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FULL PAPER

Physicochemical properties and microbiological safety of steam-blanched frozen kuini (*Mangifera odorata*) pulp

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Abstract

Kuini is an underutilize fruit and rich in nutrients. However, its short shelf life at ambient temperature limits the availability and applications of this fruit. The purpose of this study was to explore the physicochemical and safety of kuini (*Mangifera odorata)* pulp. Steam blanching (SB) treatments were given to the kuini pulp for 5 mins (S5), 10 mins (S10) and 15 mins (S15). Kuini with no treatment is considered as Control (S0). The pH and total soluble solid of steam-blanched kuini showed no significant difference ($p>0.05$). However, viscosity rapidly decreased from 8.28±0.42 millipascal/second to 6.71±0.26 millipascal/second. S15 recorded the highest moisture content as compared to the other treatments. S10 showed the highest total dietary fibre and vitamin A, while S5 recorded the highest in total sugar (19.86±0.16) and total soluble solids (18.06±0.6). Total soluble solids and total sugar were related to each other in all the treatments. No pathogens were detected showing that adequate steam blanching and freezing temperature were given to all samples. Physicochemical, minerals, vitamins and microbiological analysis of kuini pulp may indicate that the pre-treatment studied with proper storage conditions is sufficient and may impart health benefits when consumed or processed and therefore can be suggested as a good raw material source of functional food.

1. Introduction

Kuini is a species in the category of *Mangifera.* Other famous *Mangifera* species include *Mangifera indica (mango)* and *Mangifera pajang* (bambangan). Consumption of fruits is an important part of a healthy diet. Rare fruits like kuini (*Mangifera odorata*) are highly nutritious and considered an underutilized crop. These fruits are climacteric tropical fruits and grow wild in the rain forest and are usually grown in orchards or fruit gardens around houses (Rukayah, 1992; Lim, 2012). The kuini flesh has an attractive yellow colour which can turn into flavour ingredients, food colouring agents also as a raw material for the food industry. Interestingly, kuini can be eaten fresh or processed, thus, it can be commercialized at higher potential as it also contains a high level of nutrients. Nowadays, kuini and other underutilized fruit species are scattered around the country. The advantages of kuini are yet to be explored. The short shelf-life span also contributes to the importance of kuini to be processed into frozen kuini pulp. Kuini contains a variety of micro and macronutrients. The fresh kuini pulp is rich in nutrients such as carotenoid, protein and calcium as compared to other *Mangifera* species (Mirfat *et al.,* 2015). The speciality of kuini pulp can be diversified and can be commercially transformed for various types of promising products. In addition, kuini can be processed into a wide range of industrial products like juices, sherbets, jam, syrup, ice cream, yoghurt, jelly, preserve, candy and pastries.

In modern food technology, various food preservation techniques are available to achieve the main goal of food preservation. For instance, fresh mangoes are perishable and may deteriorate in a short period of time, resulting in large physical damage and quality loss, ranging from 5% to 87% if improperly handled and lack of storage facilities (Serrano, 2005). Hot water is the most common technique for heating fruit pulp but the use of water will result in the leaching of water-soluble nutrients into the water (De Corcuera *et al*., 2004). The essential operation needed for many fruits and vegetables is thermal blanching which requires cooking usually blanching for about five minutes before blending the fruits to become fruit pulps (Uan-On and Senge, 2008).

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Moreover, several types of fruits and vegetables have been processed into pulps to maintain their taste and to prolong the nutritional quality of the fruits and vegetables. Furthermore, the consistency of product quality should be the first priority in the production of fruit pulp (Troung and Walter, 1994). For example, Codex (2013) states that processed tomato pulp shall have a fairly good red colour, shall possess a homogeneous texture and a good flavour and odour characteristic of the product. Therefore, the pre-treatment gave and its processing conditions in the manufacturing process of many products absolutely affect the final product quality.

Freezing has been an established method as the most appropriate technique to extend fruits storage life, including fruit pulps and fruit purees. Barbosa-Cánovas *et al*. (2005) and Fennema (1982) reported that steam blanching sometimes takes a longer time than the water method but helps to retain water-soluble nutrients like some vitamins and minerals. Steaming is also a very critical point as it directly affects the quality of the final products. Therefore, the main purposes of steaming are to inactivate enzymes that cause a quality loss in the product during frozen storage and to reduce microbial load on the surface of fruit pulps. The different time of steaming exposure is also the main criteria to study the nutritional quality of frozen kuini pulp. Besides, steaming and storage conditions also affect the chemical compositions of fruit pulp which inappropriate storage will result in quality degradation.

