

Microbiological quality and sensory evaluation of partially dried mango for fruit salad, Kerabu Mangga

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Received:

September 22, 2018

Accepted:

February 19, 2019

Published:

March 30, 2019

Abstract

Kerabu Mangga is a fruit salad that is made from unripe matured mangoes. This salad is prepared fresh mixed with other ingredients. Since this salad has limited shelf life, the mango were dried at 60°C for one and two hours, then mixed with other ingredients in an attempt to make this salad has longer shelf life and readily available when mangoes are not in season. The effects of drying on water activity (a_w), microbial load, shelf life of 'Kerabu Mangga' during storage at room ($28 \pm 2^\circ\text{C}$) and chilled ($5 \pm 1^\circ\text{C}$) temperatures as well as determination acceptance and nutrient compositions of the prepared 'Kerabu Mangga' were carried out. Drying treatment reduced the initial water activity (a_w) of fresh mango from 0.994 to 0.953 and 0.874 after 1 and 2 h drying, respectively, and the microbial load was reduced ($\sim 0.6 \log_{10}$ CFU/g) after drying treatments. Drying at 60°C affected significantly ($p < 0.05$) the appearance and colour of the dried mango slices, without affecting the overall acceptability of the prepared Kerabu Mangga. Storage temperature affected significantly ($p < 0.05$) the microbial load (Total Plate Count), where chiller storage took 10 days compared to 12 h for room temperature to reach spoilage to occur (normally at \log_{10} 6.00 CFU/g). For the nutrient compositions, only carbohydrate contents showed significant increased at ($P < 0.05$), however, vitamin C content showed significant decreased ($P < 0.05$). Drying for only 1 and 2 hours was found to be suitable for partially dried 'Kerabu Mangga' which resulted in negligible effect on its overall acceptance. Drying the mango slices at 60°C for 2 h resulted in longer shelf life than 1 h or without heat treatment.

Keywords: Microbiological quality, Sensory evaluation, Dried mango, Kerabu mangga

How to cite this:

Lani MN, Adnan NA, Nurmahani MM, Ibrahim R and Hasan Z, 2019. Microbiological quality and sensory evaluation of partially dried mango for fruit salad, Kerabu Mangga. Asian J. Agric. Biol. 7(1): 103-115.

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Introduction

Kerabu Mangga is a mango salad which is well-known

in Malaysia and usually served with other dishes. This fruit salad consists a mixture of slices mangoes, shallots, lemon grasses, torch ginger buds, bird's eye



chilies, dried shrimps, lime juice, toasted grated coconut ('kerisik') and sugar. The preparation of 'Kerabu Mangga' does not involve any heat treatment. Nguyen and Carlin (1994) reported that the microbial counts of raw foods are typically ranged from 10^3 CFU/g to 10^9 CFU/g. However, after processing, it can be reduced to a range from 10^3 CFU/g to 10^6 CFU/g. *Salmonella* sp. was detected present in dried shrimps (Iyer and Shrivastava, 1989) while *Listeria monocytogenes* was isolated from ready-to-eat (RTE) shrimp products (Ben Embarek, 1994). Fruits and vegetables contain natural microbiota from the environment and influenced by the transportation and storage (Galati et al., 2013). In other study by Poubol and Izumi (2006), the predominant genera in mesophilic aerobic bacteria in mango cubes ('Nam Dokmai') were *Enterobacter*, *Klebsiella* and *Pantoea* and in the yeasts were *Candida*, *Cryptococcus*, and *Rhodotorula*. Since cooking is not involved in the preparation of this mango salad, this product has limited shelf life.

All the ingredients used are fresh and sliced that will allow the exudates to support microbial growth during storage that can have negative effect on the shelf life quality of the product as well as pose a safety hazard. It is envisaged that by partially drying the mango slices can maintain low microbial number in the "Kerabu Mangga", thus making it possible for this product to be widely available.

Therefore, the purpose of this study was to determine the effect of using partially dried mango as the main ingredient in an attempt to extend the shelf life and consumer acceptability of the product. Determination of the microbial loads (Aerobic Plate Count (APC), Mould and Yeast count, *Staphylococcus aureus* and *Enterobacteriaceae* count as well as the nutritional composition of prepared "Kerabu Mangga" were carried out.

