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Various parameters affecting to the production of papaya (*Carica papaya* L.) jam

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Abstract

In the post-harvest stage, papaya fruit is highly perishable due to its climacteric characteristic and high respiration rate. Papayas are typically consumed fresh, but converting them into jam as a value-added foodstuff could help minimize losses. The purpose of this research was to evaluate various papaya fruit varieties (namely Va505, Vo786, Sapna, Mangnum, Tn55) and key technical variables such as blanching temperature/time, thickness of papaya strip, gelatin ratio, sucrose ratio and lemon juice ratio concerning the color, texture and overall acceptability of papaya jam. Raw matured papaya fruits at technical maturity were selected for the experiments. Papaya strips were blanched in hot water at different temperature and time (80 °C for 30 min, 85 °C for 25 min, 90 °C for 20 min, 95 °C for 15 min and 100 °C for 10 min). These blanched papaya strips were then mixed with varying concentration of sucrose (20, 25, 30, 35, 40%), gelatin (0.2, 0.3, 0.4, 0.5, 0.6%) and lemon juice (2, 3, 4, 5, 6%). The samples were kept at 8 °C for 30 min before heating at 100 °C for 25 min. The results showed that the Sapna variety had the highest contents of beta-carotene (8.72±0.01 µg/g) and ascorbic acid (68.17±0.14 g/100 g), while the Vo786 variety had the lowest contents of beta-carotene (4.17±0.02 µg/g) and ascorbic acid (64.49±0.09 g/100 g). For the preparation of papaya jam, the papaya fruit should be peeled and sliced into strips with a thickness of 2.0 mm. These strips should be blanched primarily at 95 °C for 15 min, then mixed with 30% sucrose, 0.5% gelatin and 5% lemon juice. The mixture should be allowed to stand at 8 °C for 30 min before being heated at 100 °C for 25 min. The stripped papaya jam should then be cooled, packed in plastic bags and stored at ambient temperature for 6 months. This study successfully identified Sapna as the appropriate papaya fruit variety and verified several major parameters for jam making. The formulated papaya jam is designed to maintain its quality for long shelf-life storage.

Keywords

Blanching; gelatin; jam; papaya; variety

Introduction

Papaya (*Carica papaya* L.) is an important tropical and subtropical horticulture crop in Vietnam and other Asian countries. The fruit takes approximately 3 months from flowering to maturity. In the unripe stage, the fruit has a green peel, rigid pulp and white latex. Upon ripening, the peel turns yellow and the succulent pulp became palatable (1). It is challenging to precisely define the harvest maturity of papaya to ensure optimal fruit ripening and the best consuming attributes. Farmers often identify ripening

symptoms of papaya fruit by observing changes in the internal pulp color from cream to yellow-orange as well as modifications in the outer peel color from green to yellow-orange. Processors assess the maturity of papaya fruit by testing its total soluble solids and inner flesh color. Papaya fruit is highly preferred due to its attractive appearance, delicious taste, excellent nutritive balance and reasonable availability. Rich in fiber, vitamin C, carotene, potassium and magnesium, papaya is low in calories and sodium. However, being a climacteric fruit with a high respiration rate, papaya is highly perishable during post-harvest stage, including on the field, during transport and in preservation. Its bioactive constituents degrade quickly, leading to reduced fruit quality. Papaya is commonly consumed when ripened or processed into various preserves such as candy, marmalade, jam, jelly, nectar and syrup (2).

Several notable studies have focused on the processing of papaya fruit. In one study, 40 aonla fruits were adequately mixed with 60 papayas to produce an acceptable blended jam (3). Another study formulated papaya candy using 92.9% papaya flesh, 68.8% sugar and 2.8% pectin (4). Additionally, papaya seed flour was incorporated in different proportions (0-0.5%) to make papaya jam, with increasing papaya seed flour content improving the crude fiber of the jam (5). Both papaya jam and papaya candy were developed with papaya candy being highly preferred 40.00% preferences, followed by papaya jam with a preference of 26.66% (6).

After harvesting, papaya fruit decays quickly, with a short shelf-life life of 3-5 days at room temperature (7). Implementing an appropriate strategy is necessary to maintain papaya's nutritional attributes. Jam making has been evaluated as one of the ideal approaches to satisfy consumer demand with a healthy and nutritious processed product. Thermal treatment effectively prevents chemical and enzymatic reactions as well as microbial proliferation accountable for its deterioration. The objective of the present study is to survey the proximate composition of raw matured papaya fruits from 5 local fresh papaya varieties and to investigate the influence of various technical aspects such as blanching temperature/time, thickness of papaya strip, gelatin ratio, sucrose ratio and lemon juice ratio on the color, texture and overall acceptability of papaya jam.

