of dried guava cake) x 100.

#### 1.3 Determination of chemical and physical properties of crude pectin

All reagents were analytical grade. The α-amylase, protease and amyloglucosidase were purchased from Sigma Co. (St. Louis, MO., U.S.A.) for soluble dietary fiber (SDF) analysis.

Crude pectin powder was analyzed for moisture, ash and protein contents according to AOAC (2000). Soluble dietary fiber content of crude pectin was also analyzed according to AOAC (2000) method 993.19.

A 2% (w/v) solution of crude pectin powder was prepared for pH measurement with a

glass-electrode pH-meter (Model PB-20, Sartorius, U.S.A.). The color of the powder was measured with Hunter Colorimeter (Model ColorFlex, HunterLab, U.S.A.). Results were expressed in CIE *L**, *a**, *b** values.

Bulk density was determined by filling a preweighted 25 ml graduate cylinder with crude powder and shaking slightly. The volume of the crude powder was recorded and the content of the cylinder was weighed. The bulk density was expressed as weight per volume. Water-Holding Capacity (WHC) of the crude pectin powder was determined according to the method of Chen *et al.* (1988) with a slight modification. A 250 mg sample of crude pectin powder was placed into a 50 ml centrifuge tube, distilled water was added to bring the total volume to 25 ml, and stirred occasionally with a stirring rod. The slurry was allowed to stand for 60 min then centrifuged at 10,000 xg for 15 min. After centrifugation, the supernatant was drained and the content of the precipitate was quantitatively transferred to a moisture dish and the moisture content measured according to AOAC (2000). WHC of crude pectin was expressed as gram of water held per gram dried sample. All experiments were done in triplicate.

## 2. Production of guava juice with enzyme treatment

### 2.1 Guava juice preparation

Guava fruits (*P. guajava* L.), variety locally known as Pan Seethong with 80-90% maturity, were bought from a local market in Hat Yai, Songkhla province. The fruits were washed with tap water and trimmed to remove blemishs then cut in half. Seeds and central seed pulp were removed and the remaining unpeeled flesh was cut into small pieces and placed into a juice extractor. The extracted guava juice and cake were used for further studies.

### 2.2 Enzyme treatment for juice extraction

Enzyme treatment to optimize juice production was carried out according to the method described by Brasil *et al.* (1996) with a slight modification. Sample of 40 g and 100 g cake obtained previously were placed 40 g and 100 g each in twelve 250 ml beakers. Enzyme pectinase (derived from *Aspergillus niger*, E.C.3.2.1.15, P 4716, 25,000 PG units, Sigma Co., St Louis, MO., U.S.A.) was placed 5, 10 and 15 ml in each of the three 100 ml volumetric flasks, immediately added citrate buffer solution (pH 4.0) to bring total volume to 100 ml in each volumetric flask. 1.4 ml pectinase solution from each volumetric flask was added to each of the twelve beakers containing guava cake sample, stirred well and incubated in a water bath at 45°C to attain a product temperature of 45°C for 1.5, 2.0 and 2.5 h with occasionally stirring every 30 min. The guava cake without pectinase treatment was used as a control. After reaching each incubation times, immediately heated the pectinase treated sample at 90°C for 2 min with constant stirring to stop the reaction of pectinase. The juice was then extracted from the pectinase treated sample by pressing passed through a cheesecloth bag. Percent yield (w/w) was calculated by weighing the juice obtained from pressing the pectinase-treated sample.

Sample pH was measured with a glass-electrode pH-meter; total soluble solids (°Brix) were measured with a refractometer (N1 Brix 0~32%, Atago, Tokyo, Japan); and the color was measured with Hunter Colorimeter (Model ColorQuest XT, HunterLab, U.S.A.) using 50 ml of juice and expressed in CIE *L**, *a**, *b** values. From this study, an optimum enzyme concentration and incubation time were selected for subsequent guava juice processing.