Material and Methods

Preparation of 'Kerabu Mangga'

Matured mango of variety harum manis (maturity index 1) and other ingredients needed for making Kerabu Mangga were purchased from the local market at Batu Enam, Kuala Terengganu. Kerabu Mangga was prepared following the recipe described by Noraini (2004). About 30 g of the mango salad were washed, skin peeled and sliced of size with the thickness of 0.3 cm x 5 cm and then was packed in sterile plastic bag prior to drying.

Drying of mango slices

The slices mango in the sterile plastic bags were arranged in a single layer on the tray and immediately dried in the oven 60°C (Model OGS60, ThermoFisher Scientific, China) for either one or two hours. The slices mango was dried using the oven dryer at a constant temperature of 60°C. Kerabu Mangga was labelled A for control (fresh, sliced mango with no heat treatment), B for mango dried for 1 h and C for mango dried for 2 h. The other ingredients used in this preparation were used fresh.

Water activity (a_w) measurements

The water activity (a_w) of slices mango samples was measured at $25 \pm 1^\circ\text{C}$ by using an electronic dew-point water activity meter, Aqualab Series 3 model TE (Decagon Devices, Pullman, Washington, USA). The equipment was calibrated with saturated salt solutions in the a_w range of interest (Favetto et al., 1983). For each determination, two replicates were obtained and the average was reported (Fontana, 2001).

Microbiological analysis

Aerobic plate count (APC)

The Aerobic Plate Count (APC) was used to evaluate the microbiological quality of foods. High APC ($> 10^6$ CFU/g) indicates that the food is about to spoil. Aseptically, 0.1 ml of appropriate dilution was spread plated on Plate Count Agar medium (Merck, Germany) and the plates were inverted and incubated at 35°C for 24 hours (Ramli et al., 2014).

Yeast and Mould Count

Potato Dextrose Agar (PDA) acidified with 10% tartaric acid was used to determine yeast and mould count. Aseptically, 0.1 ml of appropriate dilutions was spread plated on PDA medium (Merck, Germany) and the sterilized glass spreader was used to spread the inoculums and the plate was allowed to dry for 15 minutes. The plates were inverted and incubated at 25°C for 120 hours (Ramli et al., 2014).

Staphylococcus aureus

The Baird Parker's medium was used for the detection and enumeration of *Staphylococcus aureus*. A 0.1 ml of appropriate dilutions was spread plated on the medium (Merck, Germany). The plates were inverted and incubated at 35-37°C aerobically for 24 h. If no colonies have developed, the plates were incubated for further 24 h (Ramli et al., 2014).



Enterobacteriaceae

Violet Red Bile Dextrose (VRBD) Agar contains dextrose and designed to enumerate bacterial colonies as a 'total *Enterobacteriaceae*'. A 0.1ml of appropriate dilutions were spread plated on VRBD medium and allowed to dry for 15 minutes. The medium was inverted to prevent condensation and incubated at 35°C for 24 h (Ramli et al., 2014).

Proximate Analyses

Moisture

Moisture content of samples was measured using air-oven following official methods of Association of Official Analytical Chemists (AOAC, 2000). A material test chamber M720 (Binder GmbH, Germany) was used to dry the samples till constant weight was obtained. A 5 g of Kerabu mangga samples in crucibles were dried in the oven at 105°C for 24 h. After drying process, the crucibles were closed and cooled in desiccators. The crucibles were weighed without the lid and the percentage of moisture content was calculated as described by the oven drying method (AOAC, 2000).

