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Original Research Article

A preliminary study of high pressure processing effect on quality changes in 'Nanglae' pineapple juice during cold storage

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ABSTRACT

Thermal processing affects sensory attributes and causes a loss in nutritional values of fruit juice products. This preliminary study was to clarify the effect of high pressure processing (HPP) as a non-thermal treatment on quality changes in 'Nanglae' pineapple juice. Fresh 'Nanglae' pineapple juice (100% juice) was prepared and treated under pressure at 400 and 600 MPa for 5 min. The condition of 80°C for 10 min was selected as conventional heat treatment (CHT). Changes in physical and chemical quality as well as microbiological quality in terms of aerobic plate count (APC) and yeast and mold (YM) were determined after treatment (0 day) and during storage at 5±1°C for 2, 4 and 6 days. The results were compared with the non-treated juice (control). It was found that after treatment, both HPP and CHT significantly reduced ($P<0.05$) APC and YM in juice samples from 6.71±0.14 and 5.89±0.13 log CFU/mL to less than 1.48 and 1.18 log CFU/mL, respectively. APC and YM were still detected at the same amount until 6 days of storage. In addition, CHT significantly degraded ($P<0.05$) ascorbic acid content in juice while HPP showed lower effect to ascorbic acid degradation. Lightness and yellowness were not significantly different ($P>0.05$) between HPP treatment and control. In contrast, yellowness of sample with CHT significantly decreased ($P<0.05$) from 3.47±0.40 to 2.90±0.44 at day 2 of storage. Moreover, TSS in HPP treated juice did not significantly change ($P>0.05$) compared to non-treated one while in CHT sample the TSS significantly increased ($P<0.05$) from 17.10±0.00 to 18.00±0.10 °Brix. In addition, pH and TA of juice were not significantly different ($P>0.05$) between HPP and CHT, while non-treated sample had higher pH and lower TA than HPP and CHT after 6 days of storage. According to the results, it may conclude that HPP can preserve quality and maintain freshness of 'Nanglae' pineapple juice and is an alternative way for the juice production. However, further study should be carried on the optimization of HPP condition and its effect on other characteristics such as bioactive compound and nutrition value should be further studied.

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INTRODUCTION

Pineapple (*Ananas comosus* L. merr) is one of the most important tropical fruit in the world. It is a good source of nutrients covering vitamin C, minerals (calcium and potassium), carbohydrates, water and crude fiber. The fiber benefits for a digestive system and helps in maintaining weight and balanced nutrition (Yahia, 2010). Moreover, vitamin C, polyphenols and carotenoid help to prevent various diseases including cancer, heart disease, diabetes, decayed tooth and obesity (Ferreira *et al.*, 2016).

In Thailand, pineapples are cultivated all year round in almost part of country. The main plantation areas are including Prachuap Khiri Khan, Rayong, Ratchaburi, Phetchaburi, Lampang, Kanchanaburi Chonburi and Chiang Rai (Office of agricultural economics, 2015). With a large amount of pineapple production, Thailand becomes one of major producer and exporter pineapple and their products in the world. Canned pineapple, pineapple juice, pineapple paste as well as dried pineapple are the important exported products which earn so much income to the country. The economical variety of pineapple are 'Pattavia', 'Intrachitdang', 'Intrachitkhao', 'Phuket', 'Nanglae', 'Sriracha', 'Tradsithong', 'Huaimun', 'Phulae', 'Petburi', 'Phuchawa' and 'MD2' (Popluechai *et al.*, 2007; Thai PBS news, 2018).

