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PRODUCTION AND CHARACTERIZATION OF 'SEKAKI' PAPAYA FRUIT PUREE AND POWDER

Kean Weng Saw[1] and Liew Phing Pui[1]✉

[1]*Department of Food Science with Nutrition, Faculty of Applied Sciences, UCSI University, No. 1, Jalan Menara Gading, UCSI Heights, 56000 Cheras, Kuala Lumpur, Malaysia.*
✉*puilp@ucsiuniversity.edu.my*

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ABSTRACT

This study was conducted to optimize enzyme liquefaction of papaya fruit using Pectinex Ultra SP-L, followed by spray-drying the liquefied puree into powder. Pectinex® Ultra SP-L was applied at different concentrations (0.5 - 2.5% v/w) and incubation time (0.5 - 2.0 hours). The puree after enzyme liquefaction was spray-dried with different temperatures of 160-200°C). Results showed that papaya puree treated with Pectinex® Ultra SP-L at 1.0% (v/w) with an incubation time of 2 hours gave the lowest viscosity (6510.10 ± 1616.37 cps), TSS value at 10.09 ± 0.68 °Brix, pH value at 4.42 ± 0.19 and color value of L*= 33.83 ± 1.61, a*=33.75 ± 1.18 and b*=44.37 ± 0.86. Spray-drying at 160°C inlet temperature yielded powder with good properties: moisture content at 5.45 ± 0.07%, water activity at 0.15 ± 0.004 Aw, hygroscopicity at 17.90 ± 1.34%, and color values L*=92.39 ± 0.01, a*=4.44 ± 0.001 and b*=12.27 ± 0.01. For proximate analysis, spray-dried papaya powder had the lowest ash content, fat content, protein content, and no fiber was detected in spray-dried papaya powder. The pH of the reconstituted powder was lower compared to the optimized puree, and the color was darker and yellow compared to the optimized puree.

1.Introduction

Food preservation is a method that has been used for a long time to prevent spoilage. Production of puree is generally performed by mixing the food and blended using a blender to the form of pulp (Sreenath et al., 1995). Enzymes, such as pectinase and cellulase, are then introduced to produce puree by enzyme liquefaction (Sreenath et al., 1995; Bhat, 2000). Enzyme liquefied puree has a lower viscosity, which is important for a spray-dryer feed to prevent clogging and an increase in feed flow rate.

Drying extends food stability and shelf-life by the prevention of microbial growth (McMinn and Magee, 1999). Besides, handling of food will be easier as the weight and volume of food is reduced as water is removed (Click and Ridberg, 2010). Spray-drying is used in the food industry, transforming a wide range of liquid food products into powder form (Jayasundera et al., 2011). The process of spray-drying involves spraying finely atomized solutions into a chamber where both hot and dry air rapidly evaporated the atomized solution leaving behind spray-dried particles Jayasundera et al., 2011; Nijdam and Langrish, 2006; Chew et al., 2019). Recent work were done on spray-drying of fruit such as 'cempedak' – a type of jackfruit, Kuini – a type of mango and 'Bintangor' orange (Pui et al., 2020a; Chng et al., 2020; Yu et al., 2021).

Papaya fruit is highly appreciated for its flavor, nutritional qualities, and digestive properties (Thomás et al., 2009). It contains vitamins, minerals, enzymes, proteins, and phytochemicals such as alkaloids, glycosides, flavonoids, etc. (Krishna et al., 2008). Research had been done on papaya to produce papaya juice, papaya powder, and other products as well. However, producing spray-dried papaya powder with enzyme-treated puree is not fully explored yet. Therefore, this research aimed to produce papaya powder from the papaya pulp, which has been treated with an enzyme. The production of papaya powder was by using a spray-dryer. Physico-chemical properties of both enzyme-treated papaya puree and spray-dried papaya powder are determined.

2. Materials and methods

2.1. Materials

2.1.1. Fruit sample and enzyme liquefaction

'Sekaki' papaya, purchased from a local fruit store in Shah Alam, Malaysia, was cut and peeled and deseeded. The pulp was cut into smaller pieces (50 mm x 50 mm x 50 mm) and blended at high speed for 1 minute. The blended papaya pulp (200 g) was added with Pectinex® Ultra SP-L at 0 to 2.5% (v/w) and incubated at 50°C for 2 hours in a water bath (Memmert, Germany) with 100 rpm (Pui et al., 2020b). It was then placed into a water bath of 95°C for 5 minutes to inactivate the enzyme, followed by an ice-water bath for 5 minutes. After the optimum concentration for the each is obtained, the incubation time (0, 0.5, 1.0, 1.5, and 2.0 hours) was determined. For each enzyme liquefied papaya, the viscosity, TSS, pH, and the color is determined, while proximate analysis was conducted on the optimized enzyme-liquefied papaya puree.

