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Product diversification from pomelo peel. Essential oil, Pectin and semi-dried pomelo peel

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Currently, agriculture has shifted to green production, in which the recycling of post-production by-products is a key issue. In the present work, by-products such as pomelos were studied to promote consumption and enhance the value of pomelo. From pomelo material, essential oils extracted from pomelo peels, pectin, and drying pomelo products have been diversified. In the extraction process of essential oils, the hydrodistillation method was applied in conjunction with the response surface method to obtain the optimal conditions of influence factors. These essential oils were quantified as well as determined for components by GC-MS. The pectin recognition process was done by immersion method in HCl acid (pH 2) and the drying process was made with a heat pump dryer under the effects of drying temperature, drying time and wind rate. The results of the essential oil products reached the highest (0.88 ±0.006 g) at the material size of 3 mm, the distillation time of 27 min, and the ratio of raw materials/solvents of 1/12 g/mL. The main components found in pomelo peeling essential oils included limonene (71.768%), γ-terponene (12,847%), α-Phellandrene (2.979%), β-myrcene (2.668%), 1R-α-pinene (2,656%), and β-pinene (1,191%). The pectin content was the highest under the temperature of 90 °C, extraction time of 60 min and ratio/solvent ratio of 1:32 g/mL. Under these extraction conditions, 48% of concentrated pectin content was obtained. Surveying conditions for drying white pomelo peels are capable of reversing: refunded drying pomelos are drying heat pumps in the following conditions: 50 °C drying temperature, the drying time of 90 min, and wind rate of 12 m/s. Product with hardness 309.862 N.

Keywords: Citrus grandis, Pomelo peel essential oil, Extract pectin, Pomelo peels products.

INTRODUCTION

Pomelo (*Citrus grandis*), which is commonly known as Nam Roi, belongs to the Rutaceae family and is popular around the world[1]. In Vietnam, it was grown firstly in Thanh Tan commune, Mo Cay Bac district, Ben Tre province and then spread across the country with many different varieties. Pomelo is one of Vietnam's main fruit trees, according to the report of the General Department of Economic Socio-Economic Reports, the General Statistics Office, the pomelo production is 433.9 thousand tons, which accounts for up to 7.5% of total fruit production, and focuses mainly in the Mekong Delta region. Today, with the advanced development of science and technology, the peels, seeds, and leaves of pomelo have been paid attention to and gradually put into research[2–4] in pharmaceuticals, food and cosmetics industries.

Pomelo is also known to contain some antioxidants, flavonoids and polyphenols, essential oils, and pectin[5–6]. Products related to pomelo peels such as pomelo peel powder are being interested in being used as an appetizer, anti-toxic, heart stimulation, and stomach tonic[7]. Pomelo peels contain high amounts of essential oils with typical fragrances that exhibit antibacterial, pain-relief, sedative, and anti-inflammatory activities. The chemical composition and antibacterial activity of the essential oil from the Shatian pomelo (*Citrus Grandis* Osbeck) have been reported with sesquiterpene and monoterpene hydrocarbon being the main compound groups with 96.64% (w/w), in which Limonene accounted for (89.96 ±1.64%), β-myrcene (4.49 ±0.38%), α-pinene (0.63 ±0.05%), 3-carene (0.48 ±0.04%), caryophyllene (0.47 ±0.04%) and other small components[8]. Malaysia pomelo peel (*Citrus Grandis* (L.) Osbeck) contained a high aldehyde content (e.g. octal, decana and citral), while some important compounds were at the trace level (e.g. β-sinensal, α -sinensal and nootkatone)[9]. The chemical composition of essential oil compounds in Citrus species (Venezuela) has been published and the main component was Linalool (50.31%) and inhibition against *Escherichia coli*, *Staphylococcus aureus,* and *Pseudomonas* have been identified. The results of contributing the quality control criteria of industrial essential oil production in separators, Venezuela[10]. The antioxidant ability of 30 types of Citrus essential oils and 14 antioxidant components have been studied (H.S. Song et al., 2001)[11]. Pectin is a high compound polygalactoronic molecule with a single molecular galactoronic and metylic The enriched content of Pectin in pomelo peels is used as a glue, thickener and emulsification factor in pharmaceutical, and food products[12–13].

One of the problems when consuming pomelos is a very low content of fruit pulp. This is the common characteristic of citrus trees as the shells often account for 50% of by-products. Thus, to promote consumption and enhance the value of pomelos at the same time, product development is necessary. Diversifying products from the components of the pomelo and especially recycling the process waste to enhance the value of pomelos are the potential directions and construction opportunities for pomelo products. For this reason, the study was conducted to examine the

conditions of extracting oil and pectin from pomelos, and the utilization of pomelo fruits to make drying pomelo peel products.

MATERIALS AND RESEARCH METHODS

Raw materials, chemicals and equipment

Material: Nam Roi pomelo peel (*Citrus Grandis* L.) was purchased at Thu Duc Market, Ho Chi Minh City, Vietnam (latitudes 10°49'36"N and longitudes 106°45'39"E) in November 2020.