'Nanglae' pineapple, a sub-variety of Pattavia pineapple, is a geographical indication (GI) of Chiang Rai province, Thailand. It has round and stout shape with thin skin and sweet taste. The pulp color is yellow like honey and skin color is green with some black or a mixture of yellow to dark orange (Kongsuwan *et al.*, 2009). With a unique taste and flavor, it becomes an economical crop of Chiang Rai. The production yield of 'Nanglae' pineapple was reported about 8,729 ton in 2018 which is 96.47% increasing from 2017 (Department of agriculture extension, 2018). However, overproduction in some season causes lower price and postharvest losses. The use of 'Nanglae' pineapple as a raw material to process pineapple product is an alternative way to overcome the stated problems as well as value added to the produce. Jam, ice cream, dehydrated product and juice are some examples of 'Nanglae' pineapple product recently available in the market. Among these products, 'Nanglae' pineapple juice is the product that may become more interesting nowadays due to consumers concern more about their health.

Beside in the process of juice production, conventional heat treatment usually applied to kill pathogens for ensuring safety and extending shelf life of the product. Pasteurization which using temperatures lower than 100^{o}C is mostly used for these purposes. However, some researchers reported that thermal processing affects in quality such as changing color and loss in bioactive compounds, antioxidant activity, vitamin and mineral. Vervoort *et al.* (2011) found that vitamin C in orange juice significantly decreased about 17.2% after treated with heat pasteurization (90°C, 1 min) compared to untreated juice. Moreover, Rattanathanalerk *et al.* (2005) reported that heat treatment also affected on color change of pineapple juice. The total color different (ΔE) was increased when increasing the processing temperature from 55°C to 95°C.

Recently, there are various non-thermal processing that can be used in juice production instead of thermal treatment while retain sensory attributes and nutrient content similar to raw or fresh fruit. High pressure processing (HPP) is one of the mentioned techniques which originated from Japan and became well-known in other countries such as USA and European countries. It can kill microorganism including bacteria, yeast and mold as well as deactivate enzyme and chemical reaction resulted in less changes of quality, maintain smell, taste and nutritional value. In Thailand, HPP became well-known in a field of food packaging and beverage. Chaikham *et al.* (2013) reported that HPP (500 MPa, 30°C, 20 min) could preserve various bioactive components including ascorbic acid, total phenolic compounds and antioxidant capacity (FRAP assay) in pennywort juice superior than pasteurization (90°C, 3 min) during chilled storage (4°C). However, there is no report on the application of HPP in 'Nanglae' pineapple juice production.

This preliminary study aims to investigate the effect of high pressure processing (HPP) compared with conventional heat treatment on quality changes in 'Nanglae' pineapple juice during cold storage. Fresh 'Nanglae' pineapple juice was treated under pressure at 400 and 600 MPa for 5 min. Changes in quality in term of color, pH, total soluble solid, titratable acidity, ascorbic acid content and microbiological quality were investigated during cold storage.

MATERIALS AND METHODS

Preparation of pineapple juice

Fully ripened 'Nanglae' pineapple (*Ananas comosus* L. merr) with free from external defects was purchased from Chiang Rai orchard in June 2018. Then, pineapple was washed with tap water, peeled and removed core with a sharp stainless-steel knife. Pineapple was cut into small pieces and juice was extracted using hydraulic press juicers (Owner Foods Machinery Co. Ltd.). After that the juice was immediately used for further experiment. Untreated 'Nanglae' pineapple juice with total soluble solid as 15.67±1.07 °Brix was used as a control in comparison with HPP and conventional heat treatment juice.

High pressure processing (HPP)

Pineapple juice was mixed thoroughly and filled by using sterile glass container into 110 mL of sterile PET bottle. Samples were subjected under different high pressure conditions as 400 and 600 MPa for 5 minutes by a HPP apparatus (Bao Tou KeFa High Pressure Technology Co., Ltd., China) with a capacity of 3.0 L at room temperature (25°C). Reverse osmosis (RO) water was used as the pressure-transmitting fluid. The treatment time in this study did not include the time of increasing or releasing pressure. After treatment, all samples were stored at 5±1°C for 2 weeks. Quality changes were determined at 0, 2, 4, 6 and 14 days of storage.

