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Effects of hot water blanching and storage time on the quality of refrigerated pineapple (*Ananas comosus*) slices

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ABSTRACT

This research was conducted to evaluate the effects of blanching and storage days on physico-chemical, sensory, and microbial qualities of pineapple slices. The pineapples (Honey Queen) were cut into circular identical slices and refrigerated at 5°C for 0, 4, 8 and 12 days after exposing to hot water blanching at 0, 70, 85 and 100°C for 1 minutes. The changes in physico-chemical parameters, such as total soluble solids (TSS), color factors, titratable acidity (TA), pH, vitamin C, total phenolic content (TPC), along with the sensory attributes and microbial count (total plate count, total coliform count, total yeast and moulds count, and *Salmonella*) of pineapples were investigated. The control sample shelf life (16 days) was maximum. We found that blanching and storage days had significant effect on physico-chemical properties, microbial load, and sensory attributes of pineapples. Findings also showed that declining trend in pH and a simultaneous rise in TA in samples throughout the storage period. The TSS was increased with the increase of blanching temperature and storage days. Vitamin C contents in pineapple slices showed a reducing trend by both blanching and during storage. The increase of blanching temperature increased the total phenolic content compared to control samples but decreased with the advancement of storage days. Irrespective of the blanching treatments, color factors (L, a, and b value) showed a declining trend during storage. In sensory evaluation, control samples obtain the highest score and denoted as "like moderately". Blanching had effectively reduced the overall microbial load of pineapples slices compared to controls. The control samples gave the better vit-c retention as well as the sensory quality of pineapples slices but poor microbial safety. The hot water blanched pineapple are microbial hygienic and safe for consumption, but showed lower shelf life.

1. Introduction

Pineapple (*Ananas comosus*) is a non-climacteric fruit belonging to the family of Bromeliaceae. Bioactive compounds such as polyphenols, anthocyanins, flavonoids, tocopherols, carotenoids, vitamin C, and various other antioxidant compounds in pineapple contribute to its antioxidant activity (Momtazi-Borojeni et al., 2017). In addition, pineapple contains bromelain, a protease enzyme, which has a number of therapeutic benefits, such as inhibiting leukemia cells (Debnath et al., 2019) and maintaining body weight (Vipul et al., 2019), and remedy for gout, arthritis, sore throats, oral cancer, and rhinosinusitis (Tanmay et al., 2018; Lee et al., 2019; Passali et al., 2018).

Fresh pineapple containing moisture content (around 80%) is tremendously perishable and spoil easily without proper handling (Orsat et al., 2006). The protease enzyme (bromelain) denatures proteins and accelerates pineapple ripening process (Wang et al., 2014). Candida, Debaryomyces, and Saccharomyces caused spoilage microbes for pineapple at ambient temperature (Joseph-Adekunle et al., 2010). Limited pineapple's shelf life makes challenging to distribute outside of production region, so

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preservation efforts requiring to extend it. There is a growing need for simple, low-cost processing methods alternatives to chemical preservatives, which extend shelf life but pose food safety, health, and environmental risks. Recently, food safety is the burning issues in developing countries like Bangladesh because of overuse preservatives. Blanching as a pre-treatment combined with minimally processing pineapple an effective strategy to mitigate postharvest loss. Processed pineapple is a very popular in modern fast-paced lifestyles due to its health appeal, texture, taste, freshness, and ease of serving when compared with other minimally processed foods. To date, evidence of the effect of hot water blanching on the quality of minimally processed pineapple is lacking.