Chemicals: sodium sulphate, ethanol, acetic acid, clohydric acid, calcium chloride anhydrous, sodium hydroxide purchased from Xilong, China with 99% purity.

Equipment: Heating Mantle heater (Glassco Laboratory Equipment Pvt. Ltd., India); Blender KL-303 (Khaluck. Home, Vietnam); TA-XT PLUS structure meter (Stable Microsystem, USA); Meters of PH S220 (Mettler Toledo, Switzerland), Memmert WNB.14 Thermostat Tank (Memmert, Germany), Memmert Unb 40 (Memmert, German), EBA 200 centrifuge (Hettich, Germany).

Extraction of essential oil

Pomelo peels were washed, drained, and had the white peel removed prior to the extraction process. 100 g of pomelo peels were placed into a blender with a surveyed water to raw materials ratio. The raw material after grinding was transferred to a small 2000 mL container to conduct essential oil distillation during different periods until the amount of essential oil tended to increase (Fig. 1).

The experiments were completely arranged randomly with the rotating single-type factors: raw material size (5, 3, 2 mm), distillation time (10, 20, 30 min), and raw material/solvent ratio (1/8, 1/9, 1/10, 1/11, 1/12, 1/13 g/mL). Fixed conditions were as follows: 100 g of green pomelo peels material, distillation time of 30 min, the ratio of raw materials/solvents of 1/10 g/mL, and water as the solvent. Three factors of material size, distillation time, the best ratio/solvent ratio were arranged in the rotating axis (Rotatable Central Composite Design) to determine the effects of these factors and optimizations of the essential oil distillation process by response surface methodology (RSM).

The crude oils were poured into a 100 mL glass beaker and then the appropriate amount of Na_2SO_4 is added to anhydrous to obtain essential oils. Samples were stored at 4 °C in dark glass bottles until analysis.

Extraction of pectin

Pomelo peels were used as the raw materials for extracting pectin. Freshly collected pomelos were selected and blanched at 90 °C in 5 seconds[14]. The material after being blanched was dried on a tray at 58.5 °C for 4 h. The materials were flipped after the first 2 h to ensure that both sides of the materials were completely dried and achieved 13.8% of moisture. The dried peels are sieved into different sizes. At the temperature of 50–90 °C (based on previous work by Homa et al.[15] and Salma et al. 2012[16]), different volumes of 0.01 N HCl acid solution were added to 10 g of crushed materials for 60–120 min to extract. A vacuum filter was used to separate the pectin extract from precipitates. After the filtration process, the pectin extract was concentrated at a temperature of 60 °C until the concentration has 18.4% Brix. In this study, the concentrated pectin extracts are used to determine the pectin content in the solution and the quality indicators of the pectin[16].

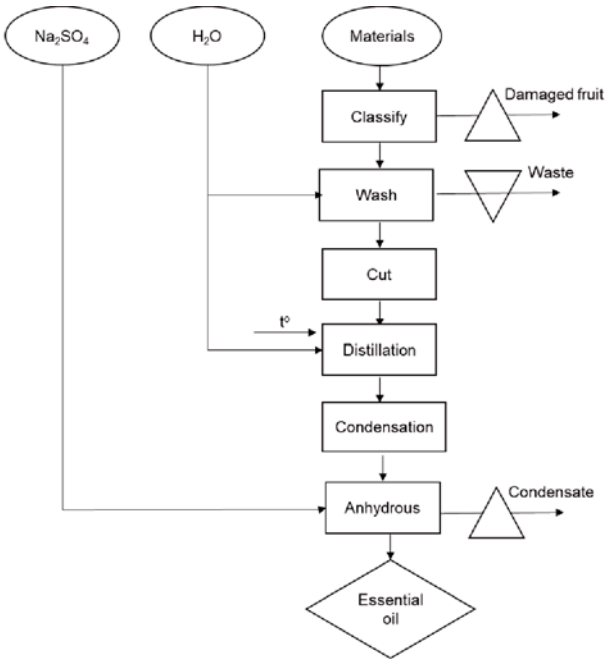

Figure 1. The essential oil extraction process

Estimation for pectin content (%) was completely random with single-type factors: material size D ($D \leq 1$, $1 \leq d \leq 5$, $5 \leq d \leq 20$, $20 \leq D \leq 25$), a ratio of raw materials/solvents (1/24, 1/28, 1/32, 1/36 g/mL) and a completely randomly with variable is hydrolysis time (60, 90, 120 min) and hydrolysis temperature (50, 70, 90 °C). The initial condition is pH 2, 1 h and the ratio of raw materials/solvents is 1/24 (g/mL).

Pomelo peel drying process

After washing with water several times, the white peel was separated from the green and cut into the size of 30 x 10 x 5 mm. 5 g materials were soaked in 60 mL of alcohol at different concentrations for 1-5 h. After soaking with alcohol, pomelo white peel was rinsed with water many times at 40–60 °C to get rid of the alcohol smell and remove the residual naringin. Then, the pomelo peel was blanched at 90 °C in 30 s and then cooled quickly at 40–50 °C for 15–90 min. The dried materials were stored in zipped bags to avoid environmental damage.