2.2. *Spray-drying*

Enzyme-treated papaya puree (500 g) were sieved and added with maltodextrin DE 10 (Bronson and Jacobs, Australia) at a concentration of 20%, and water is added with 1:1 ratio (puree: water). The papaya puree was then fed and atomized in the mini spray-dryer (Büchi, Switzerland). The spray-drying process was conducted at different inlet temperatures (160, 170, 180, 190, and 200°C) (Chang et al., 2020a). The collected powder was determined in its physico-chemical properties: moisture content, water activity, color, and hygroscopicity.

2.3. *Reconstitution of powder*

Spray-dried papaya powder was rehydrated to the same total solid content, which is 10.07 before drying (Pui et al., 2021).

2.4. *Analysis*

2.4.1. Water activity

The water activity of the sample was measured by using a water activity meter (LabMaster - aw Water Activity Meter) at room temperature (Chang et al., 2020b).

2.4.2. Color

The color of the fresh papaya fruit, enzyme liquefied papaya with 2.0% Pectinex Ultra SP-L, papaya powders, and reconstituted powders were measured using a colorimeter (ColorFlez EZ, Hunter Associates Laboratory Inc, USA). The colorimeter was calibrated against a standard white tile (Loo and Pui, 2020). Colorimetric data were expressed in terms of L*, a*, and b*, representing luminosity or lightness, green-red component, and blue-yellow component, respectively.

2.4.3. Total Soluble Solids (Brix)

The total soluble solids content of the samples was measured using a Refractometer (0-32 °Brix) or (28-62 °Brix) (Pui et al., 2018).

2.4.4. Viscosity

Were measured using a Brookfield viscometer DV-II+ Pro, USA (Wong et al., 2015). 250 mL of samples were added with spindle no.2, and the reading measured at a speed of 150 rpm.

2.4.5. pH

The pH of the samples was measured using a digital pH meter (Mettler Toledo, USA) (Pui et al., 2018).

2.4.6. Hygroscopicity

The hygroscopicity of the papaya powder was determined by placing 2g of powder in n a glass desiccator at 25 ± 1°C containing saturated Na2SO4 solution (81% RH) instead of an airtight plastic container (Cai and Corke, 2000). After 1 week, the samples were weighed, and the hygroscopicity was expressed as g of moisture per 100 g dry solids (g/100 g).

2.4.7. Proximate analysis

The fresh fruit, papaya puree, and papaya powder were analyzed in crude protein, crude fat, crude fiber, ash content, and moisture content (AOAC, 2000).

2.5. *Statistical Analysis*

Data (n=3) was expressed in terms of ± standard deviations, with the statistical analysis conducted with SPSS 22, one-way ANOVA. The Tukey's Honestly Significant Difference (HSD) was performed to determine significant differences with $p \leq 0.05$.

3.Results and discussions

3.1. Enzyme liquefaction on homogenized papaya

Table 1 shows the effect of enzyme Pectinex® Ultra SP-L with different concentrations at the incubation of 50°C on the viscosity, total soluble solids (TSS), pH, and color (L*, a* and b*) of homogenized papaya. From Table 1, the viscosities of the Pectinex Ultra SP-L treated papaya purees were lower than the control at 0% (v/w). The addition of 0.5% (v/w) enzyme did not decrease the viscosity of the papaya puree.