Production of high-quality frozen kuini pulp may fulfil the increasing worldwide demand for more natural mango variety based-flavoured beverages either singly flavoured or in multi-flavoured products (FAO, 2007). In addition, it meets the great demand for natural fruit pulp by the food manufacturer, and pharmaceutical and cosmetic industries. A daily intake of these delicious fruits can be of great benefit to our bodies in various ways. If we are beginning to eat a healthier diet, a diet high in fruits is a great way to start. Thermal processing has been shown to affect the final quality of pulps. No information is available in the literature regarding the physicochemical characteristics of kuini pulp after processing. However, scarce literature is available on fresh fruits. Thus, the present work aimed to determine the effects of steam blanching treatment on the studied characteristics. Furthermore, findings from this study could provide useful information for the food industry to identify promising products for product development with enhanced nutritional values. In addition, information on the heating stability of frozen kuini pulp could provide some basis to assist the food industry in monitoring suitable heating conditions for better production.

2. Materials and methods

2.1 Materials

Fresh kuini fruits were collected from MARDI Sintok, Kedah. Kuini at the commercial maturity stage, green outer skin with no presence of injury was selected for the study. The fruits were stored at room temperature after arriving at Food Science and Technology Research Centre, MARDI Serdang before being processed.

2.2 Sample preparation

Upon arrival to the laboratory, the fruits were cleaned and washed using a washer for 15 mins. All fruits were steamed in the retort machine without pressure (Millwall, John Fraser and Son, Ltd, London) for the three treatments, A) 5 mins (S5), B) 10 mins (S10), and C) 15 mins (S15). After steaming, the fruits were taken out and then allowed to be cooled in the freezing water for 10 mins before being pulped. The inedible portion was discarded. The fruits were ground into fine particles using a heavy-duty grinder (Panasonic MX-900M, Malaysia). Then, the pulps were pasteurized for 3 mins at 90°C before hot filling. The fruit pulps were kept in metalized aluminium and immediately blast freeze before being kept in the freezer (-18°C) prior to analysis. Raw kuini (S0) was also prepared the same way as described above, but without steaming and hot filling.

2.3 Determination of pH, total soluble solid and viscosity

The pH of the fruit pulp was determined using a benchtop pH meter (Metrohm Model 744, Herisau, Switzerland). The total soluble solid (TSS) content of the fruit pulp was determined using a refractometer with a digital thermometer (ATAGO Co. Ltd., Tokyo, Japan) at 20°C. The viscosity of frozen kuini pulp was determined using a vibro-viscometer at 25°C (Model SV-10, A&D Company Limited, Japan). All measurements were done in triplicate.

2.4 Determination of colour

The colour of the samples was measured using a reflectance colourimeter (Minolta, CM 3500d, Minolta, Osaka, Japan). The instrument was calibrated with standard black and white tiles before analysis and the mean values of three replicates were reported. The surface colour of fruit pulp was measured using the L^*, a^*, b^* scales for the top (central and outer parts) which indicate the lightness, red to green and yellow to blue, respectively.

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2.5 Proximate compositions

Proximate analysis was conducted using the Association of Official Analytical Chemists (AOAC) (2005). The moisture content was determined by drying samples (10 g) in air oven at 105°C overnight until a constant weight was achieved. The ash content was determined by incineration at 600±15°C (Method No. 930.05). Protein content was determined based on the Kjeldahl method (Method No. 978.04). A conversion factor of 6.25 was used to convert the measured nitrogen content to protein content. Fat content was determined by using a semi-continuous solvent extraction method (Method No. 930.09). Carbohydrate was calculated by the difference: carbohydrate = 100 - (g moisture + g protein + g fat + g ash).

2.6 Measurement of total dietary fibre and total sugar

Total dietary fibre was determined by the enzymatic gravimetric method, based on the AOAC (2005) (Method 985.29). The total sugar was analysed based on AOAC (2012) (Method 44.1.15). All measurements were carried out in triplicate (n = 3).

2.7 Methods of vitamin A, vitamin C and minerals analyses

Methods of vitamin A and vitamin C were based on Ismail and Fun (2003). The minerals were determined by the in-house method based on the AOAC (2012) (Method 9.1.09 and Method 50.1.14).