Bitterness removal experiment

The experiment of removing bitterness indicated by naringin concentration (mg/mL) in pomelo peel was performed completely randomly with single-type factors: soaking time (1, 2, 3, 4, 5 h), alcohol concentration (50, 60, 70, 80, 96%), the temperature of the discharge (40, 45, 50, 60 °C), and the number of discharge (1, 2, 3, 4, 5 times). The initial conditions included 500 mL of water for each discharge and the 3 s of mixing time.

Moisture content measurement

The moisture content of drying materials (%) was investigated completely randomly with single-type fac-

tors: drying time (15, 30, 45, 60, 75, 90 min) and drying temperature (40, 45, 50 °C).

Survey after drying

The post-drying process was surveyed completely randomly with single-type factors: soak water temperature (room temperature, 50 °C, 100 °C), and soaking time (1, 2, 3, 4, 5 h).

Analysis method

Moisture index of pomelo peels is determined by drying method to constant mass, ash defined according to TCVN 5253: 1990; The pH index of the material is measured by adding 50 mL of distilled water to 10 g of pomelo peels that was grounded and filtered. Quantification of glucose sugar, saccharose in pomelo shells by Bertrand method and acid hydrolysis method ([17]; the volume of pomelo essential oil after distillation was determined according to TCVN 189: 1993 and components analysis was according to the GC/MS method[18–19].

Operating conditions of GC-MS:

The chemical composition of the pomelo fruit oil was determined by GC–MS analysis using GC Agilent 6890 N instrument coupled with HP5-MS capillary column (30 mm × 0.25 mm × 0.25 mm) and MS 5973 inert. The carrier gas was He. The split rate was set at 1:50. The pressure of the head column was 9.3 psi. 25 mL of essential oil was added with 1.0 mL n-hexane and dehydrated with Na_2SO_4. The flow rate was constant at 1 mL/min. Injector temperature is 250 °C and the rate of division is 30. Oven program for samples: 50 °C kept for 2 min, then increased by 2 °C/min to 80 °C, continued to increase by 5 °C/min to 150 °C, continued to increase by 10 °C/min to 200 °C, increase 20 °C/min to 300 °C hold for 5 min. Spectra compared with the library of NIST database.

The volume of pomelo peels obtained after the drying process was divided by the material volume after soaking; The drying pomelo is stiffened by holding onto the hollow pillar, then a needle head 15 mm was forced until the head pinched through the sample. The measurement was performed in triplicates and data were recorded.

Determination of pectin content by Calci Pectate method: Pectin extracted from the green peel of pomelo, was quantified by using the calcium pectate method. The method is based on the Calcium Pectat salt in the form of a precipitate. A total of 10 g of concentrated pectin was mixed with 100 mL NaOH for 7 hours. Then, $CaCl_2$ 2 N and CH_3COOH 1N were added and the reaction was allowed for 5 min and 1 h, respectively. The mixture was then heated for 5 min, cooled down, and filtered through filter paper to obtain constant mass. The precipitate was dissolved with hot distilled water to remove chlorine ions. Finally, the mixture was allowed to dry at 105 °C to constant mass.

$$P = \frac{m \times 0{,}92 \times 100}{m_p}$$

In which: M is the mass of precipitate Calcium Pectat (g); m_p is the original sample volume (g); P is pectin content (%); 0.92 is the conversion factor from Calcium Pectat to Pectin.

Determination of naringin content: The white pomelo peel soaked in alcohol was added with 0.2 mL of NaOH and 0.2 mL of NaOH 4 N. Absorbance was measured at 420 nm of wavelength. Naringin's standard line equation was applied to estimate the amount of Naringin level that has been removed[16].

Data processing

Each experiment was repeated 3 times, calculated, and graphed with Microsoft® Office Excel 2013 software. ANOVA statistical analysis and Least Significant Difference tests are used to compare the effects of factors, handled with Statgraphics Centurion XV 9 (Statgraphics Technologies, Inc., USA), and support of JMP statistics software 10 with 95% reliability is applied to all statistics.

RESULTS AND DISCUSSION

Pomelos have an average volume of about 968 g/L of fruits, yet the peel accounts for 36.4% of the fruit (about 352 g). For each pomelo peel, the green ones contain 71.5% of the total essential oil content and the remaining is contained by white ones, along with high pectin content. The physicochemical properties of pomelo peels are presented in Table 1.