Blanching is employed to improve the texture and flavor of fruits and vegetables (Abdul Halim, 2021); protect their color, flavor, and nutrients; decrease pathogen and bacterial counts; prolong food shelf life (Reyes De Corcuera et al., 2011; Yoshida et al., 2017); and also halt the enzyme activity to prevent quality losses such as off-color, off-flavor, or texture degradation in the product (Arroqui et al., 2003; Mazza, 1983; Prakash et al., 2004; Severini et al., 2005). It is usually carried out by hot water, boiling acid or salt solutions, or steam for a few minutes (Kidmose and Martens, 1999). Fruits and vegetables are blanched at specific temperatures for 1–10 minutes, depending on the time required for enzyme inactivation (Xiao et al., 2017). The fruit was blanched with hot water for microbial disinfestation in addition to managing fungal and insect attacks. (Mustafa et al., 2005). It was an appropriate environmentally and economically friendly technique for organic producers without chemical residue (Fallik, 2004; Maxin et al., 2014). Hot water treatment increases accumulation of intracellular reactive oxygen species, disrupts mitochondria, and lowers ATP in pathogens, while increasing phenylalanine ammonia-lyase activity in the fruit (Liu et al., 2012) and also reducing fruit skin rot by inducing protective proteins (Li et al., 2013). Over blanching may lead to the loss of essential minerals, but optimum blanching ensures that nutrients remain intact (Fox et al., 1991). Optimum blanching time and temperature are essential for better nutrient retention. Therefore, the optimum blanching temperature and time are not defined for processed pineapple till now. Therefore, novel market-driven interventions of processed pineapple are urgently needed to help farmers and entrepreneurs to reduce post-harvest losses. It is very important to investigate the effect of hot water blanching on the physico-chemical, microbial, and sensory changes of minimally processed pineapple to predict the most suitable blanching condition for pineapple.

2. Materials and Methods

2.1. Sample preparation

The pineapple variety (Honey Queen), locally known as Joldungi was chosen for the research. Disease-free fresh pineapples which were harvested from a farmer's field located in the Modhupur Upazila of the Tangail district in Bangladesh. After harvesting, the fruits were immediately conveyed to the laboratory within the day of harvest for post-harvest treatments, ensuring careful handling, and were stored at 10°C overnight. Next day, pineapple samples were thoroughly washed with safe drinking water to eliminate dust, dirt, and fungicidal residues. Then, the fruits were peeled using a sharp stainless-steel knife following the removal of the crown. The hard core of the fruit was taken out using a stainless-steel pineapple corer. The pineapple pulps were cut into round slices approximately 1 cm in thickness and were packaged in transparent plastic box, with each box weighing 250 grams.

2.2. Samples treatment

A thermostatically controlled water bath was used for the blanching treatment. Pineapple slice was blanched for different temperature at 0, 70, 85 and 100°C into hot distilled water into a water bath for 1 minutes. After blanching, pineapple slices were drained out and were subsequently cooled in distilled water (27ºC ± 2) for 5 min, to reduce over boiling. The hot water blanched pineapple slices were kept at 5ºC ± 1 in a refrigerator that temperature commonly maintain in supermarkets for storage of minimally processed foods. The pineapple slice quality was assessed at 4 days interval for each treatment with three replicates over a total of 12 days storage period.

Fig 1: Sample collection, processing and analysis

2.3. Physico-chemical analyses

2.3.1. Assessment of color factor change

The pineapple slices color change was measured by reflectance using Konica Minolta Chroma meter. According to the CIE LAB system, to measure color factors L* (0=maximum darkness, 100=maximum lightness), a* defines the red greenness (negative for green and positive for red) and b* defines the blue yellowness (negative for blue and positive for yellow) were recorded. The illuminant was D65 used as reference light source and the colorimeter was calibrated. All color factor (L*, a*, b* value) were recorded in triplicate under different place of pineapple slice for each reading with three parameters.

2.3.2. Determination of pH

The pH of pineapple was measured with using an electric pH meter. The pH meter was calibrated with the use of pH 4, 6 buffer solution.

2.3.3. Determination of titratable acidity (TA, %) and total soluble solid (Brix)

Fruit juice was titrated with 0.1N NaOH with 1% phenolphthalein using as an indicator by the method by Ranganna (1997. The results were calculated as percentage of citric acid. The total soluble solids were assessed with a hand-held refractometer. TSS was recorded as °Brix from direct refractometer prism reading. Before reading taken, the refractometer was calibrated with distilled water to give a 0°Brix reading.

2.3.4. Estimation of vitamin C (mg per 100g)

The fruit vitamin C content was determined using 2, 6- dichlorophenol-indophenol dye by the method reported by Ranganna (2003). The amount of dye titrated was equivalent to the amount of ascorbic acid.