Materials and Methods

Material

Whole matured papaya fruits from 5 local fresh papaya varieties (Va505, Vo786, Sapna, Mangnum, Tn55) were collected from gardens in Soc Trang city, Soc Trang province, Vietnam. They were sorted and graded by hand based on adequate peel color, dimensions and ripeness to ensure suitable fruit quality. Seedless lemon fruits were purchased from the Soc Trang local market in Vietnam. They were cultivated using organic methods, without the use of pesticides or chemical fertilizers. After harvesting, they were promptly transported to the laboratory for experiments. All chemical reagents used were of analytical or high-performance liquid chromatography **(**HPLC) grade.

Researching method

Raw matured papaya fruits at technical maturity were selected for experiments. They were rinsed in tap water, peeled and cut into 2 parts to remove their seeds. The flesh was then sliced into strip of varying thicknesses (1,0, 1.5, 2.0, 2.5, 3.0 cm) with a consistent length of 7.0 cm. Papaya strips were blanched in hot water at difference temperature/time combinations (80/30, 85/25, 90/20. 95/15, 100/10 °C/s). After blanching, the papaya strips were dripped in a basket for 5 min to remove excess water. The blanched papaya strips were then mixed with sucrose (20%, 25%, 30%, 35%, 40%), gelatin (0.2%, 0.3%, 0.4%, 0.5%, 0.6%), lemon juice (2%, 3%, 4%, 5%, 6%)**.** These samples were kept at 8 °C for 30 min before being heated at 100 °C for 25 min. the stripped papaya jam was then cooled, packed in plastic bags and stored at ambient temperature for 6 months. The quality of the raw papaya fruit jam was examined based on the beta-carotene content (µg/g), ascorbic acid content (g/100 g) and moisture content (%). The beta-carotene content (µg/g) was analyzed using high-performance liquid chromatography (8). The ascorbic acid content (g/100 g) was evaluated by 2,6-dichlorophenolindophenol titration.

The moisture content (%) of raw papaya fruits was determined by comparing the initial weight and final weight of samples after drying at 105 °C to a constant weight.

The quality attributes of the stripped papaya jam were evaluated based on color, texture and overall acceptability using a 9 point-Hedonic scale, where and 1=dislike extremely, 2= dislike moderately, 3= disagree regularly, 4= disagree slightly, 5= neither like nor dislike, 6= like slightly, 7= like regularly, 8= like moderately, 9= like extremely.

Statistical analysis

The experiments were conducted with triplicate repetitions, resulting in a total 130 jam samples. The data were presented as mean±standard deviation. Statistical analysis was performed using Statgraphics Centurion version XVI. The mean value and standard deviation were calculated from the analysis of random samples to estimate the population statistics. It is expected that 95% of the results would lie within the range we described, with the lower and upper bounds of this $\bar{x} \pm 2s$ range defined as the 95% confidence limits of the results.

Results and Discussion

Proximate composition of local fresh papaya varieties

The proximate composition of raw matured papaya fruits from 5 local fresh papaya varieties (namely Va505, Vo786, Sapna, Mangnum, Tn55) was presented in Table 1. It is noticeable that there was no significant difference in moisture content among the five papaya varieties. The highest contents of beta-carotene (8.72±0.01 µg/g) and ascorbic acid (68.17±0.14 g/100 g) were recorded in the Sapna variety, while the lowest contents of beta-carotene

Table 1. Chemical composition of raw matured papaya varieties

Papaya varieties	Va505	Vo786	Sapna	Mangnum	Tn55
Beta-caroten (µg/g)	7.57±0.02^{ab}	4.17±0.02^{c}	8.72±0.01^{a}	5.25±0.03^{bc}	6.39±0.00^{b}
Ascorbic acid (g/100 g)	67.25±0.12^{ab}	64.49±0.09^{c}	68.17±0.14^{a}	65.34±0.08^{bc}	66.84±0.11^{b}
Moisture content (%)	87.36±0.05^{a}	88.02±0.03^{a}	87.59±0.07^{a}	87.43±0.04^{a}	87.81±0.06^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

(4.17±0.02 µg/g) and ascorbic acid (64.49±0.09 g/100 g) were observed in the Vo786 variety. Raw matured papaya fruit from the Sapna variety was selected for further experiments. The flavor attribute of papaya strongly relies on variety, maturity and postharvest management (9). Beta-carotene contents in yellow-fleshed papaya and red-fleshed papaya were observed at 1.4 ± 0.4 µg/g and 7.0 ± 0.7 µg/g (10). Papaya varieties could be classified by their leaf profile, stomatal appearance, amount of middle leaf vascular, quantity of manoj at the leaf sideline, wax covering on the leaf facial and petiole coloring. Papaya fruits contain a high % of vitamins, minerals, phytochemical constituents and essential metabolites (11).