Surveying the distillation of pomelo essential oils

Three main factors that affect the extraction process have been identified as raw material size, distillation time, and raw material/solvent ratio. Figure 2 shows the

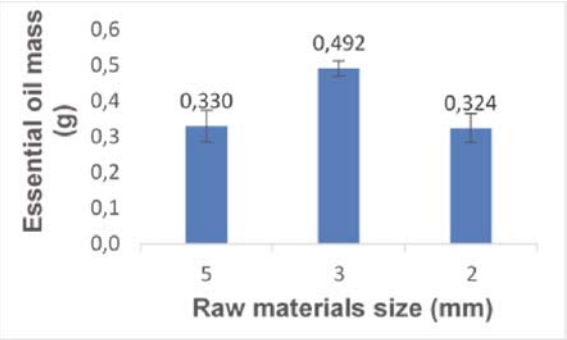

Figure 2. Effect of materials size on essential oil mass

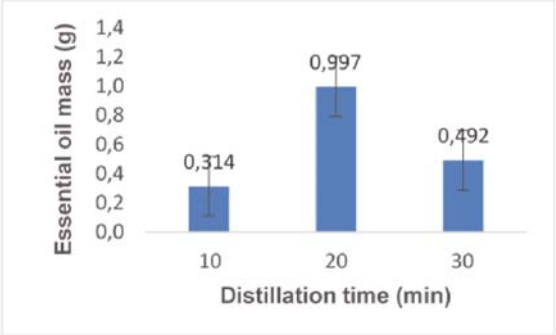

Figure 3. Effect of materials size on essential oil mass

Table 1. The physicochemical property of pomelo peels

Composition / structure	Humidity (%)	Ash (%)	pH	Glucose (%)	Saccharose (%)	Pectin (%)
Raw pomelo peels	80.159 ± 0.03	1.003 ± 0.057	5.327 ± 0.05	0.378	0.228	13.432
green pomelo peels	79.340 ± 0.05	0.820 ± 0.04	5.253 ± 0.02	0.322	0.221	11.031
White pomelo peels	84.28 ± 0.03	0.167 ± 0031	5.267± 0.02	0.02	0.114	7.0748

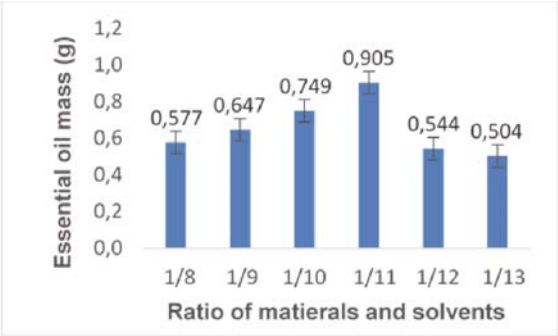

Figure 4. Effect of material/solvent ratio essential oils

effect of raw material size on the obtained essential oil content. When reducing the size of 5 mm to 3 mm, the essential oil volume increases and reaches the highest value of 0.492 g. However, when reducing the size to 2 mm, the amount of essential oil decreases. Different raw material size due to the raw material grinding time in different grinding processes leads to variation in the level of disruption into cells. At the size of 3 mm, the cell wall was broken under the force of the grinder so the essential oil rapidly dissolves into the solvent, thus resulting in high essential oil content. If the size is too big, the essential oil takes a long time to dissolve into the solvent, leading to low quality of the oil. In contrast, the small size with a long grinding time causes the cell wall to break completely, leaking the essential oil into the environment. ANOVA statistical results for P-value = 0.022 <0.05 show that the size of raw materials affects essential oils in 95% confidence. The LSD classification test results indicate the size of 3 mm with a significant difference compared to the size of 5 mm and 2 mm. So raw material size of 3 mm was selected to perform the next experiments.

Figure 3 shows that when increasing distillation time from 10 min to 20 min, the essential oil volume increases significantly and reaches the highest value of 0.997 g. However, the amount of essential oil decreases as the distillation time prolongs to 30 min. The distillation time is an important factor, in allowing the essential oil to separate from the solvent. Statistics ANOVA shows that the distillation time affects the number of essential oils at 95% confidence, confirmed by LSD test. Therefore, 20 min of distillation time is suitable for subsequent experiments.

Figure 4 shows that when increasing the material/solvent ratio from 1/8 to 1/11 g/mL, the essential oil mass increases and the highest value is 0.905 g. The amount of essential oil decreases when the rates of material solvent were 1/12 and 1/13 g/mL. Solvents are an indispensable component during essential oil distillation that is capable of dissolving substances to form a solution. A sufficient amount of solvent could dissolve many essential oils, thus reducing waste and loss of solvents. The ratio of raw materials/solvents such as 1/8, 1/9 and 1/10 g/mL produced the low amount of essential oil of 0.577 g, 0.647 g, and 0.749 g, respectively, as the amount of solvent was not enough for osmosis, diffusion and dissolving the essential oils. The ratio 1/12 and 1/13 g/mL also produced 0.544 g, and 0.504 g of essential oils, respectively, due to excessive solvent, heat, and distillation time. ANOVA results show that the ratio of raw materials/solvents affects essential oils in 95% confidence. The LSD classification test results indicate a ratio of 1/11 g/mL showed a difference from the other rates. Therefore, the ratio of 1/11 g/mL is the most suitable selected to save the used solvent.

From the results of the preliminary survey experiments of factors affecting essential oil content, the following center points were selected: the material size of 3 mm; distillation time of 20 min, and the ratio of 1/11 g/mL. From the selected elements, the optimal experimental matrix is set in a rotating type as Table 2.