2.3.5. Assessment of total phenolic content (TPC, gallic acid equivalents in mg/100g)

The total phenolic content of the extracts was determined by the modified Folin-Ciocaltu method (Imran and Khan, 2014) and result were expressed as gallic acid equivalents, in mg/100g pineapple fresh weight.

2.3.6. Enumeration of microbial load

The microbial profiles of the pineapple slices were determined by using the total number of bacteria, yeast, and mould analyses (AOAC, 2005). Aseptically homogenizing fifty grams (50g) of pineapple slices was performed in 450ml of sterile 1% peptone solution as diluent with a homogenizer. After homogenization, a tenfold dilution series were made and plated on different agar media by surface spreading method. Total viable, total coliform, total yeast and moulds count were determined and the respective culture media were Plate count agar (PCA), Violet Red Bile Agar (VRBA), Oxytetracycline-Glucose Yeast Extract Agar (OGYEA). Xylose Lysine Desoxycholate Agar (XLDA) was use to Salmonella detection. The plating process was carried out in triplicates, with bacteria incubated at 36±1ºC and assessed after 24 hours and 48 hours. The count of cfu/g was determined by multiplying the bacterial number by the dilution factor. The culture plate was kept at ambient temperature (25ºC) for yeast and molds count during the incubation period. The total yeast counts were assessed within a period of 48 hours, while the total mould counts were evaluated over a span of 3 to 5 days. The horizontal method outlined in ISO 6579-2002 was employed for the detection of Salmonella sp., specifically targeting *Salmonella Typhimurium* and *Salmonella Paratyphi*. Microbial analysis was carried out on the 12th day of storage.

2.4. Sensory analysis

Organoleptic properties of pineapple slice evaluation were performed by using randomly selecting 25 semi-trained panelists. The semi-panelists were instructed to use a seven-point hedonic scale to evaluate the taste, texture, sweetness, color, and overall acceptability (Kumar and Shukla, 2017). The sensory scale included: like extremely = 7, like moderately = 6, like slightly = 5, neither like nor dislike = 4, dislike slightly = 3, dislike moderately = 2, dislike extremely = 1.

2.7. Statistical analysis

The effects of blanching and storage time on physico-chemical, sensory and microbial quality of pineapple slices were evaluated based on a two-way analysis of variance (ANOVA). All statistical analyses were carried out using Agricole R package.

3. Results and Discussion

3.1. Effect of blanching and storage days on physico-chemical quality of pineapple slices

The physico-chemical parameters such as pH, TSS, total acidity, and vitamin c of pineapple slices are shown in Table 1. The study result exhibits that blanching and storage days had significant ($p < 0.05$) effect on pH and total acidity (TA) content in pineapple slices. The pH value of samples was increased with a corresponding reduce in total acidity (TA) with the increase of blanching temperature. A marked declining trend in pH and a simultaneous rise in TA were recorded in both blanched and control samples throughout 12 days of storage. After a storage period of 12 days, the highest recorded total acidity (TA) for control (0°C) pineapple samples was 1.39%, while the lowest pH value was 3.59. The pineapple samples blanched and un-blanched pH range were from 3.59 to 4.17 over the storage period. According to Andrade (1999), found that the pH value of pineapple ranges from 3.0 to 4.0. The study could be concluded that with the advancement of storage period, the average pH values of pineapple decreased and TA increased in both blanched and un-blanched samples. During storage, carbohydrates (sugar) are fermented into chemical byproducts like alcohol and carbon dioxide (CO_2), resulting in a lowered pH and increased acidity in fruits (Asare et al., 2014). The fungus *Aspergillus niger* produces organic citric acid naturally, and contamination may lead to increase in acid concentration (Show et al., 2015). The progressive increase in acidity with prolonged storage duration acts as an indicator to forecast contamination and microbial proliferation, including fungi, which are able to ferment sugars, thereby increasing acidity and resulting in a lower pH level. The findings of the research indicated that pineapple blanched at 100°C was most effective in retaining the quality attributes of fruits as evidenced by reflected in lower acidity and higher pH levels during the 12 days of storage. However, the finding of the present study similar with the results reported by Chaturvedi (2013) who concluded that storage of intermediate moisture carrot shreds increase total acidity level.