Effectiveness of blanching temperature/time (°C/s) to color, texture and overall acceptance of papaya jam

The temperature and time used in blanching has a significant impact on the color, texture and overall acceptance of papaya jam, as clearly presented in Table 2. The highest organoleptic scores of colors, texture and overall acceptance were recorded for papaya jam that was primarily blanched at 95/15 (°C/s). Therefore, papaya strip should be blanched under these condition to achieve the best jam quality. This blanching condition was selected for the next experiments. In papaya fruit processing, polyphenol oxidase activity facilitates the enzymatic browning reaction to oxidizing phenols to o-quinones, forming melanins (12). Blanching is one of the universal thermal pre-treatments commonly applied to prevent the adverse effects on the fresh-cut layer during thermal condensation and long-term preservation. Blanching not only inhibits darkening but also decontaminates pathogenic bacteria (13). Papaya cubes should be blanched in water at 95/10 (°C/s) to process the dehydrated product (12).

Effectiveness of thickness of papaya strip to color, texture and overall acceptance of papaya jam

The thickness of the papaya strip had a significant influence on the texture and overall acceptance, but it did not affect the color of the papaya jam. The results were thoroughly presented in Table 3. At a papaya strip thickness of 2.0 cm, the highest scores of texture and overall acceptance were reported, while the lowest scores for texture and overall acceptance were recorded at a thickness of 1.0 cm. Therefore, papaya strip should be sliced to a thickness of 2.0 cm for process papaya jam. In another study, papaya fruit was peeled, cut into 1 cm cubes, soaked in sugar syrup and then dried at a temperature of 50 °C to achieve a moisture content of 12% to obtain stable dried papaya (12).

Effectiveness of gelatin ratio to color, texture and overall acceptance of papaya jam

Gelatin supplemented in jam-making showed a noticeable difference in texture and overall acceptance but had no effect on the color of papaya jam, as illustrated in Table 4. There was an increasing trend in texture and overall acceptance scores with the addition of more gelation. However, at 0.5% and 0.6% gelatin incorporation, papaya jam showed no significant difference in texture and overall acceptance. To save production costs, gelatin should be added at 0.5% for papaya jam making. It is worth noting that the supplementation of 11% gelatin could improve the quality attributes of papaya jelly candy (14). Texture is a key variable in the acceptance of jam (5). Additionally, papaya candy is highly preferred over papaya jam due to its attractive color and uniformed appearance (6).

Table 2. Effectiveness of blanching temperature/time (°C/s) to color, texture and overall acceptance of papaya jam

Temperature/time (°C/s)	80/30	85/25	90/20	95/15	100/10
Color	5.12±0.01^{c}	5.58±0.03^{bc}	6.71±0.05^{ab}	7.15±0.00^{a}	6.03±0.02^{b}
Texture	5.94±0.00^{c}	6.31±0.02^{bc}	7.19±0.04^{ab}	7.68±0.03^{a}	6.70±0.04^{b}
Overall acceptance	5.55±0.03^{c}	6.19±0.04^{bc}	6.93±0.01^{ab}	7.52±0.02^{a}	6.46±0.00^{b}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Table 3. Effectiveness of thickness of papaya strip to color, texture and overall acceptance of papaya jam

Thickness (cm)	1.0	1.5	2.0	2.5	3.0
Color	6.36±0.02^{a}	6.47±0.01^{a}	6.50±0.03^{a}	6.41±0.06^{a}	6.39±0.00^{a}
Texture	3.07±0.03^{d}	5.06±0.00^{bc}	7.03±0.01^{a}	5.34±0.05^{b}	4.63±0.02^{c}
Overall acceptance	4.75±0.01^{c}	5.90±0.03^{b}	6.79±0.02^{a}	6.27±0.01^{ab}	5.28±0.03^{bc}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Table 4. Effectiveness of gelatin ratio (%) to color, texture and overall acceptance of papaya jam