### 2.3 Guava juice formulation

The selected optimum enzyme concentration and incubation time were used to prepare guava juice in the same manner as described in 2.2. Guava juice was formulated with five different °Brix to acid ratios, including 24.0, 28.0, 32.0, 35.0 and 40.0 as shown in Table 1, pasteurized at 85°C for 5 min, cooled and stored at 4°C before sensory evaluation.

### 2.4 Sensory Evaluation

A 9-point hedonic scale (Larmond, 1977) was used to determine which °Brix to acid ratio in guava juice was most liked. Thirty panelists

(Prince of Songkla University students) evaluated guava juice with five different °Brix to acid ratios as described above. Sensory evaluated attributes included: color, turbidity, odor, flavor and overall acceptability.

**3. Production of guava juice fortified with pectin as dietary fiber**

**3.1 Preparation of guava juice fortified with pectin**

Crude pectin was obtained from guava cake extraction and guava juice was prepared with selected optimal formulation as described in 1.2 and 2.3, respectively. Formulated guava juice was added with various amounts of crude pectin contents including 0.00, 0.25, 0.50 and 0.75% (w/w), heated to reach the temperature of 85°C at the coldest heating point, immediately filled into 300 ml glass bottles, capped and pasteurized with a steam water spray automated batch retort (FMC Food Tech, Belgium) at processing temperature of 101°C for 7 min. Guava juice product was measured chemical and physical properties, sensory evaluation was also conducted.

**3.2 Measurements of chemical and physical properties**

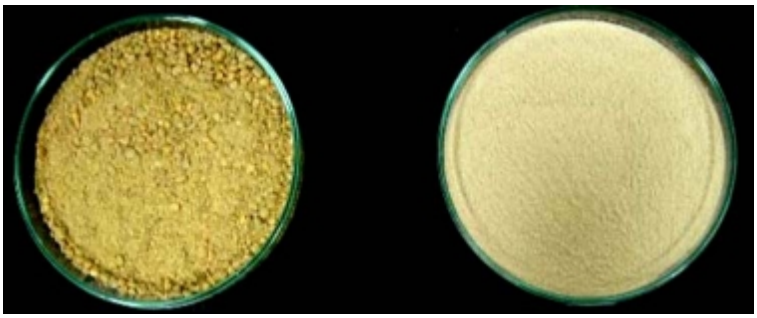
The pH and total soluble solids (°Brix) were measured according to the methods as described above. Total acidity was measured using standard 1% phenolphthalein solution, titrated against 0.1 N NaOH, the result was expressed as gram of anhydrous citric acid per 100 g of sample. The color was measured as described above; turbidity was measured using the percent transmission at 650 nm with Hunter Colorimeter (Model ColorQuest XT). 100 ml of juice was poured into 250 ml beaker, allowed to stand for 3 h, 40 ml of the supernatant was transferred to a glass cell, the percent transmittance was determined using water as a blank. Viscosity was measured with Brookfield viscometer (Model DV-II+, U.S.A.) using spindles #1 at 15°C.

**3.3 Sensory evaluation of guava juice product**

To evaluate which pectin concentration of fortified guava juice was most liked, thirty panelists evaluated guava juice products using a 9-point hedonic scale with similar manner as described in 2.4. Sensory evaluation attributes included: color, turbidity, odor, flavor, mouthfeel and overall acceptability.

**4. Statistical analyses**

All experiments were conducted in duplicate. Data in 2.2 were analyzed using two-way analysis of variance (ANOVA). The sensory evaluation data conducted in 2.4 and 3.3 were analyzed using randomized complete block (panelists) design with one-way treatment structure. Data from 3.2 was analyzed as a completely randomized design. Significant level was established at $p \leq 0.05$. Duncan's New Multiple Range Test