Table 1. Effect of different concentrations of Pectinex® Ultra SP-L on the viscosity, total soluble solids (TSS), pH, and color of papaya puree at 50°C for 2 hours

Analysis	Enzyme Concentration (%)					
	Control (0)	0.5	1.0	1.5	2.0	2.5
Viscosity (cps)	8783.59 ± 559.67^{a}	8920.76 ± 2365.64^{a}	6510.10 ± 1616.37^{b}	6064.17 ± 788.14^{b}	4651.02 ± 917.17^{b}	5849.43 ± 1916.49^{b}
TSS (°Brix)	9.57 ± 0.50^{a}	9.67 ± 0.48^{a}	10.09 ± 0.68^{a}	9.52 ± 0.41^{a}	10.06 ± 0.49^{a}	10.13 ± 0.34^{a}
pH	4.57 ± 0.24^{a}	4.41 ± 0.19^{a}	4.42 ± 0.19^{a}	4.38 ± 0.15^{a}	4.33 ± 0.10^{a}	4.40 ± 0.15^{a}
Color (L*)	34.32 ± 0.45^{a}	33.56 ± 0.23^{b}	33.83 ± 1.61^{ab}	32.13 ± 1.58^{c}	32.90 ± 0.30^{bc}	32.77 ± 0.62^{bc}
Color (a*)	33.76 ± 0.98^{a}	33.60 ± 0.84^{a}	33.75 ± 1.18^{a}	32.95 ± 1.22^{a}	33.33 ± 1.24^{a}	33.24 ± 1.75^{a}
Color (b*)	42.73 ± 0.43^{ab}	43.23 ± 1.52^{ab}	44.37 ± 0.86^{a}	42.11 ± 1.52^{b}	43.05 ± 1.92^{ab}	43.05 ± 1.92^{ab}

Data on viscosity, TSS, pH, and color of papaya puree are means ± standard deviations where n = 3. For each row, superscripts of the same letter are not significantly different at $p \leq 0.05$, as measured by the Tukey HSD test. Abbreviations: HSD = honestly significant difference, TSS = total soluble solids, L* = degree of lightness and darkness, a* = degree of redness or greenness, and b* = degree of yellowness or blueness.

However, the viscosity of the papaya puree decreases after the addition of 1.0% (v/w) enzyme, followed by no further increase in viscosity when enzyme with 2.5% (v/w) is added into papaya purees. The enzyme pectinases can help in the extraction, clarification, increasing the yield and decreasing the viscosity of fruit juices by the degradation of pectin-containing substances (Demir et al., 2001). The pectinaceous substances possess a high water holding capacity, and this developed a cohesive network structure (Tapre and Jain, 2014). The degradation of pectin by the enzyme Pectinex® Ultra SP-L lead to the reduction in the water holding capacity and thus released the free water into the system, which is responsible for further reduction in viscosity (Sin et al., 2006).

In the aspect of total soluble solids (TSS), there was no significant difference ($p > 0.05$) between the enzyme concentrations at 0% to 2.5% (v/w) on the TSS of the enzyme-treated homogenized papaya, which indicates that increasing the concentration of the enzyme did not affect the TSS of the papaya puree. This is similar to pH as well, with no significant effect ($p > 0.05$) with the addition of pectinase concentration.

From Table 1, L* value at 0% (v/w) was 34.32 ± 0.45 and it decreases to 33.56 ± 0.23 and 32.13 ± 1.58 for the L* value at 0.5% (v/w) and 1.5% (v/w) respectively. With an increase to 2.0% (v/w) and 2.5* v/w, the puree shows no significant difference in the L* values. L* values range from black (0) to white (100). As the concentration of enzyme increases, the color of the enzyme liquefied papaya becomes darker. This was possibly due to the degradation of thermo-labile pigments resulting in the formation of dark compounds that reduced the luminosity (Dutta et al., 2006).

The a* value represents the redness and greenness of the powder, where positive value shows the redness intensity while a negative value shows greenness intensity. As for the value of a*, results show that there was no significant difference ($p > 0.05$) between the color of a* with the enzyme concentration, which indicates that increasing in enzyme concentration would not affect the redness of the enzyme liquefied papaya puree. Based on the value obtained, the color of the enzyme liquefied papaya appears reddish due to lycopene found in papaya (Quek et al., 2007).

The b* value represents the blueness and yellowness of the powder, where positive value shows the intensity of yellowness, while a negative value shows the intensity of blueness (Chang et al., 2020a). The b* value increases to 44.37 ± 0.86 at 1.0% (v/w), to 43.05 ± 1.92 for both 2.0% (v/w) and 2.5% (v/w). Based on the value, the color of the enzyme liquefied papaya appears yellowish but hard to observe as the redness covers the yellowness color. The yellowness of the papaya was due to the β-carotene found in the papaya (Quek et al., 2007).