Gelatin ratio (%)	0.2	0.3	0.4	0.5	0.6
Color	7.41±0.04^{a}	6.25±0.03^{a}	7.36±0.05^{a}	7.30±0.02^{a}	7.42±0.04^{a}
Texture	6.17±0.01^{c}	6.74±0.06^{bc}	7.11±0.03^{b}	7.83±0.01^{ab}	8.00±0.03^{a}
Overall acceptance	6.33±0.05^{c}	6.61±0.02^{bc}	7.20±0.04^{b}	7.48±0.03^{ab}	7.64±0.01^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Effectiveness of sucrose ratio to color, texture and overall acceptance of papaya jam

Sugar played an important role in the quality of papaya jam. In the present study, sucrose addition in different proportions (20%-40%) was thoroughly verified and the results were depicted in Table 5. Sugar did not create a significant difference in papaya jam color. There was an increasing trend in texture and overall acceptance was noticed when adding the sucrose from 20% to 30%; however, a decelerating trend in texture and overall acceptance was noticed when increasing sucrose beyond 30%. Therefore, sugar should be supplemented at 30% to obtain adequate acceptance for papaya jam. Sugar addition facilitated the reduction of water activity to a sufficient level to ensure the microbial durability of processed products. Pathogenic bacteria cannot proliferate in a medium with water activity (a_w) below 0.85, while an a_w lower than 0.62 is enough to inhibit fungi and yeasts (15). Papaya jam including 55% sucrose and 45% flesh was highly evaluated (2). A sucrose content of 35.48% was recommended to obtain the best papaya jelly candy **(**14**),** while an amount of 68.8 % sugar was needed to formulate papaya candy (4).

Effectiveness of lemon juice ratio to color, texture and overall acceptance of papaya jam

Different proportions of lemon juice (2-6%) were added in papaya jam making. There was an accelerating trend of consumer preference in respect of color and overall acceptance when increasing lemon juice ratio. However, there was no clear difference in texture among papaya jam samples treated with lemon juice (2-6%). Lemon juice at 5% and 6% caused no significant difference in texture and overall acceptance; hence 5% of lemon juice was recommended to supplement stripped papaya in jam preparation. All results were illustrated in Table 6. In another report, papaya candy was formulated with 3 citric acid levels of 0.5%, 0.75% and 1.0%. Results revealed that total soluble solids decreased with an increase in citric acid proportion (16). Lemon juice plays an important role in providing acidity to convert non-reducing sugar to reducing sugars or chelating metal ions (3). An amount of 0.1% of citric acid was suggested to be added into papaya to obtain the best candy (17).

Conclusion

Papaya possesses specific quality attributes with numerous proximate, health-related, sensory, marketable and cultural values. Despite being available in large quantities during harvest, it is often underutilized in processed forms. This research successfully examined different papaya fruit varieties and various technical parameters essential for jam production. The Sapna variety emerged as the best performer among the papaya varieties studied. The transformation of papaya fruit into value-added products like jam represents an effective strategy for controlling post-harvest losses.

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Compliance with ethical standards

Declaration: The author strongly confirms that this research is conducted with no conflict of interest.

Ethical issues: None

Table 5. Effectiveness of sucrose ratio (%) to color, texture and overall acceptance of papaya jam

Sucrose ratio (%)	20	25	30	35	40
Color	7.75±0.01^{a}	7.79±0.02^{a}	7.82±0.00^{a}	7.75±0.01^{a}	7.83±0.05^{a}
Texture	7.08±0.00^{c}	7.41±0.03^{bc}	8.16±0.02^{a}	8.01±0.04^{ab}	7.74±0.00^{b}
Overall acceptance	7.29±0.03^{c}	7.63±0.00^{bc}	8.07±0.03^{a}	7.88±0.02^{ab}	7.79±0.00^{b}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

Table 6. Effectiveness of lemon juice ratio (%) to color, texture and overall acceptance of papaya jam

Lemon juice ratio (%)	2	3	4	5	6
Color	7.65±0.05^{c}	8.12±0.01^{bc}	8.30±0.06^{b}	8.43±0.03^{ab}	8.54±0.02^{a}
Texture	7.99±0.02^{a}	8.05±0.00^{a}	8.04±0.01^{a}	8.08±0.00^{a}	7.96±0.04^{a}
Overall acceptance	7.70±0.04^{c}	8.08±0.03^{b}	8.09±0.04^{b}	8.15±0.01^{ab}	8.29±0.03^{a}

Figures are the mean of three replications; Figures in row followed by the same letter/s are not differed significantly (α = P=0.05).

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