**A: Dried guava press cake (peel, pulp, seeds)** **B: Crude pectin powder**

**Figure 1. A: Dried guava press cake B: Crude pectin powder produced from dried guava press cake**

**Table 1. Five different °Brix to acid ratios of guava juices**

| Formula | Total soluble solids (°Brix) | Total acidity (as % citric acid) | °Brix - acid ratio |
|---|---|---|---|
| 1 | 12 | 0.5 | 24 |
| 2 | 14 | 0.5 | 28 |
| 3 | 16 | 0.5 | 32 |
| 4 | 14 | 0.4 | 35 |
| 5 | 16 | 0.4 | 40 |

**Table 2. Chemical and physical properties of crude pectin powder**

| Chemical properties | Crude pectin** | Physical properties | Crude pectin** |
|---|---|---|---|
| Moisture | 4.71±0.18 | *L** | 81.17±0.21 |
| Protein | 0.34±0.21 | *a** | 4.76±0.04 |
| Ash | 68.48±0.26 | *b** | 15.43±0.07 |
| SDF | 20.70±0.16 | WHC (g.water/g.solid) | 0.90±0.01 |
| pH | 3.06±0.02 | Bulk density (g/ml) | 0.96±0.05 |

****Determination was done in triplicate**

(DMRT) was used to determine significant difference between treatment means. SPSS for Window Version 10.5 was used for all statistical analyses.

## Results and discussion

### 1. Extraction and characterization of crude pectin

#### 1.1 Chemical and physical properties of crude pectin

Figure 1 shows dried guava press cake and crude pectin powder from dried guava cake. The observed yield of crude pectin was 30.50± 0.34% (dried weight basis) that is not shown. Chemical and physical properties of crude pectin powder are shown in Table 2. From the result, crude pectin contained 68.48±0.26% (dwb) ash, whereas a low protein content of 0.34±0.21% (dwb) was observed. The CIE LAB color was studied, the following color coordinate was determined: lightness (*L**), redness (*a**, red-green) and yellowness (*b**, yellow-blue) (Lario *et al*., 2003). *L**, *a** and *b** values of crude pectin were 81.17±0.04, 4.76±0.04 and 15.43±0.07, respectively. The observed lightness of crude pectin was pretty close to that of commercial pectin (*L** = 80.57) which reported by Pattanagul *et al*. (2005).

The particle size, chemical composition and structure of dietary fiber influenced the water-holding capacity that had a significant effect on fecal output and stool hardness. The WHC of crude pectin was low (0.90±0.01 g water/g solid), whereas, bulk density was high (0.96±0.05 g/cm$^3$). Lario *et al*. (2003) reported that water holding capacity depended on fiber production processing and also on its chemical and physical structure.

### 2. Production of guava juice with enzyme treatment

#### 2.1 Enzyme treatment for juice extraction

The effects of enzyme treatment at different enzyme concentrations and incubation times are shown in Table 3. As enzyme concentrations and incubation times increased, a gradual increase in °Brix was observed along with a decreased in pH. Similar results were obtained by Imungi *et al*. (1980), Askar *et al*. (1992), Brasil *et al*. (1995) and Chopda and Barrett (2001). Pectinase enzyme which released carboxylic acids and