The vitamin C also known as ascorbic acid is one of the primary organic acids in pineapple fruit and acts as a good antioxidant. The data analysis showed that both blanching treatments and storage days had a significant ($p < 0.05$) effect on vitamin C contents degradation in pineapple slices. The Vitamin C contents in un-blanched and blanched at 70, 85, 100 °C pineapple slices were 31.11, 28.27, 27.66, and 23.05 mg/100g respectively at initial day of storage, indicating that blanching treatments significantly affect the degradation of ascorbic acid levels in pineapple. This declining trend could be attributed to the oxidation and heat labile nature of ascorbic acid (Brar et al., 2020; Zheng and Lu, 2011). Thus, elevated-temperature blanching treatment quickly degraded the heat labile vitamins. The control sample (un-blanched) treated at 0/1(°C/min) exhibited the highest level of ascorbic acid (22.56 mg/100 g) retention whereas the sample blanched at 100/1(°C/min) retained the lowest ascorbic acid (12.25 mg/100 g) content over 12 days of storage. The table 1 also shows that vit-c content decreased with the increase of storage time. Similar result found that the Vit- C (ascorbic acid) content degraded in all samples during storage condition (Minh 2021). Another research show that hot water blanching, such as 53°C for 6 hours in orange or 50°C for 5 minutes in mango, had no significant effect on ascorbic acid content (Mustafa et al., 2005; Mansour et al., 2006). Evidence suggests that hot water blanching treatment plays a crucial role in stabilizing ascorbic acid levels in mango during ambient storage as well as cooled storage (Pholoma et al., 2020; Niazi et al., 2021). This research findings is dissimilar with present research may be due to different fruits and low temperature blanching treatment.

The total soluble solids (TSS) is mainly indicating the highest sugar concentration which is made up of carbohydrates, amino acids, mineral salts, water soluble vitamins, and organic acids (Dereje and Abera, 2020). Table 1 shows the Brix value of control and blanched pineapple samples during refrigeration storage at 5°C. The statistical analysis show that blanching treatments and storage days had significant ($p < 0.05$) effect on TSS content in pineapple samples. Among the blanching treatments, pineapple slices blanched at 100°C retain the highest amount of total soluble solids (15°Brix) compared to control and other blanched samples over the refrigeration storage periods. Table 1 also reveal that TSS is increased with the increase of blanching temperature and advancement of storage days. At 12 days of storage, the pineapple slices blanched at 100°C contain maximum TSS and increase 1.3°Brix than initial storage days. However, the Brix value increased with the increase of storage time. Because of the degradation of complex carbohydrate (polysaccharides) into simple sugars that dissolve in water and the simultaneous loss of moisture through respiration during storage. The similar result found that blanching temperature enhance the total soluble solids, as reported for mangoes at 46.5°C for 45 minutes (Nyanjage et al., 1998) and bananas at 53°C for 9 minutes (Amin and Hossain, 2013). The research finding is in compliance with the present study that one reported by Minh (2021) where pineapple TSS were reduced with the storage time due to may be different blanching temperature or different pineapple variety.

Table 1: Effect of blanching and storage days on physico-chemical quality of pineapple slices during refrigerated (5°C) storage

Quality Parameters	Blanching temperature (°C)	Storage days			
		0	4	8	12
	0	3.82 ± 0.0145^{a}A	3.78 ± 0.007^{a}B	3.67 ± 0.004^{a}C	3.59 ± 0.007^{a}D
	70	3.80 ± 0.009^{b}A	3.77 ± 0.011^{b}B	3.75 ± 0.005^{b}C	3.64 ± 0.12^{b}D