Conventional heat treatment (CHT)

Pineapple juice was mixed thoroughly and heated at 80^{o}C for 10 minutes according to Chia et al. (2012). After treatment, pineapple juice was filled by using sterile glass container into 110 mL of sterile PET (polyethylene terephthalate) bottle and stored at the same condition of sample treated with HPP as well as the sampling time and quality determination.

Determination of juice color

Color measurement of pineapple juice was measured using a color reader CR-10 (Konica Minolta, Inc., Japan). The values were expressed in term of L* (lightness) and b* (yellow-blue).

Determination of pH, total soluble solid (TSS) and titratable acidity (TA)

Pineapple juice was mixed thoroughly. The pH of pineapple juice was measured using pH meter (Binder, Scientific Promotion Co., Ltd). The pH meter was calibrated with pH 4.0 and 7.0 standard buffer solutions before used. Total soluble solid content (TSS) was measured using digital hand refractometer (ATAGO, Japan) and expressed as °Brix. Titratable acidity was determined according to AOAC (2000). Five milliliters of pineapple juice was titrated with 0.1 N NaOH. One percent of phenolphthalein was used as an indicator.

Determination of ascorbic acid content

Ascorbic acid content in all samples were determined according to AOAC (2000). Five milliliters of metaphosphoric acid-acetic acid solution was added to 50-ml erlenmeyer flask. Then, two milliliters of sample was added. The samples were titrated with indophenol dye solution until rose-pink color appeared and persisted for at least 5 seconds. The ascorbic acid content was expressed in mg/100 ml.

Determination of microbiological quality

Aerobic plate count (APC) and yeast and mold count (YM) in all samples were determined using 3M PetrifilmTM Aerobic Count Plate (AOAC official method 990.12, 1995) and 3M PetrifilmTM Yeast and Mold Count Plate (AOAC official method 997.02, 1997). One mL of each sample was serially diluted with 0.1% sterile peptone water and 1.0 mL of each dilution was pipetted to petrifilm. The incubation temperature of 37±1°C for 48±3 hr and 25±1°C for 3-5 days was employed for aerobic count plate and yeast and mold count plate, respectively. Colonies were enumerated and expressed in log CFU/mL.

Statistical analysis

The data obtained were expressed as mean ± standard error from triplicate determinations. All data was subjected to Statistic Analysis System version 22.0 software (SPSS, Inc., IBM). Analysis of variance (ANOVA) and Duncan's multiple range tests were used to determine the effects of treatment on dependent variables during storage. The result was considered at P<0.05 statistical significance.

RESULTS AND DISCUSSION

Color in terms of L*(lightness) and b* (yellow-blue)

Color of 'Nanglae' pineapple juice during storage was observed in terms of L* and b* values (Figures 2 and 3). There was not significantly different (P>0.05) between untreated juice and both HPP treated samples (400 and 600 MPa) along the storage time. HPP did not affect on L* and b* values in pineapple juice. While CHT significantly changed (P<0.05) b* value of juice sample toward more negative position from 4.53±0.32 to 3.53±0.25 at the end of storage day, which indicated less yellow color of pineapple juice. A similar result in b* value change in pineapple juice treated with CHT was also observed in cloudy apple juice. Yi *et al.* (2017) reported that CHT (85°C, 5 min) caused significantly color change by decreasing of b* value in cloudy apple cultivar 'Pink Lady', 'Granny Smith' and 'Jonagold' from 45.48±0.14 to 41.88±0.33, 40.40±0.40 to 35.06±3.12 and 42.85±0.30 to 38.66±0.68, respectively. The color changes in juice after CHT was the results of decreasing of polyphenol oxidase (PPO) and peroxidase (POD) activity. Moreover, the losses of yellowness due to CHT accelerated carotenoid isomerization in pineapple juice (Chen *et al.*, 1995).