The effects of incubation time on homogenized papaya were shown in Table 2. With the increase of incubation time, it was found that the viscosity decreases. The lowest viscosity was found at 2.0 hour incubation time with a value of 4260.90 ± 483.79 cps. The total soluble solids increase slightly, while its pH decreases with 0.5 hours, followed by no significant effect ($p > 0.05$), with a further increase in incubation time. L* values were not affected by an increase in incubation time, while there has not been any significant difference ($p > 0.05$) in the a* value until 2.0 hours. The b* value of papaya puree varies from 40.83 to 43.39 after incubation. The optimization of the parameters for enzyme liquefaction was determined by the viscosity and color of the end product. Pectinex® Ultra SP-L enzyme at a concentration of 1.0% (v/w) and an incubation time of 2.0 hours produced puree with more desirable properties, as it exhibits the lowest viscosity, which was 4260.90 ± 483.79 and the color values of (L*, a*, and b*) which were 30.26 ± 4.13, 32.70 ± 1.15 and 40.83 ± 0.69. The product, after liquefaction, will be used as a spray-drying feed.

3.2. Production of papaya powder by spray-drying

Figure 1 shows the yield of the powder obtained from the spray-drying at 5 different inlet temperatures (160, 170, 180, 190 and 200°C). The inlet temperature of 160°C had the highest yield, which was 11.12 ± 0.02%. With a further increase in inlet temperature, the powder yield continues to decrease. At inlet temperatures of 200°C, the yield was decreased by 7.12 ± 0.02%.

Higher inlet temperature causes the powder to stick to the chamber wall and thus reducing the amount of powder produced. Chengini and Ghobadian (2007) also reported that powder produced at high temperatures resulted in a powder that is stickier, as the inlet temperature was above the glass transition temperatures for the spray-dried powders.

Table 2. Effect of different incubation time of Pectinex® Ultra SP-L on the viscosity, total soluble solids (TSS), pH and color of papaya puree at 50°C for 2 hours

Analysis	Time (hour)				
	Control (0)	0.5	1.0	1.5	2.0
Viscosity (cps)	11590.65 ± 182.82^{a}	9299.37 ± 941.24^{b}	6806.17 ± 421.53^{c}	5498.10 ± 420.67^{d}	4260.90 ± 483.79^{e}
TSS (°Brix)	9.81 ± 0.10^{a}	10.47 ± 0.20^{b}	10.47 ± 0.20^{b}	10.31 ± 0.20^{b}	10.51 ± 0.20^{b}
pH	4.49 ± 0.13^{a}	4.25 ± 0.15^{b}	4.23 ± 0.21^{ab}	4.20 ± 0.16^{ab}	4.18 ± 0.10^{b}
Color (L^*)	30.90 ± 0.01^{a}	31.81 ± 0.29^{a}	32.12 ± 0.11^{a}	31.12 ± 0.61^{a}	30.26 ± 4.13^{a}
Color (a^*)	33.65 ± 0.04^{a}	34.08 ± 0.38^{a}	34.38 ± 0.31^{a}	33.83 ± 0.61^{a}	32.70 ± 1.15^{b}
Color (b^*)	38.59 ± 0.04^{a}	42.23 ± 0.15^{b}	43.39 ± 0.37^{c}	42.65 ± 0.62^{c}	40.83 ± 0.69^{ab}

Data on viscosity, TSS, pH, and color of papaya puree are means ± standard deviations where n = 3. For each row, superscripts of the same letter are not significantly different at $p \leq 0.05$, as measured by the Tukey HSD test. Abbreviations: HSD = honestly significant difference, TSS = total soluble solids, L* = degree of lightness and darkness, a* = degree of redness or greenness, and b* = degree of yellowness or blueness.