Ash content

A drying ash method was used to determine the ash content in 'Kerabu Mangga' samples (AOAC, 2000). A 5g sample was weighed in the crucible and was heated slowly until no smoke produced from the sample. Then, the crucibles were transferred into the muffle furnace at 550°C until the next day. The remaining inorganic materials was cooled and weighed and the percentage ash of 'Kerabu mangga' sample was calculated as follow:

Percentage of ash

$$= \frac{\text{Weight of ash}}{\text{Initial sample weight}} \times 100$$

Crude fat content

Determination of crude fat content was performed following Soxhlet method previously described by AOAC, 2000. Extraction cups were dried at 100°C, cooled and weighed (W_2). Then, 2 g of sample (W_1) was weighed inside the extraction thimble and the crude fat content process was determined by using the Soxtec Extraction for 1 h using petroleum ether. The ether was evaporated in distiller and the crude fat obtained from aluminium container was dried at 103°C for 2 hours using oven. The samples were evaporated

in desiccators for 15 to 20 minutes before it is weighed (W_3). Percentage of crude fat was calculated as follows:

$$\text{Percentage of crude fat} = \frac{W_3 - W_2}{W_1} \times 100$$

W_1 = Sample weight (g)

W_2 = Weight of extraction cup (g)

W_3 = Weight of extraction cup with crude fat (g)

Crude protein content

The crude protein content of "Kerabu Mangga" was determined using Kjeltac 2100 Distillation Unit System according to method described by AOAC (2000). A 2 g of ground "Kerabu Mangga" sample was weighed and placed into the digestion flask. The catalyst tablets of Kjeltabs Cu 3.5 and 12 ml H_2SO_4 was added into the digestion flask. Exhaust system was connected to the digestion tubes in the rack and then the water aspirator was operated to full flow. The rack and the exhaust system was placed on the Digested Heater Block D36 of 42°C and after 5 minutes, the water aspiration was turned down and continued to digest. The digestion was completed when green or blue solution was formed.

The exhaust system was connected to let it cooled for 10 to 20 minutes even after the rack of tubes was removed. Then, 75 ml of distilled water was added. For distillation process, 25 ml of boric acid and 10 drops of bromocresol green solution was prepared. The digestion tube was placed in the distillation unit and 50 ml sodium hydroxide (NaOH) solution was added into the tube and steam generator distilled the sample for 5 minutes. After that, the distillation was titrated with hydrochloric acid (HCl) until the grey point was achieved. A nitrogen-to-protein conversion factor of 6.25 was used for the determination of crude protein in the samples. Crude protein content was calculated using the formula shown below:

$$\text{Percentage of } N = \frac{(T - B) \times N \times 14.007}{\text{Weight of sample in mg}} \times 100$$

$$\text{Percentage of crude protein} = \% \text{ of } N \times F \times 100$$

Where, T = Volume of sample titration

B = Volume of blank titration

N = Normality HCl/ acid

Crude fiber content



The crude fiber was determined using Crude Fibertec® 2021 Crude fiberCap system. Dried Crude fiberCap capsule with lid was weighed as (W_1). A 2.0 g of ‘Kerabu Mangga’ samples was added into the pre-dried capsule (W_2). The extraction flask was boiled and added with sulphuric acid. Condensers were put on extraction flask and the water pipe was opened for reflux system for 20 minutes. The extraction flask was washed and dried up. Then, the reagent was changed from sulphuric acid with sodium hydroxide. Lastly, the crude fiber was washed with acetone to remove the crude fat. Capsule was added with 120 ml acetone and stirred for 30 minute. The capsules were dried in oven for 2 hour at 130°C. The capsule was weighed after cooled for (W_3). The capsule was then placed in crucible for ashing for 4 hours at 600°C (W_4). The capsule was weighed again for (W_5). The crude fiber was determined by:

$$\text{Percentage of crude fibre} = \frac{W_3 - (W_1 \times C) - (W_5 - W_4 - D)}{W_2} \times 100$$

W_1 = Beginning capsule weight (g)

W_2 = Weight of sample (g)

W_3 = Weight of capsule + weight of residue (g)

W_4 = Weight of crucible (g)

W_5 = Weight for total ash (g)

C= Error

D= Capsule ash (g)

Carbohydrate

The total carbohydrate content (%) in the samples was calculated by difference method as follows:

$$\text{Carbohydrate (\%)} = 100 - (\% \text{ moisture} + \% \text{ crude protein} + \% \text{ Crude fibre} + \% \text{ Crude fat} + \% \text{ ash})$$

Ascorbic acid

The amount of ascorbic acid were determined according to Jagota and Dani (1982) method using Folin reagent and the absorbance was read at 760 nm. The standard solution was prepared by dissolving 0.05g of 2,6 dichlorophenolindophenol in 100 ml distilled water and filtered. Ascorbic acid solution was prepared by dissolving 0.05g ascorbic acid (Sigma-Aldrich, Germany) in 60 ml 20% metaphosphoric acid and diluted to 250 ml.