**Table 3. Effects of enzyme concentrations and incubation times on guava juice**

| Enzyme Concentration (%) | Incubation time (h) | % Yield | pH | °Brix | Color | | |
|---|---|---|---|---|---|---|---|
| | | | | | *L** | *a** | *b** |
| 0 | 0 | 67.56±0.31$^{j}$ | 4.08±0.03$^{a}$ | 9.27±0.24$^{d}$ | 64.35±0.60$^{a}$ | 2.18±0.08$^{ns}$ | 25.23±0.21$^{e}$ |
| 0.05 | 1.5 | 70.71±0.42$^{i}$ | 3.84±0.03$^{b}$ | 10.37±0.14$^{c}$ | 33.90±0.58$^{bc}$ | 2.10±0.17$^{ns}$ | 27.96±0.44$^{c}$ |
| | 2.0 | 74.18±0.15$^{h}$ | 3.78±0.02$^{c}$ | 10.57±0.15$^{bc}$ | 33.51±0.94$^{bc}$ | 2.26±0.36$^{ns}$ | 27.03±0.60$^{d}$ |
| | 2.5 | 75.42±0.27$^{f}$ | 3.74±0.02$^{de}$ | 10.78±0.08$^{b}$ | 34.36±0.52$^{bc}$ | 2.02±0.38$^{ns}$ | 26.54±0.50$^{d}$ |
| 0.10 | 1.5 | 74.71±0.15$^{g}$ | 3.79±0.03$^{c}$ | 10.68±0.10$^{b}$ | 33.97±0.48$^{bc}$ | 2.77±0.29$^{ns}$ | 28.98±0.47$^{ab}$ |
| | 2.0 | 77.81±0.36$^{d}$ | 3.77±0.02$^{cd}$ | 10.78±0.16$^{b}$ | 33.66±1.01$^{bc}$ | 2.48±0.43$^{ns}$ | 29.08±0.74$^{ab}$ |
| | 2.5 | 79.40±0.30$^{b}$ | 3.73±0.02$^{ef}$ | 11.07±0.21$^{a}$ | 34.18±0.56$^{bc}$ | 2.03±0.44$^{ns}$ | 28.90±0.96$^{ab}$ |
| 0.15 | 1.5 | 76.45±0.35$^{e}$ | 3.77±0.03$^{cd}$ | 10.68±0.08$^{b}$ | 33.67±0.62$^{bc}$ | 2.42±0.46$^{ns}$ | 28.51±0.61$^{abc}$ |
| | 2.0 | 78.56±0.34$^{c}$ | 3.73±0.02$^{ef}$ | 10.78±0.19$^{b}$ | 31.78±0.99$^{d}$ | 2.80±0.82$^{ns}$ | 29.20±0.93$^{a}$ |
| | 2.5 | 79.89±0.24$^{a}$ | 3.70±0.03$^{f}$ | 11.18±0.13$^{a}$ | 33.36±0.64$^{bc}$ | 2.33±0.28$^{ns}$ | 29.23±0.56$^{a}$ |

**Means ± standard deviation in each column with the same letters are not significantly different (p > 0.05)**

galacturonic acid during enzyme treatment might contribute to a decrease in pH of guava press cake sample (El-Zoghbi *et al*., 1992).

The %yield of guava juice increased, with increasing of pectinase concentrations and incubation times. Chopda and Barrett (2001) reported that pectinase assisted in pectin hydrolysis, which caused a reduction in pulp viscosity and a significant increased in juice yield. Yields of cloudy juice were significantly affected by temperature and time used for enzyme treatments. The results also showed that significantly high yields of guava juice were obtained using 0.15% pectinase concentration incubated for 2.5 h, however, the enzyme treatment of 0.10% pectinase concentration incubated for 2.5 h was found to be the best suit for commercial application, regarding to the efficiency and its cost-effective. Therefore, the selected optimum pectinase concentration and incubation time for juice processing were 0.10% and 2.5 h, respectively.

### 2.2 Sensory Evaluation

Table 4 shows the results of sensory evaluation of guava juice with five different °Brix to acid ratios. The perceived scores of color attributes from the °Brix to acid ratios of 24, 32, 35 were significantly ($p<0.05$) less than those from °Brix to acid ratios of 28 and 40. The likeness scores for turbidity, odor, flavor and overall acceptability of guava juice with °Brix to acid ratio of 40 were significant greater than those of guava juice with °Brix to acid ratios of 24, 28, 32 and 35. It also noted that perceived likeness scores for all attributes shown in Table 4 were in the range of like moderately to like slightly. Moreover, commercial guava juice contained the °Brix to acid ratio ranged from 37 to 45. This study also pointed out that guava juice with the °Brix to acid ratio of 40 was significantly greatest preferred in the overall acceptance. Therefore, 40 °Brix to acid ratio was selected for subsequent guava juice processing.