Table 2. RSM's optimal experimental layout

Factors \ Code	–1	0	+1
Raw material size (mm)	2	3	5
Distillation time (min)	10	20	30
Ratio of materials and solvents	1/9	1/11	1/13

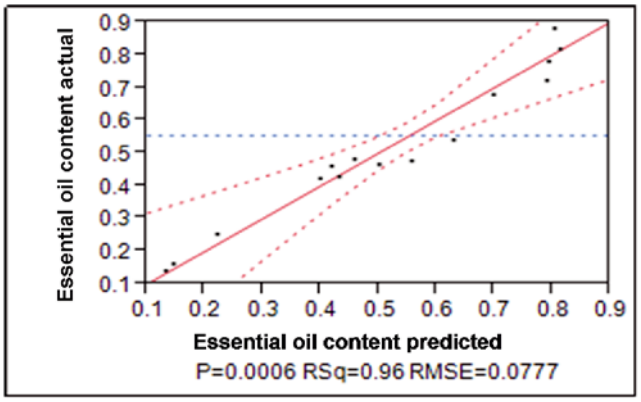

Figure 5. The model predicts essential oil

It can be seen from Figure 5 that the p value = 0.0006 (<0.05) and RSQ = 0.96 (> 0.8) means the linear prediction model is considered good, and suitable to use. Therefore, the equation predicts the essential oil mass:

$$Y = 0{,}8 - 0.07X_1 + 0.08X_2 + 0.14X_3 - 0.09X_1X_2 - 0.18X_1^2 - 0.16X_3^2$$

In which: X_1 is the size of the material (mm), X_2 is the distillation time (min), X_3 is the ratio of raw materials/solvents.

Table 3. Optimal and practical conditions

Factors	Predict	Experimental
Raw material size (mm)	2.633	3
Distillation time (min)	27.576648	27
Ratio of materials and solvents	12.109135	12
Essential oil mass (g)	0.8902322	0.88

When conducting experiments under the above conditions, the actual essential oil mass is 0.88 g (Table 3). The essential oil content is predicted to be 0.89 g, which is 1.15% different from the actual obtained essential oil content. This proves that this model is meaningful and suitable to represent essential oils distillation in pomelos. The components of essential oils were assessed by the GC-MS method and evaporative ingredients in pomelo peel essential oils are shown in Table 4. A total of 10 components have been identified, accounting for 94.11% of the total compounds. As shown in Table 4, the main components include: Limonene (71.768%), γ-Terponene (12,847%), α-Phellandrene (2.979%), β-myrcene (2.668%), 1R-α-pinene (2.656%), and β-pinene (1.191%).

The composition of the remaining four compounds fluctuated 0.501% to 0.767%. A similar result was also reported by Kenya, SM Njoroge et al.[20], where pomelo (*Citrus grandis* Osbeck) grown in Kenya was found to contain 98.8% of essential oils compounds and 94.8% of which was limonene, followed by α-terpinene (1.8%) and α-pinene (0.5%). In China, pomelo essential oil (*Citrus maxima*) obtained by the steam distillation method contained Limonene (46.83%) and β-caryophyllene epoxide (20.17%) as the main components[21]. The richness of volatile compounds in essential oils may be due to the use of different extracts techniques. In addition, the compound of the essential oil also belongs to the growth conditions and harvesting time[22].

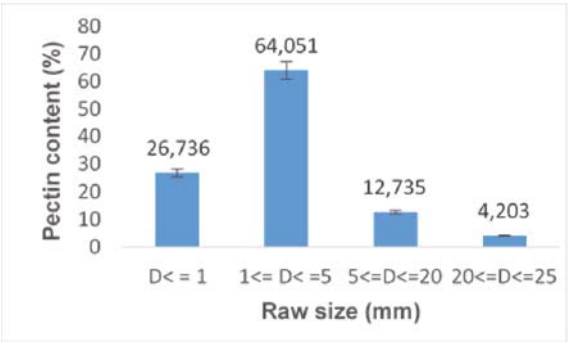

Figure 6. Effect of raw material size on pectin content

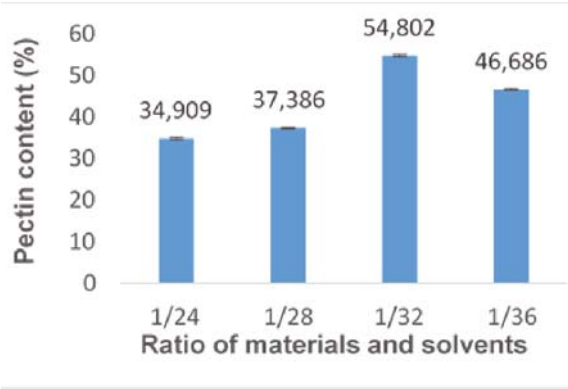

Figure 7. Effect of ratio of materials and solvents on pectin content

Survey pectin extraction process

Figure 6 demonstrates the effect of raw material size on the pectin content. The size of the material is an important factor, changing the exposure surface between raw materials and solvents. Small-sized particles tend to have higher pectin content[23].