2.8 Microbiological analysis

Microbiological examination (total plate counts, yeast and mould and coliforms count) was carried to all the fruit pulps. Duplicate samples (10 g) were taken and analysed separately. Samples were placed in sterile stomacher bags and homogenized with 90 mL Ringer's solution using a laboratory blender (Seward Stomacher Model 400, UK). From the homogenate, serial dilutions were prepared in Ringer's solution, and each dilution was poured into duplicate plates. Total plate counts (TPC) were determined by poured plate methods using standard Plate Count Agar (PCA) (APHA, 2001). All plates were incubated at 37°C for 48 hrs. The microbes were counted and expressed as log CFU/g samples. Yeast and mould counts were determined by the same method using Potato Dextrose Agar (PDA). All plates were incubated at 32°C for 72 hrs. The microbes were counted and expressed as log CFU/g samples. Total coliforms in the homogenate were estimated by Most Probable Number (MPN) method (AIFST, 1997). All tubes were incubated at 37°C and examined after 24 hrs and up to 48 hrs for gas.

2.9 Statistical analysis

Experimental data obtained were subjected to statistical analyses using the commercial SPSS computer program (SPSS Version 20.0 SPSS Inc., Chicago, IL, USA). Data were averaged and mean comparisons were performed using ANOVA and a Duncan Multiple Range Test at 95% confidence. All measurements were carried out in triplicate (n = 3). The experiments were replicated twice.

3. Results and Discussion

3.1 pH, total soluble solid, colour and viscosity

pH, total soluble solid (TSS), colour and viscosity of frozen kuini pulp treated with steam blanching (SB) are presented in Table 1. pH is a measure used to specify the acidity or basicity of an aqueous solution, while total soluble solid is usually a measurement of sugar content which includes the organic acids, carbohydrates, proteins, fat and minerals of the fruits. Kuini pulp showed a slight increase in TSS for 5 mins of steam blanching, however, it expressed no significant difference ($p>0.05$) among all the treatments. There was not much variation in pH and TSS for all the treatments when compared to the control. This phenomenon might be possible due to the steam blanching given which deactivates enzymes in the pulp. The 5 mins (S5) steam blanching given showed higher total soluble solids as compared to the control which is responsible for more sweetness in the pulp. Chemical attributes like TSS, total acidity (TA) and TSS/TA are used to describe the taste

Table 1. Physical parameters of frozen kuini pulp

Parameter	S0 (Control)	S5 (5 mins)	S10 (10 mins)	S15 (15 mins)
pH	4.78±0.01^{a}	4.72±0.02^{a}	4.85±0.02^{a}	4.79±0.01^{a}
Total soluble solid (°Bx)	16.9±0.40^{a}	18.0±0.60^{a}	17.7±0.30^{a}	17.5±0.10^{a}
Colour (L*)	39.95±0.01^{d}	47.99±0.03^{c}	51.08±0.02^{a}	51.72±0.01^{a}
Colour (a*)	-3.25±0.01^{c}	-1.25±0.01^{a}	-1.26±0.01^{a}	-1.74±0.02^{b}
Colour (b*)	23.84±0.02^{a}	17.27±0.01^{c}	23.87±0.03^{a}	22.33±0.04^{b}
Viscosity (millipascal/s)	8.28±0.42^{a}	7.05±0.37^{b}	6.96±0.79^{c}	6.71±0.26^{c}

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

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(flavour) in terms of sourness or sweetness. Therefore, the steam blanching technique is the appropriate approach to preserve the fruit pulp as the higher the fruit maturity degree, the lower the storage quality. Viljakainen *et al*. (2002) reported that a low pH and a high concentration of acidity are crucial for fruit preservation.

The viscosity of treated kuini pulp decreased slightly among the treatment which could be due to the breakdown of the cell during the steam blanching. The control (no heat-treated) and steam blanching (S0) showed the highest viscosity and significant difference ($p<0.05$) as compared to other treatments. From an initial level of 8.28±0.42 millipascal/second, the viscosity decreased in parallel to the time given for the steam blanching, respectively. Following this point, the viscosity of 15 mins steam blanching recorded the lowest in viscosity (6.71±0.26 millipascal/second). From the study, S10 and S15 showed no significant difference ($p>0.05$). Viscosity is an important factor in fruit pulp as it affects the functionality of the pulp. Fleshy fruits undergo structural and compositional changes owing to the depolymerization of pectins and an increase of water-soluble polyuronides during ripening (Brady, 1987). These modifications lead to softening of tissue and facilitate microbial attacks, which can result in a decrease in the fruit quality (Brady, 1987). Thus, fully matured fruits could be more perishable than immature fruits in terms of storage quality. A study reported that blanching resulted in a significant reduction of vegetable soybean hardness by 17.28% for a sample blanched at 100°C for 2.5 mins and continued to decrease with increased blanching time (Xu *et al.,* 2012). Lucia *et al*. (2011) reported that by grinding and changing the particle size, the apparent viscosity of the apple pulp also decreased.