Sensory analysis

Three samples of ‘Kerabu Mangga’ stored at different temperatures (Room Temperature and Chilled Temperature) were placed in small closed plastic containers and randomly coded. The samples were presented to 30 untrained panellists in small trays. The ‘Kerabu Mangga’ samples were evaluated based on six attributes which were the appearance, colour, odour, flavour, texture and overall characteristics of the samples. The attributes were scored using the 9-points hedonic scale ranging from dislike extremely (0) to like extremely (9). The sensory analysis was carried out for one time in order to determine the consumer’s acceptance of ‘Kerabu Mangga’ stored at different temperatures.

Statistical analysis

Statistical analyses were conducted using Minitab, version 14 for Windows. All the determinations were carried out in triplicate and data were expressed as mean \pm standard deviation. The significant differences of means were compared using the Fisher’s LSD test from one-way ANOVA (Analysis of Variance) at a significant level of $P < 0.05$.

Results and Discussion

Water activity (a_w) measurement

Drying mango slices at 60°C for either one (sample B) or two hours (sample C) significantly ($p < 0.05$) reduced the water activity compared to control (sample A, mango slices without heat treatment) (Figure 1). Raw non-heat treated mango slices showed water activity (a_w) which is 0.994. This result is similar to that reported by Nieto et al. (2000) where a_w of fresh raw mango was 0.99. High a_w of fresh mango (0.99) would easily deteriorate during storage (Nieto et al., 2000). Drying of mango slices at 60°C reduced the a_w of sample B to 0.95 and 0.86 of sample C. Drying time was shown to be the primary factors in influencing a_w . Although Pott et al. (2005) noted that drying mango slice to final a_w of 0.6 instead of 0.45 had reduced the drying time significantly and enhanced the product stability without affecting product colour and market value, longer exposure of shredded mango at 60°C however, caused browning reaction. Park et al. (1980) suggested that moderate drying temperature and high water activity (a_w) in the sample might be ascribed to elevated polyphenol oxidase activities, resulting in the formation of coloured quinoid compounds.



Drying time of more than two hours has reduced more than 30% of moisture content. Drying of shredded mango for more than two hours resulted in considerable shrinkage and produced an unacceptable product. Shrinkage during drying of fruits occurs when the viscoelastic matrix contracts into the space previously occupied by the water removed from the cells (Aguilera, 2003).

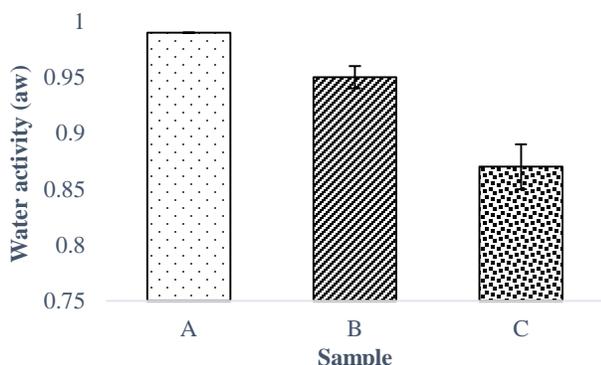


Fig. 1. Water activity (a_w) measurement of shredded mango. Values are the mean ± standard deviation of two replicates (n = 2). Significant level was defined at (P < 0.05).