High pectin content when the material is small in size D <= 5 and the highest is 64,051% when 1 <= D <= 5. When increasing the material size, the pectin content dropped sharply if D exceeds 5 mm. During the extraction process, small size particles have more advantages than large ones when combined with solvents, as it is easier for them to contact, dissolve into solvents, and facilitate protopectin conversion Pectin[24]. For large--sized raw materials, the solvent is limited to grain cells, the time of penetration is longer, so the pectin content is obtained less. Statistical results ANOVA shows that the size of the material affects the pectin content. The LSD table shows that the size 1 <= D <= 5 is different from the remaining dimensions. So 1 <= D <= 5 was selected as the parameter for the next experiments.

Figure 7 shows that when increasing the rate of solvents in raw materials, the pectin content increases and reaches the highest value of 54.802%. However, the pectin content decreases when the ratio of raw materials/solvents is 1/36. The proportion of solvents is an important factor for pectin content as the rate of increased solvents would increase (1) the surface area between the raw materials and solvents[25], and (2) the dissolution of solids and solvents as it penetrates deeply into the material cells, hence enhancing pectin extraction efficiency. On the other hand, when the solvent reduces a high amount of the pectin content, causing the extract to dilute, the pectin content obtained is low. The results from ANOVA show that the ratio of material/solvent significantly affected the pectin content up to 95%. According to the LSD classification test table, the ratio 1/32 g/mL is significantly different, as compared to the remaining rates. Therefore, the ratio of materials and solvents 1/32 g/mL was selected for the next experiments. The above results are consistent with the research of Bahare et al.[26], the authors have chosen the ratio of 1/30 g/mL when surveying the influence of raw material/solvent on pectin-extraction performance lemon peels.

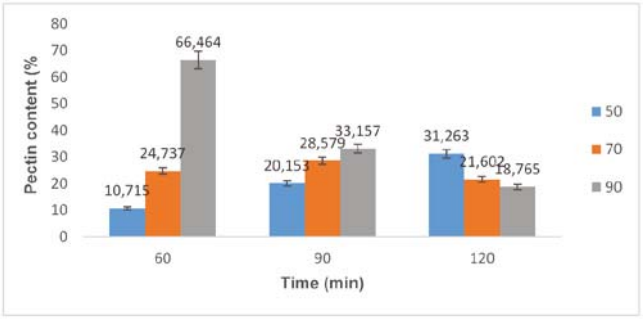

Figure 8. Effect of time and extraction temperaturę on pectin content

Figure 8 shows the effects of time and temperature on pectin content. Time has been found to play a role in increasing the pectin content[26]. The temperature accelerates the solvent and diffusion of the solvent into

Table 4. Essential oil analysis results by GC-MS

No.	Retention (time)	Compound	Percent	MW	Match	R.Match
01	5.287	α-Thujene	0.501	136	884	894
02	5.536	1R-α-Pinene	2.656	136	950	952
03	6.583	Sabinen	0.501	136	903	923
04	6.748	β-Pinene	1.191	136	937	941
05	6.976	β-Myrcene	2.668	136	904	904
06	7.484	α-Phellandrene	2.979	136	920	921
07	8.242	Limonene	71.768	136	954	954
08	8.814	γ-Terponene	12.847	136	956	964
09	9.385	(+)-2-Carene	0.767	136	932	932
10	23.701	Diisooctyl phthalate	0.529	390	880	946

the plant tissues, increasing the pectin extraction productivity[27]. At a temperature of 50 °C and the time of extracting 60 min, the pectin content obtained is 10.715 ±0.004%. When increasing the time to 120 min at the same temperature, the pectin content increased to 31.263 ±0.039%, yet the efficiency has not been significantly improved. If the temperature increases to 90 °C and the extraction time is 60 min, the pectin content is 66.464 ±0.003% produced high-efficiency product quality.

This result is consistent with the study of Xue et al.[28], wherein the process of extracting pectin, acid addition was kept as short as possible to prevent breaking glycoside and ester bonding. This can negatively affect the molecular weight and glue properties of pectin, reducing the pectin content obtained. At a temperature of 90 °C with an extraction period of 90 min and 120 min, the pectin content tends to decrease by 33.157 ±0.049% and 18.765 ±0.023%, respectively. Extracting pectin with high temperatures with extended time can cause pectin hydrolysis into short-chain sugar which is unable to precipitate by using normal acids, thus reducing pectin content[22]. Statistical results ANOVA shows that P-value <0.05, indicating that the temperature and time affected the pectin content with a reliable level of 95%. These two factors interact with each other. LSD results indicate 60 min and 90 °C significantly different from the remaining time and temperature. Therefore, 60 min and 90 °C were selected for the next experiments. Similar results have been reported with Nurul and colleagues[29], Foo et al.[30] selected 60 min and 90 °C when surveying the influence of time and temperature on pectin extraction performance from sweet potato peels.