3.2 Colour

Food colour is a critical factor for the acceptance of food items by consumers. Colour is the first impression to the consumers to choose products. Regarding the treatments, lightness increased in the frozen fruit pulp in parallel to the steam blanching in increasing order, Control<S5<S10<S15. Prevention of colour changes during storage could be associated with the inhibition of PPO (polyphenol oxidase) activity in steam blanching samples since the PPO enzyme is responsible for the browning of the fruits (Loannou and Ghoul, 2013; Yadav and Singh, 2014). On the other hand, the lightness might decrease in pulp due to the inadequate thermal processing given to kuini pulp during the pre-treatment. Loss of carotenoids to some extent and browning reactions during thermal processing could be responsible for the decrease in the yellowish colour component. The darker colour in kuini pulp can be characterized by a browning reaction or Maillard reaction as the result of the chemical reactions between sugars and proteins (Potter and Hotchkiss, 1995). The dominant colour in kuini pulp is yellow and hence can be best represented by Hunter colour b (yellowness) to distinguish the colour difference of the resulting frozen kuini pulp as affected by the different steam blanching process time.

3.3 Proximate composition, total dietary fibre, total sugar and vitamins

The proximate composition, total dietary fibre, total sugar and vitamins of the studied frozen kuini pulp are shown in Table 2. Moisture content was less affected by steam blanching treatment. It ranged from 81.26±0.13 to 82.76±0.03. However, there was a significant difference ($p<0.05$) except for the control and S5 which might be contributed by fewer steam blanching treatments given to the samples. As expected, no fat content was detected in all the treatments. Fruits are high in water content and mostly low in fat content. Moreover, blanching may decrease the amount of carbohydrate, fat and water-soluble protein in certain fruits and vegetables. The total carbohydrate content showed the highest in the untreated sample (17.12±0.15). Overall, the carbohydrate content was influenced primarily by the moisture content of the samples.

The longer time given for steam blanching showed slight lower total dietary fibre content in fruit kuini pulp. However, for S10, the total dietary fibre was higher than S5; it could probably contribute to the ash content which was also higher in S10 if compared to S5. From the study, blanching and freezing had either no effect on the dietary fibre or in some cases increased the available amounts. Furthermore, the importance of taking fibre for the normal function of the digestive system has also been long appreciated.

Total sugars were positively correlated with TSS in which the total sugar increased from 13.21 g/100 g in the control sample until the 5 mins steam blanching (19.86 g/100 g) and decreased at 10 mins (16.63 g/100 g) and 15 mins steam blanching (10.29 g/100 g). For untreated samples, the possibility of browning and biochemical reactions could be related to their total sugar content (Liu *et al.,* 2010).

All vitamins are either fat-soluble or water-soluble. Vitamins A, D, E and K are all fat-soluble while vitamins C and the B complex are water-soluble. Blanching helps to protect fat-soluble nutrients from breaking down, but in the process, some water-soluble nutrients are lost. Vitamin A showed the highest in a sequence of S10>S0>S15>S5. The highest was recorded

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Table 2. Proximate composition, total dietary fibre, total sugar and vitamin of frozen kuini pulp.