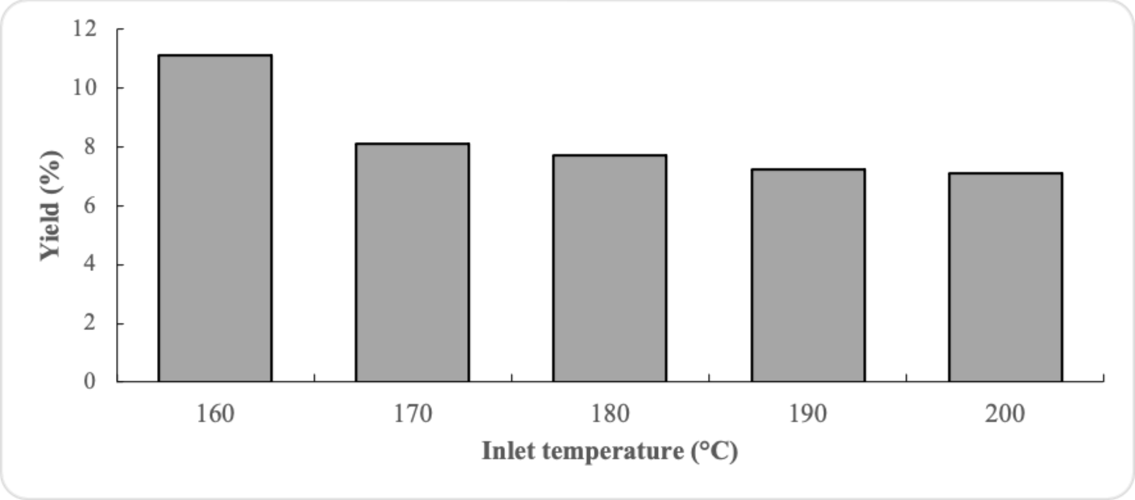

Figure 1. The yield of papaya powder spray-dried under different inlet temperature

Table 3 shows the comparison of analyses of hygroscopicity, moisture content, water activity, and color (L*, a* and b*) of spray-dried powders at different inlet temperatures. There was no significant difference (p > 0.05)s in the moisture content of the spray-dried papaya powder produced at 160-190°C. The moisture content of papaya powder decreases when produced at 200°C, with a value of 5.03 ± 0.97%. Water activity is different from moisture content as it measures the availability of free water in a food system that is responsible for any biochemical reactions (Wong et al., 2015). Higher water activity indicates more free water is available for biochemical reactions and hence, shorter shelf life (Quek et al., 2007). From Table 5, there was also no significant difference (p > 0.05) between the water activity of spray-dried powder, with a range of 0.14 – 0.16Aw. The powders can be considered microbiologically stable (Quek et al., 2007; Fávaro-Trindade et al., 2010). Besides, the hygroscopicity of the spray-dried papaya powder was also not significantly different (p > 0.05).

Based on the results in Table 3, the highest value of L* was at an inlet temperature of 160°C with a value of 92.39 ± 0.01, which means that the powder had become lighter in color. One explanation is that papaya contains sugars, which could contribute to the browning of the powders at higher inlet temperatures (Quek et al., 2007). It is reported that the reduced lightness of the powder was due to the caramelization and Maillard reactions on the powder during the drying process (Jittanit et al., 2010). Following an increase in temperature from 170°C, with a value of 90.40 ± 0.01, which shows that the powder is darker. Beyond that temperature, there is no further increase in L*.

The papaya powder produced has values ranging from 4.44-4.62, indicating it is slightly reddish. On the other hand, yellowness, the b* of the papaya powder, show a decrease when spray-dried at 160°C to 180°C, followed by an insignificant decrease from 180°C to 200°C ($p > 0.05$). β-carotene in papaya undergo degradation by oxidation and heat (Goula and Adamopoulos, 2005). Dehydrated products have large surface-to-mass ratios that are easily susceptible to oxidative decomposition. β-carotene is easily oxidized because of the large number of conjugated double bonds in its structure (Phisut, 20012). These reactions of oxidation and thermal degradation cause color loss of carotenoids in foods (Quek et al., 2007).

Based on results obtained in Table 5, optimization of inlet temperature was determined based on 1 main parameter, which was the yield. The optimized inlet temperature for the spray-drying of papaya (160°C) produced powder with the moisture content and the water activity 160°C were 5.45 ± 0.07 and 0.15 ± 0.04, respectively. The values of hygroscopicity and color (L*, a* and b*) of spray-dried papaya powder at 160°C were 17.90 ± 1.34%, 92.39 ± 0.10, 4.44 ± 0.10 and 12.27 ± 0.01, respectively.

3.3. Proximate analysis

Table 4 shows the results of proximate analysis of fresh fruit, optimized enzyme liquefied homogenized papaya, and optimized spray-dried papaya powder. In comparison to the optimized puree, the moisture content of the fresh fruit of papaya was lower (89.82 ± 0.02%). The moisture content of puree was higher than the moisture content of fresh fruit due to the enzyme degradation of the pectin inside the fruit, which causes water holding capacity to breakdown and release free water into the system (Manjunatha et al., 2014).Moisture content in fruit powder was at 5.26 ± 0.02%. The low moisture content of spray-dried powder can prolong its shelf life as water content was too low for the growth of microorganism spoilage.