Surveying the process of drying pomelo

Survey removes bitter matter in pomelo

Figure 9 shows the influence of alcohol concentrations and soaking time on naringin concentration. Alcohol is a common solvent that is capable of dissolving flavonoids, especially naringin. In general, when alcohol concentrations increased from 50% to 96%, causing Naringin concentration decreased. This can be explained because the amount of alcohol is too much-diluted solution, Naringin concentration decreases. When increasing soaking time from 1 h to 5 h, Naringin concentration increase and reach the highest value of 0.0178 mg/ml at 5 h and 50%. However, at the same concentration of 50% alcohol, 5 h and 4 h soaking time has an insignificant difference. Long soaking time causes naringin to dissolve completely into the solvent, increasing the extraction efficiency. ANOVA statistical results show that alcohol concentration and soaking time have an impact on Naringin levels at a 95% confidence level. These two factors interact with each other. Implementing the LSD classification test on the concentration shows a distinct difference at 50% concentration, as compared to 60, 70, 80 and 96% concentration. LSD results of time show that 5 h was significantly different from 1, 2, 3, and 4 h. Therefore, alcohol content of 50% and the soaking time of 5 h were selected to perform the next experiments. The above results are both similar to the studies of Zhou et al.[31], where 50% and 90 min have been selected when surveying the influence of alcohol content and extraction time Naringin levels from pomelos. On the other hand, Nguyen Cam Van et al.[32] showed that 70% alcohol concentration in 1 h is suitable for extraction of naringin from pomelo by ultrasonic extraction method.

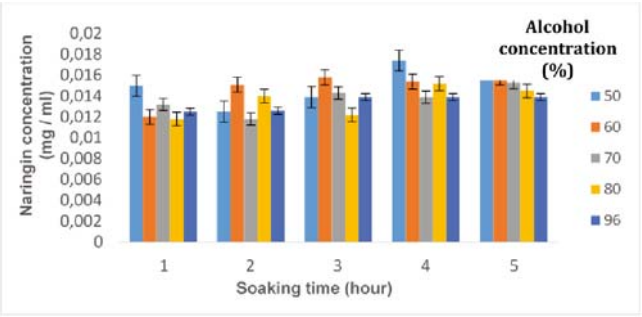

Figure 9. Effect of soaking time and alcohol content on naringin content

Figure 10 shows the effect of the flush temperature on Naringin concentration. High temperature encourages Naringin to dissolve easily into water, thereby reducing the bitterness of pomelos. When the water is discharged at a temperature of 50 °C, the concentration of Naringin 0.0005 mg/mL, which is higher than the 45 °C discharges temperature with a concentration of 0.0011 mg/mL. When the soaked water temperature increases to 60 °C, the naringin concentration decreases to 0.0006 mg/mL. By feeling, the sample of pomelo at this temperature has been corrupted, the structure of pomelo is destroyed. The appropriate discharge temperature not only increases the efficiency of bitter separation but also contributes to holding the structure of pomelos, ensuring sensory and quality. ANOVA statistics show that P-value = 0.0000 <0.05, indicating that the flush temperature affects the Naringin concentration at a 95% confidence level. LSD table shows that the 50 °C temperature is significantly different from 45 °C and not different from 60 °C. Therefore, 50 °C is the right temperature to perform the next experiment. The results are different compared to the research of Zhou et al.[31], who also selected 60 °C when studying the effect of extraction temperature on naringin levels from pomelos. By using the ultrasonic extraction method, Nguyen Cam Van et al.[32] chose 55 °C as the optimal temperature for an experiment.

Figure 11 shows the influence of the amount of discharge on naringin concentration. To increase the bitterness effect, the number of discharges is an important parameter that helps to reduce the smell of alcohol and to limit microorganisms while eliminating the residual

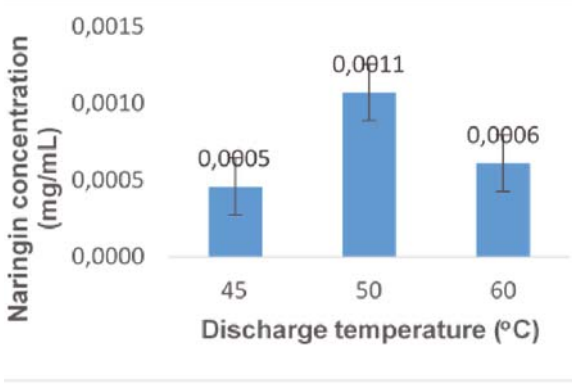

Figure 10. Effect of the water temperature on naringin concentration

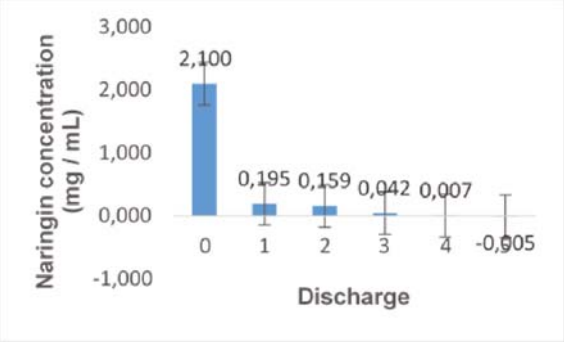

Figure 11. Effect of the number of discharges on Naringin concentration

amount of naringin. Initially, without discharge, very high naringin levels are 2.1 mg/mL. When increasing the number of discharges once up to 3 times, Naringin concentration decreased from 0.195 mg/mL to 0.042 mg/mL. When it adds to the number of discharges to 4–5 times, Naringin concentration decreases but not significantly. ANOVA statistics results show that the number of discharge factors affects Naringin levels with a 95% confidence level. The LSD shows the difference and contributes to the proven experimental execution of the number of factors with practical significance. The results showed that the first and the second time of discharge was different from the remaining times. Therefore, 3 times of discharge with water is reasonable for both saving time and the cost of reducing naringin content in pomelos.