Parameter	S0 (Control)	S5 (5 mins)	S10 (10 mins)	S15 (15 mins)
Moisture (g/100 g)	81.26±0.13[c]	81.22±0.03[c]	81.61±0.06[b]	82.76±0.03[a]
Ash (g/100 g)	0.65±0.00[b]	0.68±0.04[a]	0.77±0.05[a]	0.63±0.03[b]
Fat (g/100 g)	ND	ND	ND	ND
Protein (g/100 g)	1.07±0.04[a]	0.88±0.02[b]	0.98±0.04[a]	0.81±0.03[b]
Carbohydrate (g/100 g)	17.12±0.15[a]	16.85±0.09[b]	16.96±0.05[ab]	15.81±0.04[c]
Energy (kcal/100 g)	78.0±0.00[a]	74.0±0.00[b]	77.5±0.70[a]	70.0±0.00[c]
Total dietary fibre (g/100 g)	2.87±0.01[a]	2.53±0.02[b]	2.71±0.03[a]	2.67±0.02[b]
Total sugar (g/100 g)	13.21±0.19[c]	19.86±0.16[a]	16.63±0.13[b]	10.29±0.01[d]
Vitamin A (beta-carotene) (mg/100 g)	29.98±0.03[a]	21.84±0.17[b]	33.61±3.84[a]	29.43±0.87[a]
Vitamin C (mg/100 g)	49.7±0.6[a]	46.1±0.2[b]	45.6±0.3[b]	43.4±1.8[c]

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

in S10 (33.61±3.84 mg/100 g) while the lowest in S5 (21.84±0.17 mg/100 g). The thermal processing of mango reportedly affected the beta-carotene stability, inactivation of peroxidase and polyphenol oxidase (Vásquez-Caicedo *et al.,* 2007). The beta carotene fluctuation is mainly due to the degradation of carotenoid pigment and several works also have been carried out to investigate the relationship between carotenoid degradation and colour changes during the thermal process (Saxena *et al.,* 2012). Ascorbic acid is particularly sensitive to thermal treatments, such as blanching and breaking down easily under exposure to heat. On the other hand, immediate chilling of the fruits in ice water after steam blanching to stop the processes produced by the heat given will minimize the reduction in nutrient content. Therefore, a suitable time is recommended since too short a time will fail to achieve its intended purpose, while blanching is inappropriate and also destroys more nutrients.

Vitamin C is decreasing in parallel to the steam blanching time given to the samples. Control (S0) showed the highest in vitamin C and S15 showed the lowest in vitamin C content. It showed that more heat given influenced the vitamin C in frozen kuini pulp. Ascorbic acid is very sensitive to the enzyme phenolase, temperature, pH, oxygen and light (Coultate, 2007). However, a reduction in ascorbic acid was expected. The higher retention of vitamin C in the frozen kuini-treated pulp might be attributed to its antioxidative potential which prevents the conversion of ascorbic acid to dehydroascorbic acid. According to studies, steaming seems to be the best method to maintain the nutritional quality of broccoli (Bongoni *et al.,* 2014). Therefore, the processing design needs to be controlled to achieve the product qualities identified and accepted by the consumers.

3.4 Mineral content

The mineral content of raw and steam blanched frozen kuini pulp are shown in Table 3. Phosphorus, potassium, calcium and magnesium make up most of the minerals. Generally, mineral contents will decrease as the fruits are exposed longer time for steam blanching. As was found in this investigation, potassium and iron, there was an increasing trend as parallel to the time given for steam blanching in increasing order. It could probably be due to the solubility of the minerals. On the other hand, the range of sodium concentrations in the samples was very large. The highest sodium content was recorded in the control sample (2.25±0.04 mg/100 g), while the lowest sodium content was found in S15 (0.60±0.73 mg/100 g). Sodium is needed in the regulation of blood pressure, acid-base balance, nerve impulse transmission, blood volume, muscle function and normal cell function. But, accumulating evidence suggests that the average consumption of sodium in the world is well above the necessary intake for the correct functioning of the body (Elinge *et al*., 2012). Most of the treated samples showed low levels of sodium thus, frozen kuini pulp can be included in the diet to improve the daily dietary meal plan for those who need dietary restrictions of sodium.

Many factors can contribute to the steam blanching process which affects the water-soluble nutrient contents such as the degree of heating, the surface area exposed to water, pH and oxygen, and the presence of transition metals. Under-blanching can be prone the enzymatic activities, which give the worst outcomes if compared to unblanched. However, over-blanching or steaming affects the colour, nutrients and flavour. Hence, the appropriate blanching condition must be properly chosen to match the physiological characteristics of a specific commodity. Therefore, in long-term storage, pre-treatment with steam blanching and freezing still can be

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Table 3. Mineral content of frozen kuini pulp.