## 3. Production of guava juice fortified with dietary fiber

### 3.1 Chemical and physical properties of guava juice fortified with pectin

Table 5 shows the results of chemical and physical properties of guava juice fortified with pectin. It was found that the greater the pectin was added (0, 0.25, 0.5, 0.75%) the lower the pH and % transmittance were obtained. In contrary to the total acidity and viscosity of fortified guava juice. This may be due to the hydrolysis of guava pectin occuring during juice processing. Wilson (1980) reported that hydrolyzed guava pectin contained 72% D-galacturonic acid, 12% D-galactose and 4% L-arabinose. The greater the

**Table 4. Sensory evaluation of guava juice with different ºBrix to acid ratio**

| Formula | Total soluble solids (ºBrix) | Total acidity (as % citric acid) | ºBrix to acid ratio | Sensory attributes | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Color | Turbidity | Odor | Flavor | Overall acceptability |
| 1 | 12 | 0.5 | 24 | 7.03±0.85$^{b}$ | 6.57±0.90$^{b}$ | 6.37±1.00$^{c}$ | 5.93±1.23$^{d}$ | 6.13±1.01$^{c}$ |
| 2 | 14 | 0.5 | 28 | 7.27±0.83$^{a}$ | 6.53±1.04$^{b}$ | 6.57±0.97$^{bc}$ | 6.43±0.97$^{c}$ | 6.63±0.96$^{b}$ |
| 3 | 16 | 0.5 | 32 | 7.07±1.01$^{b}$ | 6.63±1.16$^{b}$ | 6.67±0.84$^{b}$ | 7.07±0.87$^{ab}$ | 6.80±0.85$^{b}$ |
| 4 | 14 | 0.4 | 35 | 7.10±0.76$^{b}$ | 6.63±0.93$^{b}$ | 6.50±0.68$^{bc}$ | 6.93±0.91$^{b}$ | 6.80±0.92$^{b}$ |
| 5 | 16 | 0.4 | 40 | 7.30±0.79$^{a}$ | 6.87±0.82$^{a}$ | 6.80±0.71$^{a}$ | 7.17±1.05$^{a}$ | 7.30±0.65$^{a}$ |

**Means ± standard deviation in each column with the same letters are not significantly different (p > 0.05)**

**Table 5. Chemical and physical properties of fortified guava juice**

| Pectin (%) | Chemical and physical properties of guava juice | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | ºBrix | Total acidity (%) | *L** | *a** | *b** | %Transmittance (650 nm.) | Viscosity (Cps.) |
| 0 | 4.30±0.06$^{a}$ | 15.80±0.37$^{a}$ | 0.40±0.01$^{d}$ | 24.15±1.08$^{c}$ | 0.47±0.29$^{b}$ | 34.17±0.59$^{b}$ | 24.33±1.01$^{a}$ | 14.68±0.36$^{d}$ |
| 0.25 | 4.23±0.03$^{b}$ | 15.50±0.15$^{ab}$ | 0.47±0.01$^{c}$ | 26.34±0.32$^{a}$ | 0.18±0.03$^{c}$ | 35.82±0.21$^{a}$ | 22.65±0.74$^{b}$ | 17.48±0.32$^{c}$ |
| 0.50 | 4.20±0.05$^{bc}$ | 15.27±0.16$^{b}$ | 0.56±0.01$^{b}$ | 25.69±1.07$^{ab}$ | 0.74±0.09$^{a}$ | 35.52 ±0.52$^{a}$ | 22.82±0.48$^{b}$ | 21.90±0.77$^{b}$ |
| 0.75 | 4.14±0.04$^{c}$ | 15.27±0.55$^{b}$ | 0.63±0.02$^{a}$ | 25.04±0.79$^{bc}$ | 0.77±0.14$^{a}$ | 35.44±0.53$^{a}$ | 19.44±0.51$^{c}$ | 25.32±1.37$^{a}$ |