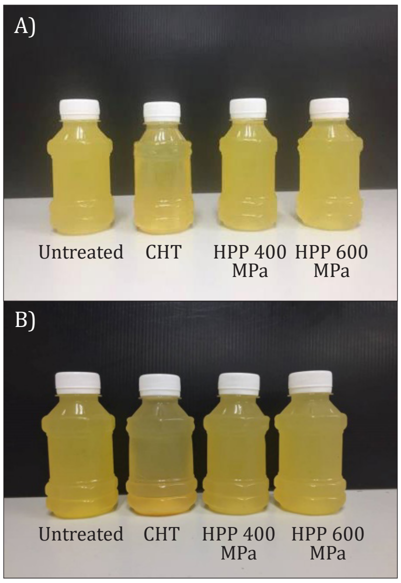

Figure 1. 'Nanglae' pineapple juice stored at 5±1°C A) After treatment (Day 0) B) At the end of storage (Day 14).

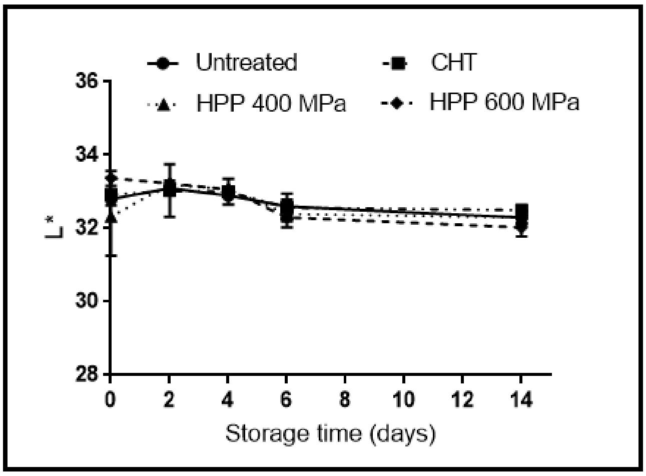

Figure 2. Changes in L* values of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

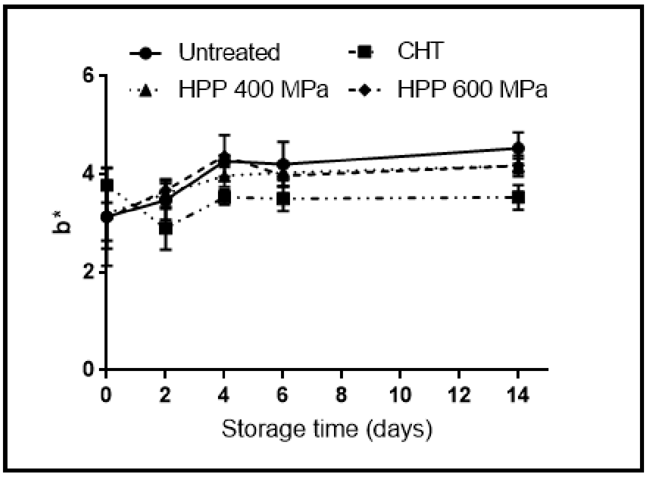

Figure 3. Changes in b* values of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

pH

After treatment, HPP and CHT slightly decreased pH of 'Nanglae' pineapple juice (Figure 4) and pH of both treated samples were not significantly different (P>0.05) until the end of storage. The similar result has also been reported in *Opuntia dillenii* cactus juice treated with HPP 600 MPa for 10 min. After HPP, pH of cactus juice was slightly decreased from 3.68±0.02 to 3.65±0.01 (Moussa-Ayoub *et al*., 2017). While the pH of untreated pineapple juice significantly increased during storage time. The increasing of pH value mainly caused by some microorganisms that able to survive in acidic environment of juices which they were able to regulate their internal pH at neutral pH using active and passive homeostasis. After that, they modified pH of juice to suitable pH for growth (Kaddumukasa *et al*., 2017).