Parameter	S0 (Control)	S5 (5 mins)	S10 (10 mins)	S15 (15 mins)
Phosphorus (mg/100 g)	16.28±1.61[a]	16.06±0.80[a]	17.28±1.22[a]	15.52±0.20[a]
Potassium (mg/100 g)	224.32±11.39[d]	229.98±4.48[c]	245.85±16.97[a]	240.95±9.64[b]
Sulphur (mg/100 g)	4.30±0.13[b]	1.25±0.38[d]	3.64±0.15[c]	4.49±1.03[a]
Aluminium (mg/100 g)	0.31±0.02[b]	0.19±0.07[a]	0.13±0.04[b]	0.09±0.00[c]
Calcium (mg/100 g)	15.24±1.03[a]	16.81±0.32[a]	17.02±1.10[a]	16.04±0.00[a]
Magnesium (mg/100 g)	26.10±2.54[a]	22.55±1.12[d]	24.94±1.61[b]	23.64±0.89[c]
Manganese (mg/100 g)	0.93±0.09[a]	0.74±0.13[c]	0.84±0.05[b]	0.76±0.03[c]
Iron (mg/100 g)	0.22±0.25[b]	0.34±0.36[a]	0.36±0.04[a]	0.35±0.05[a]
Copper (mg/100 g)	0.33±0.05[a]	0.21±0.02[c]	0.25±0.02[b]	0.21±0.02[c]
Zinc (mg/100 g)	0.43±0.02[a]	0.36±0.02[c]	0.39±0.06[b]	0.37±0.01[c]
Boron (mg/100 g)	0.25±0.03[a]	0.25±0.01[a]	0.26±0.02[a]	0.26±0.01[a]
Sodium (mg/100 g)	2.25±0.04[a]	1.67±0.25[ab]	1.32±0.15[ab]	0.60±0.73[b]

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

considered the best preservation method for fruits and vegetables.

On the other hand, minerals are essential for the human body to function well. Periodically review of new findings and existing reference values for their intake are established (Padovani *et al.,* 2006). Compliance with the recommended nutrient intakes (RNI) to identify the dietary intakes of the population and the risk of inadequate intakes of certain nutrients are important to meet the human needs of most healthy individuals (National Coordinating Committee on Food and Nutrition, 2017).

3.5 Microbiological analysis

A total of three analyses have been conducted which are total plate count, yeast and mould and total coliforms to analyse the microbial growth among the treatments. There was no significant difference ($p>0.05$) in microbial growth in all treatments. No visual mould growth was detected for all samples when stored at frozen storage. It showed that adequate freezing temperature and proper hygiene throughout the process contributed to the invisible mould growth observed. It was important to ensure safety, so the products can last long in the packaging materials during storage periods. Besides providing for microbiological stability, the concentration of fruit pulps also leads to economic packaging, transportation and distribution of the final products (Belibagli and Dalgic, 2007). On the other hand, the microbiological analysis has been done for the final product to ensure the safety of the product was achieved.

The microbiological study showed that all samples were acceptable and safe to be consumed. Frozen kuini pulp is an intermediate product that can be applied to other processed food products. Steam blanching is done as a pre-freezing treatment to extend fruit storage life and decrease fruit deterioration by inactivating deteriorative enzymes and destroying spoilage microorganisms. Steam blanching on the other hand can improve the quality of kuini pulp including colour stability and viscosity while decreasing microbial counts. Total coliforms were undetectable for steam blanching treatments throughout the studies as shown in Table 4. Generally, mould simply grows in high-moisture products. However, steam blanching coupled with the freezing method was able to increase the microbiological safety of the products.

4. Conclusion

The study showed that 10 mins steam blanching of frozen kuini pulp (S10) produced better nutritional compositions as compared to the other treatments. Furthermore, it might increase the availability of

Table 4. Microbiological analysis of frozen kuini pulp

Parameter	S0 (Control)	S5 (5 mins)	S10 (10 mins)	S15 (15 mins)
Total plate counts (CFU/g)	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]
Yeast and mould counts (CFU/g)	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]
Coliforms counts (CFU/g)	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]	<1.0×10[a]

Values are presented as mean±SD. Values with different superscripts within the same row are statistically significantly different ($p<0.05$).

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naturally occurring nutrients and minerals components besides improving the physical characteristics of the pulp. Therefore, moderate steaming time and proper handling of the pulp are important steps to be considered in order to retain the nutritional composition and pulp stability. Further studies could be conducted to identify which phenolic compounds of raw and steamed kuini pulp that are responsible for the nutritional compositions, and also to evaluate the effect of steaming, boiling and thawing on other *Mangifera* species.

Conflict of interest

The authors declare no conflict of interest.

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