Table 3. Physico-chemical analysis of spray-dried papaya powder

Analysis	Inlet temperature (°C)				
	160	170	180	190	200
Moisture content (%)	5.45 ± 0.07^a	5.35 ± 0.57^a	5.12 ± 0.13^a	5.27 ± 0.74^a	5.03 ± 0.97^b
Water activity (A_w)	0.15 ± 0.04^a	0.15 ± 0.01^a	0.14 ± 0.01^a	0.15 ± 0.01^a	0.16 ± 0.01^a
Hygroscopicity (%)	17.90 ± 1.34^a	17.29 ± 0.04^a	17.14 ± 0.62^a	17.06 ± 0.22^a	16.05 ± 0.49^a
Color (L^*)	92.39 ± 0.10^a	90.40 ± 0.10^b	90.70 ± 0.60^b	90.52 ± 0.20^b	90.91 ± 0.40^b
Color (a^*)	4.44 ± 0.10^b	4.62 ± 0.04^a	4.64 ± 0.10^a	4.48 ± 0.07^b	4.49 ± 0.20^b
Color (b^*)	12.27 ± 0.01^a	13.18 ± 0.01^b	13.40 ± 0.05^c	13.33 ± 0.02^{bc}	13.43 ± 0.02^c

Data on moisture content, water activity, hygroscopicity, and color of spray-dried papaya powder are means ± standard deviations where n = 3. For each row, superscripts of the same letter are not significantly different at $p \leq 0.05$, as measured by the Tukey HSD test. Abbreviations: HSD = honestly significant difference, L* = degree of lightness and darkness, a* = degree of redness or greenness, and b* = degree of yellowness or blueness.

Table 4. Proximate analysis and water activity of fresh papaya fruit, optimized papaya puree, and spray-dried papaya powder

Analysis	Fresh fruit	Puree	Powder
Moisture Content (%)	89.54 ± 0.01^b	89.82 ± 0.02^a	5.26 ± 0.02^c
Ash Content (%)	0.22 ± 0.02^b	0.41 ± 0.01^a	0.20 ± 0.02^c
Crude Protein (%)	1.34 ± 0.01^b	1.44 ± 0.01^a	0.31 ± 0.02^c
Crude Fat (%)	0.18 ± 0.02^a	0.13 ± 0.02^b	0.01 ± 0.01^c
Crude Fiber (%)	11.65 ± 0.03^b	24.81 ± 0.02^a	0.00 ± 0.00^c
Water Activity (A_w)	0.96 ± 0.01^b	0.97 ± 0.01^a	0.16 ± 0.01^c

Data on moisture content, ash content, protein content, fat content, and the crude fiber content of fresh papaya pulps, optimized enzyme-liquefied papaya puree, and optimized spray-dried papaya powder are meant ± standard deviations where n = 3. For each row, superscripts of the same letter are not significantly different at $p \leq 0.05$, as measured by the Tukey HSD test. Abbreviations: HSD = honestly significant difference.

Enzyme liquefied homogenized papaya had the highest amount of ash content due to the composition of minerals, which were released into the system upon the breakdown of tissues by the Pectinex® Ultra SP-L enzyme (Qin et al., 2005). However, the spray-dried powder produced the least amount of ash. The addition of maltodextrin increased the amount of non-papaya solids in the powders samples, which in turn lowered the ash content of maltodextrin added powders (Grabowski et al., 2006).

The protein content for fresh fruit was 1.34 ± 0.01%, which was lower compared to the protein content of enzyme liquefied homogenized papaya but significantly higher than spray-dried powder. The protein content was 1.44 ± 0.01% for the enzyme liquefied papaya puree and 0.31 ± 0.02% for the papaya powder. The low protein content in powder was due to the thermal degradation of the protein. Ignário and Lannes (2007) also reported similar results of reduced protein content in the spray-drying of egg yolk. Thus, the lower protein content of the powders could be attributed to the destruction of lysine through interaction with reducing groups of carbohydrates at high temperatures (Grabowski et al., 2006).