Microbial analysis

Aerobic plate count (APC)

The control (sample A) had higher APC (4.90 CFU/g) than the heat treated samples (Figure 2A) in the beginning. However, towards the end of storage time, there was no significant difference in all three samples including those samples that have been dried at 60°C for one or two hours. The reductions of APC at 0-hour in treated samples were supported by previous study by Bang et al. (2010) reported that dry heat treatment for 6 hours significantly decreased the number *Escherichia coli* O157:H7. Shaw et al. (1993) noted that total bacterial count of mango skin ranged between 4 and > 100 CFU/20 cm². High bacteria counts of mango flesh may be the result of contamination during manual peeling process.

There was no significant difference (P > 0.05) between drying time with Aerobic Plate Count (APC). Even though the final a_w after drying treatments was reduced in the range of 0.85-0.99, bacteria could be detected present in ‘Kerabu Mangga’ made with the heat treated mango slices. Sliced mango fruit are very perishable because they contained less pericarp that protect the fruit (Tovar et al., 2001). Additionally, sliced fruits suffer physiological changes that occur in wounded viable tissue (Baldwin et al., 1995). The

wounded viable tissues allow microbes to penetrate into mango flesh and deteriorate it until become undesirable. Sample A had the longest generation time which was 1.64 hours. The generation times (gt) of treated samples were as follows; Sample B- 1.31 hours and Sample C- 1.39. Treated samples have shorter generation time and the finding was supported by Roday (1999) where the length of generation time was influenced by the environmental factors such as food availability, pH, temperature, moisture content, and presence of oxygen and inhibitors effect. Generation time became shorten if the condition is favorable and lengthens if the condition is less favorable.

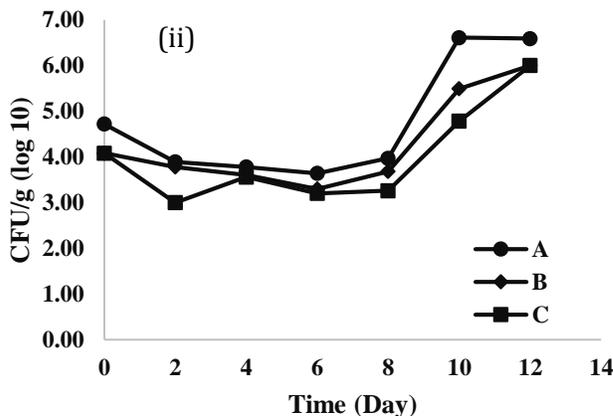
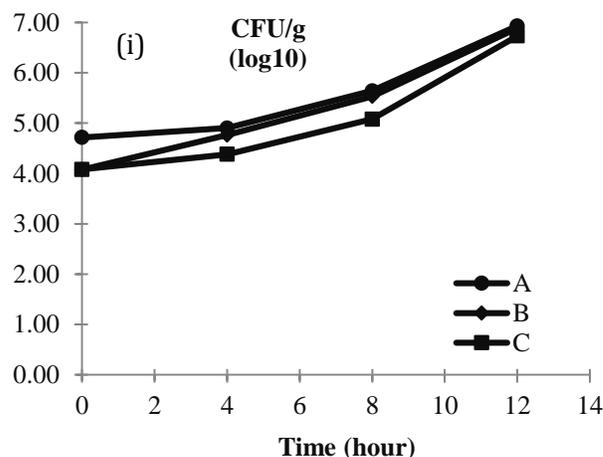


Fig. 2. Aerobic plate counts (APC) of different samples of kerabu mangga stored at (i) room temperature 28°C ± 2°C and (ii) chill temperature 5°C ± 1°C

Based on the calculated generation time, drying treatment increased the generation time from 1.50 days for Sample A to 1.81 days for Sample B and 1.87 days for Sample C. Storing ‘Kerabu Mangga’ at



chilling temperature (5°C) significantly ($p < 0.05$) reduced the Aerobic Plate Count (APC) and lengthened the generation time (Figure 2B). There was no clear trend observed between these samples at 14 days although the APC generally decreased until day 8 and started to increase towards day 12. Chilling of fruits and vegetables does not completely inhibit microorganisms but reduces the growth rates (Nguyen and Carlin, 1994).