Survey drying process

Figure 12 shows the dry curves through 3 basic stages: The first stage after 15 min we see a quick decrease in moisture because this is the product heating stage, moisturizing the surface Fast evaporation. The second phase is from 15 min to 30 min, which is a stable evaporation stage that makes evaporation more stable, the evaporation of the faces of drying products and the end-stage is 30 min onwards. At that time, the drying velocity decreases, gradually moisture with humidity. At a temperature of 40 °C and 45 °C, moisture decreases very quickly in the first 15 min but the product storage time must not belong and the product after drying has a brittle crunch. At a temperature of 50 °C, the product retains the structure, long-time, hardness of 309,862 N. When the drying temperature, the faster the drying time is faster because the temperature plays an important role in helping to escape Moisture surface drying products. When the higher the drying temperature causes the lower moisture, the lower drying agent pushes the surface to

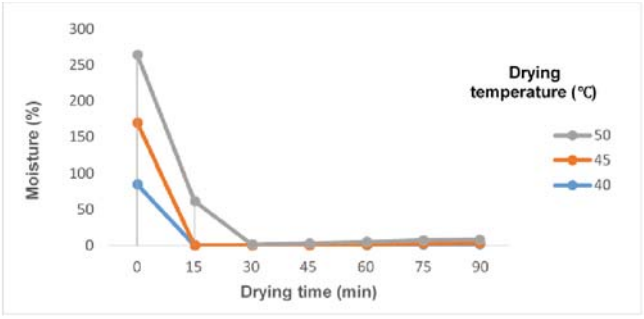

Figure 12. Effect of time and temperature dying up moisture

evaporate faster. So choose the drying time of 90 min at a temperature of 50 °C as appropriate.

Survey after drying

Figure 13 shows the effects of soaking water temperature and soak time on the ability to complete the pomelo peels. When changing the water temperature soaked from the usual temperature to 50 °C, the ability to reverberate increases and reaches the highest value of 100% at 3 h and 5 h. However, when increasing the soaking temperature to 100 °C in both times above, the ability to refund slightly. At the remaining time, the ability to revert continues to increase. Statistical results ANOVA indicates that the time with p-value > 0.05 does not affect the ability to complete, as compared to the soaked temperature with p-value < 0.05. High temperatures would increase the evaporation rate of pomelo peels and limit the shrinkage of products, helping pomelos with high efficiency. However, when an overheating water temperature would cause the product to be corrupted and destroy its structure of the product. LSD results show that the survey temperature levels showed no difference between 50 °C and 100 °C, thus the soaked water temperature of 50 °C was selected for saving time and ensuring the structure for pomelo peels after soaking. Therefore, to achieve good efficiency, the present study has proposed to soak products into water at a temperature of 50 °C for 1–3 h.

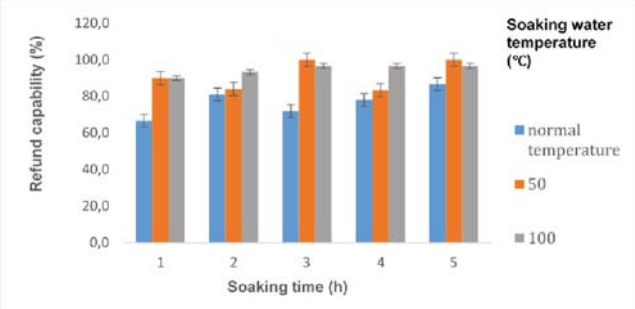

Figure 13. Effect of soaking water temperature and time soaking up moisture

CONCLUSION

Dried pomelo peels are white, uniformly structured, and have a hardness of 309.862 N. The dried fruit can be stored for a long time. Appropriate conditions of essential oil distillation are as follows: Raw material size is 3 mm, distillation time is 27 min with a ratio of materials and solvent of 1/12 g/mL to achieve essential oil efficiency is 89.88%. To extract pectin from pomelos to be best effective, the size of the material is 1 <= D <= 5 with the ratio of 1/32 (g/mL) was selected when the temperature and the extraction time are 90 °C and 60 min, respectively. Approximately 48% of concentrated pectin was achieved. Before drying, naringin in pomelos is removed by soaking in alcohol with concentrations of 50% in 5 h and discharge with water at a temperature of 50 °C for 3 times. Suitable conditions for pomelo drying are 50 °C in 90 min. Soaked pomelo peels had an ability to complete 100% in the conditions of soaking water at 50 °C for 1–3 h.

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