**Means ± standard deviation in each column with the same letters are not significantly different (p > 0.05)**

amount of D-galacturonic acid, the lower the pH was observed. Contrary to the pH, the greater the total acidity was obtained. In addition, decreasing the ratio of dissociated to nondissociated acid groups by lowering the pH rendered pectin molecules reducing in hydrophilic portions, contributing to great tendency to form gels which paid a major role in increasing the viscosity of guava juice (Wang *et al.*, 2002). The ºBrix of fortified juice was less than that of the control. The *L** (lightness, *L** = 25.04-26.34) and *b** values (yellowness, yellow to blue, b* = 35.44-35.82) of fortified guava juice were significantly different than those of the control (*L** = 24.15, *b** = 34.17). The *a** value (redness, red to green) of 0.25% pectin fortified guava juice was significantly less than that of the control. Whereas the 0.50 and 0.75% pectin fortified guava juices had the *a** values greater than that of control. The results pointed out that 0.50%-0.75% pectin fortified guava juices were more green, more red and lighter than the control.

### 3.2 Sensory evaluation of fortified guava juice

Table 6 shows the sensory evaluation of fortified guava juice. The sensory attributes including color, turbidity, odor, flavor, mouthfeel and overall acceptability were evaluated by 30 panelists. It was found that the greater the amounts of crude pectin were added, the less the perceived scores in almost all attributes were observed. Therefore, the amount of 0.25% crude pectin was selected for subsequent guava juice processing. As compared to the control (0% pectin), the results pointed out that guava juice fortified with 0.25% crude pectin was not significantly different (p> 0.05) in the observed percieved scoras of sensory attributes including color, flavor, mouthfeel and overall acceptability. Whereas the percieved scores in turbidity and odor attributes were less signi-

**Table 6. Sensory evaluation of fortified guava juice**

| Treatment | Pectin (%) | Sensory attributes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Color | Turbidity | Odor | Flavor | Mouthfeel | Overall acceptability |
| 1 | 0 | 7.47±0.51[a] | 7.13±0.57[a] | 7.07±0.78[a] | 7.27±0.78[a] | 7.13±0.68[a] | 7.27±0.74[a] |
| 2 | 0.25 | 7.40±0.68[a] | 6.90±0.71[b] | 6.27±0.74[b] | 7.33±0.66[a] | 7.17±0.53[a] | 7.23±0.57[a] |
| 3 | 0.50 | 7.30±0.65[a] | 6.90±0.66[b] | 6.03±0.81[c] | 6.63±0.56[b] | 6.90±0.61[b] | 6.67±0.48[b] |
| 4 | 0.75 | 6.80±0.76[b] | 6.80±0.66[b] | 5.67±1.09[d] | 6.77±0.86[b] | 6.80±0.71[b] | 6.53±0.68[b] |

**Means ± standard deviation in each column with the same letters are not significantly different (p > 0.05)**


**Figure 2. A: Guava juice without crude pectin fortification, B: Guava juice fortified with crude pectin**

ficantly different ($p<0.05$) than those of the control. This may be due to most panelists preferred natural aroma flavor of guava juice significantly greater than those of guava juice fortified with crude guava pectin. Crude pectin added into guava juice influenced on the likeness in flavor of fortified guava juice. Figure 2 shows guava juice without crude pectin fortification and guava juice fortified with crude pectin.

## Conclusions

Pectin extraction from commercial guava cake was performed and 30.50±0.34% yield of crude guava pectin containing 20.70±0.16% SDF was achieved. The optimum conditions for guava juice extraction were 0.10% v/v pectinase concentration and incubation time of 2 h at 45°C. It was found that guava juice processing was optimized at the °Brix to acid ratio of 40, followed by the addition of 0.25% crude pectin (soluble dietary fiber), and pasteurization at 110°C for 7 min. As compared to guava juice without the addition of crude pectin (control), there was no significant difference in perceived sensory scores from almost all evaluated attributes except the turbidity and odor attributes. This study also suggests that the process of deodorization may be needed for further commercial guava pectin production and utilization.

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