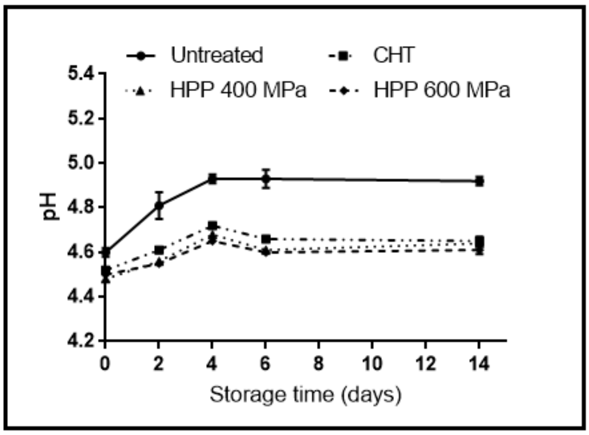

Figure 4. Changes in pH of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

Total soluble solid (TSS)

After treated with HPP, TSS of pineapple juice was not significantly different (P>0.05) compared to untreated juice (Figure 5). TSS of pineapple juice treated with HPP at 400 MPa and 600 MPa was 17.03±0.12 °Brix and 16.93±0.06 °Brix respectively and retained the same level until the end of storage time. The similar result was found in white grape juice treated with HPP at 300 and 600 MPa for 3 min (Yin-Hsuan et al., 2017). On the other hand, TSS of juice sample treated with CHT significantly increased (P<0.05) from 17.10±0.00 oBrix to 18.00±0.10 °Brix. The increasing of TSS in juice treated with CHT can be explained by water evaporation during thermal processing (Tandon *et al*., 2003).

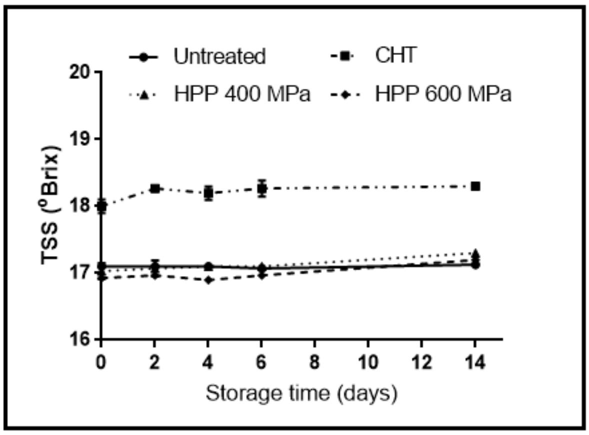

Figure 5. Changes in total soluble solid of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

Titratable acidity (TA)

After HPP and CHT, TA of 'Nanglae' pineapple juice was not significantly different (P>0.05) until the end of storage time (in a range of 0.33-0.37 g/100 mL) but significantly higher (P<0.05) than untreated juice (Figure 6). The reduction of TA in untreated pineapple juice due to the metabolic activities of microorganism that accumulate organic acid from sugar produced which some microorganism such as yeast in juice reduced sugar content and fermentation leading to spoilage (Sodeko *et al*., 1987;Abbo *et al*., 2006). The slightly increasing TA after storage for 2 days results from the formation of slime, gas, off-flavor, turbidity and changes in acidity (Murdock & Hatcher, 1975).

Ascorbic acid content (ACC)

CHT and HPP (400 and 600 MPa) significantly affected to ACC in 'Nanglae' pineapple juice. ACC decreased from 3.14+0.68 mg/100 mL to 1.57±0.34 mg/100 mL, 2.36±0.00 mg/100 mL and 2.36±0.00 mg/100 mL, respectively (Figure 7). Lower percentage of ACC reduction as 24.84% was observed in HPP treatment while almost 50% of ACC loss was found in CHT juice.

Xu e*t al*. (2018) found that after HPP treatment at 500 MPa for 10 m, ACC in clear and cloudy kiwifruit juice decreased as 1.83% which lower than CHT (4.15%). Therefore, HPP may influence ascorbic acid degradation. However, HPP showed better ascorbic acid retention after treatment compared to CHT. The higher loss in ACC in pineapple juice treated with CHT due to ascorbic acid is heat sensitive bioactive compound. Heat accelerates ascorbic oxidation, its losses two of hydrogen and converted into dehydroascorbic acid or diketogulonic acid during thermal processing (Hounhouigan *et al*., 2014; Mills *et al*., 1949; Odriozola-Serrano *et al*., 2008).