Yeast and mould counts

There was no significant difference ($P > 0.05$) between drying treatment with mould and yeast load (CFU/g). Drying treatment able to reduce the water activity (a_w) until 0.874 but this final a_w after drying treatments still provide suitable medium for the growth of mould and yeast since the minimum a_w for mould and yeast growth is 0.62 (Bell et al., 2005).

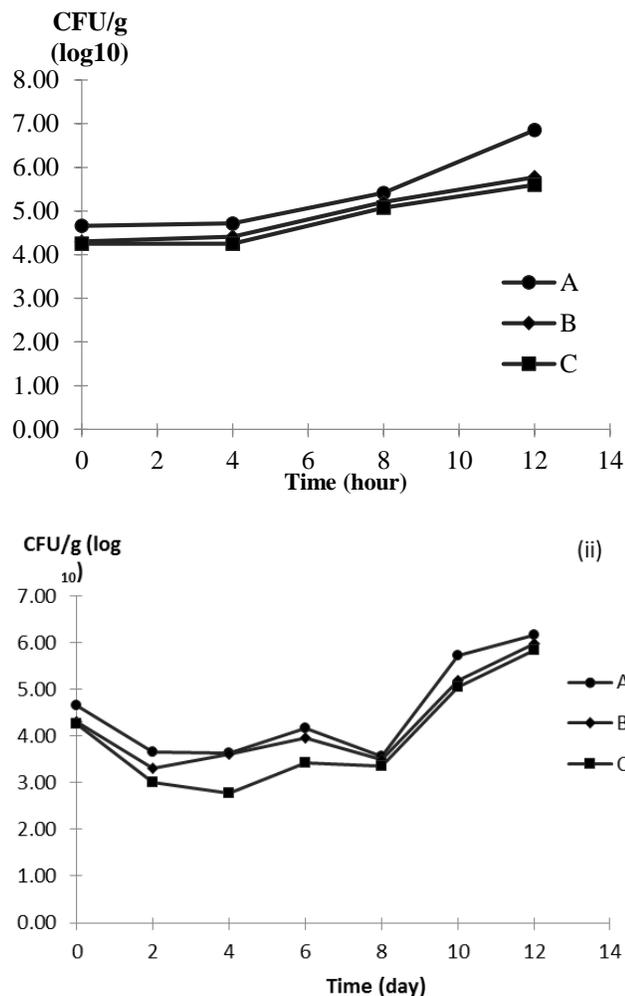


Fig. 3. Yeast and mould counts of different samples of kerabu manga stored at (i) room temperature 28°C ± 2°C and (ii) chill temperature 5°C ± 1°C

The total yeast and mould count of ‘Kerabu Mangga’ for all samples stored at room temperature (28 ± 2°C) was ranging from 4.18 CFU/g to 6.90 CFU/g at the end of storage days. (Figure 3A). In general, the trend of mould and yeast growth increase in all samples throughout the storage time hence drying at 60°C for one or two hours did not reduce the yeast and mould count of ‘Kerabu Mangga’. This could be related to the water activity of these samples as stated in section 3.1 which was considerably high and unable to inhibit the growth of spores when plated in fresh media. Moreover, another reason for this result could possibly be due to the fresh ingredients used. Abadias et al. (2007) reported that grated carrot, arugula, corn salad and mixed salads contained high mean counts for moulds and yeasts with values 6.1, 5.8, 5.5 and 5.4 log₁₀ CFU/g, respectively. However, there was significant difference ($P < 0.05$) between storage time and mould and yeast counts (CFU/g).

The yeast and mould count of ‘Kerabu Mangga’ was significantly ($p < 0.05$) reduced when stored at chilling temperature. The counts were reduced from 4.81 CFU/g to 3.52 CFU/g for sample A; from 4.22 CFU/g for both sample B and C to 3.50 and 3.31 CFU/g, respectively at day 8 of storage as shown in Figure 3B. Low temperature storage not only reduced the metabolic rates that is usually high in cut fruits other but also slowed down the microbial growth (Lamikanra, 2002). There was no significant difference ($P > 0.05$) between drying treatment in ‘Kerabu Mangga’ samples with mould and yeast counts (CFU/g). The yeast and mould count of ‘Kerabu Mangga’ was not significantly ($p > 0.05$) affected by drying temperature and time, however, there was significant reduction ($p < 0.05$) in yeast mould count during chilling temperature storage.