pH	85	3.91±0.008^{c}A	3.97±0.002^{c}B	3.90±0.0123^{c}C	3.70±0.014^{c}D
	100	4.09±0.018^{d}A	4.17±0.029^{d}B	4.01±0.013^{d}C	3.94±0.031^{d}D
TTA (%)	0	0.97±0.011^{a}A	1.02±0.01^{a}B	1.09±0.0144^{a}C	1.13±0.006^{a}D
	70	0.93±0.007^{b}A	0.98±0.034^{b}B	1.05±0.017^{b}C	1.11±0.029^{b}D
	85	0.85±0.014^{c}A	0.89±0.021^{c}B	0.95±0.016^{c}C	1.08±0.001^{c}D
	100	0.69±0.023^{d}A	0.73±0.017^{d}B	0.81l±0.031^{d}C	1.02±0.025^{d}D
TSS (Brix)	0	13.2±0.031^{a}A	13.8±0.018^{a}B	14.3±0.015^{a}C	14.7±0.024^{a}D
	70	13.8±0.013^{b}A	14.1±0.022^{b}B	14.4±0.037^{b}C	14.8±0.029^{b}D
	85	13.9±0.011^{c}A	14.5±0.017^{c}B	14.9±0.027^{c}C	15.3±0.002^{c}D
	100	14.6±0.020^{d}A	15.0±0.014^{d}B	15.5±0.011^{d}C	15.9±0.019^{d}D
Vit. C (mg/100ml)	0	31.11±0.023^{a}A	29.94±0.002^{a}B	26.5±0.019^{a}C	22.56±0.021^{a}D
	70	28.27±0.031^{b}A	27.82±0.017^{b}B	24.65±0.013^{b}C	20.42±0.010^{b}D
	85	27.66±0.022^{c}A	25.10±0.016^{c}B	19.34±0.011^{c}C	17.59±0.039^{c}D
	100	23.05±0.045^{d}A	21.30±0.021^{d}B	16.31±0.027^{d}C	12.25±0.020^{d}D

Values are mean ± standard deviation (n = 3). Different lowercase letters (a–d) in the same column indicate significant differences among blanching temperatures, while different uppercase letters (A–D) in the same row indicate significant differences across storage days (Tukey's HSD test, $p < 0.05$).

3.2. Effect of blanching and storage days on total phenolic contents of pineapple slices

The data pertaining to the effect of blanching treatments on pineapples fruits total phenolic contents during storage are presented in following Fig.2. The statistical data analysis exhibits that blanching temperature and storage days had significant ($p<0.05$) effect on total phenolic contents in pineapple slices. As illustrated in Fig.2, the phenolic content of control (0°C) pineapple pulp was 50.23 mg GAE/100 g, where as a remark increase was observed in samples blanched at 70, 85, and 100°C (52.96, 65.45, and 71.02 mg GAE/100g respectively). The rise in total phenols content with the increase of blanching temperature due to the rupture of pineapple cells. This cell disruption is responsible for the diffusion of phenolic compounds into the extracellular space or the conversion of phenolic complexes into free molecules, which ultimately enhancing their identifiability (Queiroz et al., 2010). Similar results were found by Liu et al., (2016) that blanching to mango pulp significantly increased phenolic compared to un-blanched samples. The present study also conclude that phenolic compound was reduced with the prolong storage time. This reduction is may be due to the degradation of phenol compounds into another. The contradict findings is found by Gomez et al., (2022) that storage time has increasing trend to phenolic contents in pineapple slices. This dissimilar result due to different treatment applied.

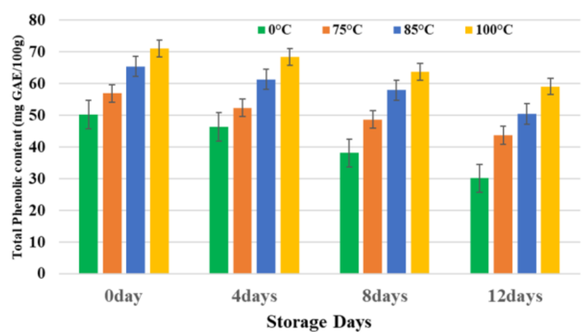

Fig 2: Effect of Blanching and storage days on TPC

3.3. Effect of blanching and storage days on color factors of pineapple slices

Color acts as a distinctive visual qualitative parameter that may impact consumer preferences. Fruit pigmentation is mainly attributed to inherent phytochemicals and bioactive compounds, which act as a fruit quality indicator during processing and storage. Table 2 represents the effect of blanching treatments on pineapple slices and changes in color factors (L, a, and b value) during storage at 5^{0}C. The initial reference control pineapple sample (non-blanched) color factors of