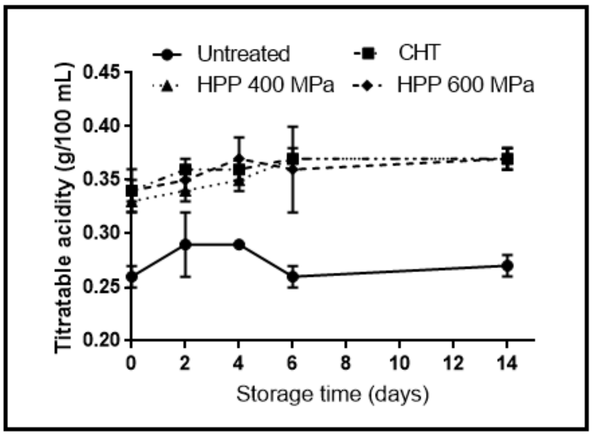

Figure 6. Changes in titratable acidity of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

Microbiological quality

Initial population of APC and YM in 'Nanglae' pineapple juice were 6.71±0.14 and 5.89±0.13 log CFU/mL, respectively. After CHT and HPP treatment, APC and YM significantly decreased to lower than 1.48 and 1.18 log CFU/mL, respectively and still in the same level until the end of storage time. On the other hand, gradual increase in APC and YM was observed in untreated juice sample along the storage time. The number of APC exceeded the safety level of 4 log CFU/mL (HPA, 2009).

Yuan *et al*. (2018) reported that HPP at 400 and 600 MPa for 2.5 and 5 min could inactivate microbial in aronia berry puree to below 2.0 log CFU/mL. The possible mechanism of microbial inactivation is when pressure increase, the structure and cytoplasmic organelles were irreversibly deformed and intracellular material leaked out. Therefore, the microbial inactivation occurs due to permeabilization of the cell membrane (Rastogi *et al*., 2007).

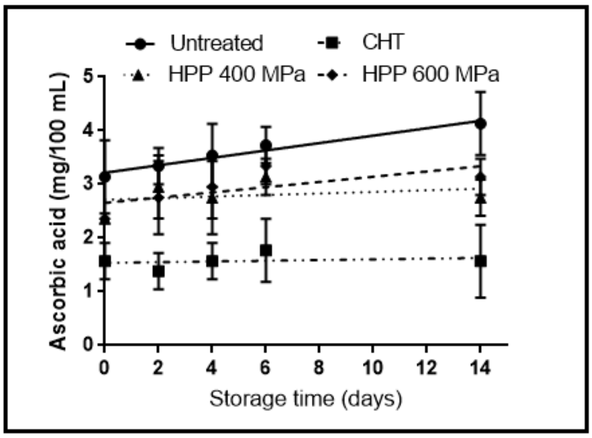

Figure 7. Changes in ascorbic acid content of untreated, conventional heat treatment and high pressure processing (400 and 600 MPa) 'Nanglae' pineapple juice stored at 5±1°C for 14 days.

CONCLUSIONS

This preliminary study found that HPP at 400 and 600 MPa provided similar results in all quality changes of 'Nanglae' pineapple juice. HPP exhibited a better retention of color and ascorbic acid content in 'Nanglae' pineapple juice compared to CHT. In addition, HPP could reduce the number of aerobic plate count and yeast and mold count similar to CHT which ensure safety of HPP treated 'Nanglae' pineapple juice. Therefore, HPP as a non-thermal technology could be an alternative technique which provides high nutrient and quality in the HPP product to convectional thermal processing. A further study will focus on effects of HPP on bioactive compound and antioxidant activity in 'Nanglae' pineapple juice.

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