From Table 4, the fat content of fresh fruit was higher than the optimized puree, while fat in spray-dried powder was the lowest. The cause of the decrease of fat content in spray-dried papaya powder was due to lipid oxidation. Spray-drying greatly increases the surface area, which exposes more area in papaya powders for oxidation and degradation to take place, thus reducing the fat content (Gharsallaoui et al., 2007). Fiber content increases in enzyme liquefied papaya puree, and no fiber were found in spray-dried papaya powder (Table 4). The high fiber content in enzyme liquefied puree might be due to the breakdown of tissues by an enzyme that releases fiber into the system (Norjana and Noor Aziah 2011). The fiber was not detected in spray-dried powder as the feed was filtered before spray-drying. This is needed for preventing the clogging of the spray-dryer (Phisut, 2012).

As shown in Table 4, the highest water activity content was found in enzyme liquefied homogenized papaya with a value of 0.970 ± 0.01 and followed by the second-highest water activity content with a value of 0.960 ± 0.01, which was found in fresh papaya fruit. The lowest amount of water activity content was found in spray-dried papaya powder with a value of 0.158 ± 0.01. The water activity in both fresh papaya fruit and enzyme liquefied papaya puree were higher $Aw > 0.6$, which was considered to be suitable for microorganism growth. As for spray-dried powder, the water activity was $Aw \leq 0.6$ was considered to be microbiologically stable, which was suitable in increasing shelf life (Chang et al., 2020a).

3.4. Reconstitution of optimized powder

Total soluble solids (TSS), pH, and color (L*, a*, and b*) for optimized spray-dried powder were exhibited in Table 5. The value of pH for the reconstituted powder was at 4.00 ± 0.01. When compared to the pH of the optimized papaya puree, the pH was lower. The pH was lower compared to the pH of the fresh papaya fruit might be due to the release of carboxyl groups from the pectin molecules during enzymatic liquefaction. The carboxyl groups, in turn, lower the pH of the due to its acidic properties (Gharsallaoui et al., 2007).

Table 5. Analysis of reconstituted optimized powder

Analysis	Optimized Puree	Reconstituted Powder
TSS (°Brix)	10.09 ± 0.68^a	10.07 ± 0.00^a
pH	4.42 ± 0.19^a	4.00 ± 0.01^b
Color (L*)	33.83 ± 1.61^a	22.67 ± 0.23^b
Color (a*)	33.75 ± 1.18^a	-1.54 ± 0.15^b
Color (b*)	44.37 ± 0.86^a	3.12 ± 0.01^b

Data on moisture content, ash content, protein content, fat content, and the crude fiber content of fresh papaya pulps, optimized enzyme-liquefied papaya puree, and optimized spray-dried papaya powder are meant ± standard deviations where n = 3. For each row, superscripts of the same letter are not significantly different at $p \leq 0.05$, as measured by the Tukey HSD test. Abbreviations: HSD = honestly significant difference.

The value of L*, which was the lightness, had a value of 22.67 ± 0.23. In comparison with the original L* of optimized papaya puree, the value was lower, which means the reconstituted powder had become darker. The decrease in lightness could be due to non-enzymatic browning occurring during the spray-drying (Fávaro-Trindade et al., 2010). As for a* value, the value obtained in reconstituted powder was -1.54 ± 0.15. The value of a* was lower when compared to the value of a* in optimized papaya puree. Obtaining a negative value in a* shows that the reconstituted spray-dried powder had lost the redness color. The degradation and oxidation of lycopene, which was responsible for the red color of the papaya due to the usage of high temperature in spray-drying, caused the redness to lose its color (Sousa et al., 2008). The value of b* for reconstituted optimized spray-dried papaya powder was lower when compared to the value of b* of optimized papaya puree. As a result of b* shows a positive value, the reconstituted spray-dried powder shows still contained yellowness. Thermal degradation and oxidation of β-carotene caused the yellowness to be lost (Quek et al., 2007).

4. Conclusions

Papaya has been one of the most popular fruits in many countries due to its slightly sweet, musky undertones with soft flesh. The optimization of enzyme liquefaction includes enzyme concentration and incubation time. The viscosity of papaya puree decreased with the increase of concentration and incubation time of both enzymes. 1.0% (v/w) Pectinex® Ultra SP-L with an incubation time of 2 hours was chosen as the optimum condition for enzyme liquefaction. In the determination of the optimum inlet temperature, powder sprayed at 160°C has the highest yield and favorable properties such as low moisture, water activity and hygroscopicity. The produced 'Sekaki' papaya powder has the potential to be used as functional ingredients for other food products.

5.References

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