'L', 'a' and 'b' values were recorded 65.11, -16.34 and 42.32 respectively. Table 2 also show pineapple slice became lightness (increase L value), and loss in greenness (reduce '-a' value) and yellowness (reduce '+b' value') by blanching. Blanching treatments and storage duration significantly affected color attributes ('L', 'a' and 'b' values). The maximum lightness 'L' value was recorded 84.23 and 67.12 for samples blanched at 100°C; the minimum lightness 'L' value was 65.11 and 38.61 for control samples (0°C) during storage at initial and 12days respectively (Table 2). The short duration of blanching treatment inactivates the enzyme, which appeared more lightness among the blanched samples (Priyadarshini et al., 2023). Similar results were found by Lopez-Malo et al., (2008) that mango lightness 'L' value reduced with the increase of storage time probably due to non-enzymatic browning reaction. As shown in Table 3, the negative a ∗ value indicated the greenish color of pineapple slice, which were the highest and lowest greenness '-a' value observed for control (0°C) and samples blanched at 100°C respectively over the storage periods. The pineapple slices greenness ('-a' value) was reduced with the increased of blanching temperature and storage days for all samples. At 0°C blanched samples were more greenish in color than other blanched samples over the storage periods. Liu et al., (2016) observed that blanching slightly lessen mango pulp redness (+a value). The highest yellowness ('+b' value) was recorded for control samples (0°C) compared to other blanching treatments (70, 85, and 100°C). Among the samples, the un-blanched sample (0°C) showed the highest yellowness '+b' value in contrast to blanched samples, which recorded the lowest value during over the storage. Both blanching temperature and storage days significantly reduce the yellowness ('+b' value) in all pineapple samples. Lie et al., (2016) also reported that mango pulp exposed to blanching combined with high-pressure processing showed more noticeable significant color factors (L*, a*, and b* values) reductions that indicating lower brightness and yellowness.

3.4. Effect of blanching on microbial load of pineapple slices at 12 days of storage

Ensuring the microbiological safety of processed food is crucial for consumer well-being; otherwise, failure to maintain this safety pose to severe foodborne illnesses. The process food containing microbial load (bacteria, fungi, and yeast) acts as an indicator for food safety and hygiene. The microbial growth observed in the blanched samples during refrigeration storage has been presented on the table 4. All the blanched and control samples were also counted for total viable count, coliform count, yeast count, mold count, and salmonella (cfu/g) detection after 12^{th} days of storage. The microbial count statistical data analysis show that blanching temperature had significant ($p<0.05$) effect on total microbial load reduction in pineapple slices. Maximum microbial count reductions were attained for the samples blanched at 100°C. After 12 days of storage, the highest total viable, coliform, and yeast count (12.93, 5.66, 12.03 $\times 10^7$ cfu/g) were observed for control (0°C) samples and the lowest were observed for sample blanched at 100°C (2.5, 1.7, 1.66 $\times 10^7$ cfu/g) respectively. Among samples, blanched at 100°C showed the lowest overall microbial load due to high temperature blanching treatment. Neither Salmonella typhimurium nor moulds were growth detected on respective culture media in the both blanched and un-blanched samples. The presence of yeast on culture media was detected by fermentative smell and microscopic examination from the both control and blanched samples.

3.5. Effect of blanching on sensory quality of pineapple slices at 12 days of storage

The sensory assessment of fruit is a very vital step for food processing industry. The sensory attributes (except sweetness) varied significantly with the variation of blanching temperature (Table 4). Samples without balancing treatment (0°C) attained highest sensory attributes ranking as "very good", whereas it was lowest for balancing treatment at 100°C. In case of sweetness preference, the effect of blanching was insignificant ($p=0.7$). Kaushik et al., (2016) fount that prolonged thermal processing causes to loss of sensory attributes of mango. However, the control samples achieved best consumer overall acceptability and ranked as "like moderately".

Table 2: Effect of blanching and storage days on color factors of pineapple slices during refrigerated (5°C) storage

Color Factors	Blanching temperature (°C)	Storage day 0	4	8	12
L*	0	65.11	60.57	46.44	38.61
	70	71.54	68.66	59.26	50.10
	85	76.45	72.55	65.58	55.18
	100	84.23	81.12	74.49	67.12
a*	0	-16.34	-13.54	-10.52	-8.38
	70	-14.23	-11.41	-9.08	-7.05
	85	-12.11	-9.94	-7.97	-5.74
	100	-8.91	-7.49	-6.50	-4.15
b*	0	42.32	38.58	30.75	23.77
	70	35.45	32.17	26.57	22.72
	85	31.02	28.40	22.40	19.19
	100	27.75	24.30	20.20	17.14

All value were the triplicates mean. L*, =lightness (0=maximum darkness, 100=maximum lightness), a*= (+a* redness/-a* greenness), b*= (+b* yellowness/ -b* blueness).

Table 3: Effect of blanching on microbial quality of pineapple slices during refrigerated (5°C) storage at 12 days

Blanching temperature (°C)	Total viable count	Total coliform count	Total yeast count	Total mould count	Salmonella
0	12.93^{a}	5.66^{e}	12.03^{i}	ND*	ND*
70	4.46^{b}	3.60^{f}	4.56^{j}	ND*	ND*
85	4.16^{c}	2.73^{g}	3.03^{k}	ND*	ND*
100	2.5^{d}	1.76^{h}	1.66^{l}	ND*	ND*

In a column with dissimilar letter are differ significantly at the 5% level. ND* = microorganisms were not detected on culture media. Colony Counts were expressed as $\times 10^{7}$cfu/g).

Table 4: Effect of blanching on sensory quality of pineapples slice during refrigerated (5°C) storage at 12 days

Blanching temperature (°C)	Sweetness	Color	Flavor	Texture	Overall acceptability
0	6.3^{a}	6.0^{a}	5.0^{a}	6.1^{a}	6.2^{a}
70	6.3^{a}	5.8^{a}	5.1^{ab}	5.8^{ab}	5.5^{a}
85	6.2^{a}	5.3^{ab}	4.6^{bc}	5.1^{bc}	4.3^{b}
100	6.0^{a}	4.7^{b}	3.9^{c}	4.3^{c}	3.2^{c}

Data are mean rank of sensory attributes (like extremely = 7, like moderately = 6, like slightly = 5, neither like nor dislike = 4, dislike slightly = 3, dislike moderately = 2, dislike extremely = 1). In a column, figures with similar uppercase letter(s) do not differ significantly at the 5% level, whereas figures with dissimilar uppercase letter(s) differ significantly.

3.6. Effect of hot water blanching on pineapple slices shelf life

Processed fruit shelf life is the period of time between fruit lose its quality attributes and until unacceptable to consumers. Generally, processed fruits are defined by a shorter shelf life than whole fruits due to surface area contamination as a result higher ethylene production, respiration, and transpiration rates and also microbial growth and enzyme activity. Figure 3 depicts the effect of hot water blanching on pineapple slices shelf life. The shelf life was evaluated by visual appearance and taste. This research was found that the blanching has negative effect on pineapple slices shelf life enhancing. The control samples shelf life were 15 days whereas blanched sample shelf life range was 13-14 days. The hot water blanching accelerates to reduce the shelf life in pineapples.

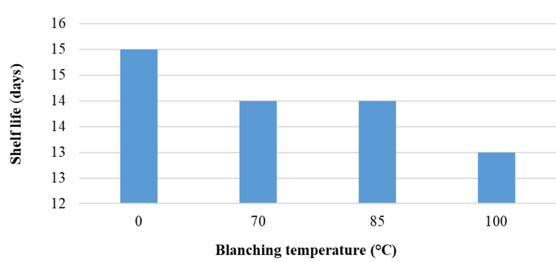

Fig 3: Effect of blanching on pineapple slice shelf life

4. Conclusion

Blanching by hot water was regarded as a pre-treatment for minimal processed fruit as safe for environment and no chemical residues. The vitamin C retention was significantly reduced by blanching and storage days. The blanching temperature and storage days were significantly affected the physico-chemical properties and color factors changes of pineapple slices and enhance the total phenolic contents. The pineapple blanched at 100°C was ensure a microbiologically safe but sensorially gave inferior quality. Therefore, hot water blanching could not be recommended for pineapple slices extending shelf life. Finally, further research is recommended to assess the effect of different blanching method on minerals and vitamins content of process pineapple and also enzyme activity.

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Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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