Enterobacteriaceae

The *Enterobacteriaceae* family is a useful indicator to verify the hygienic process in food production. Members of *Enterobacteriaceae* usually present in raw food ingredients especially animal and plant origin (Bell et al., 2005). Generally, the trend of *Enterobacteriaceae* count increased for all samples ranging from 3.2-4.31 CFU/g) towards the end of storing time at 12 hours. However, it must be noted that there was no significant difference ($P > 0.05$) between treatment of samples and *Enterobacteriaceae* count. (Figure 4)

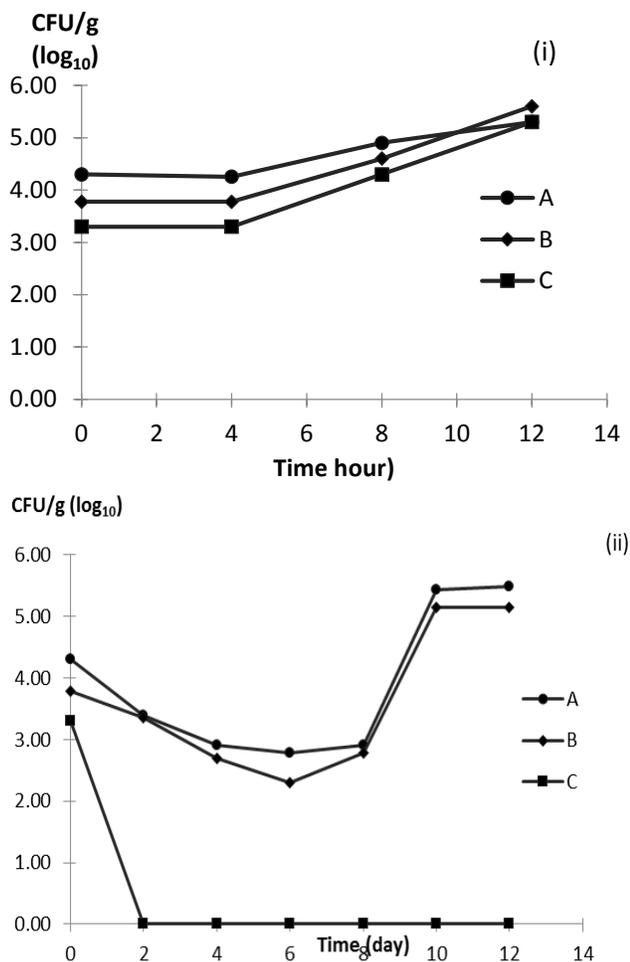


Fig. 4. *Enterobacteriaceae* counts different samples of kerabu manga stored at (i) room temperature 28°C ± 2°C and (ii) chill temperature 5°C ± 1°C

It was observed the total *Enterobacteriaceae* count fluctuated during storage at 5°C (Figure 4ii). During the first six days, the *Enterobacteriaceae* count was reduced, but increased after eight day storage for sample A (control) and sample B (drying at 60°C for one hour). In contrast, drying the mango slices at 60°C for two hours totally eliminated *Enterobacteriaceae* from the “Kerabu Manga”. Similar observation was reported by Bell et al. (2005) who reported that *Enterobacteriaceae* should be absent in heat processed foods because of the mild heat treatment.

Staphylococcus aureus

Staphylococcus aureus has been isolated from vegetables and fresh cut products (Jo et al., 2011), but there have no report of staphylococcal food poisoning from such products. Humans may also be carriers of *S. aureus* and can be present in skin cracks adjacent to

the fingernails, cuts and wounds (Lampila and McMillin, 2012). In this study, the trend for *S. aureus* count increased over storage time for all samples (3.00-5.50 CFU/g) when stored at room temperature (Figure 5i). This could be due to the preparation of ‘Kerabu Manga’ sample in aseptic way which was no direct contact with the handler.

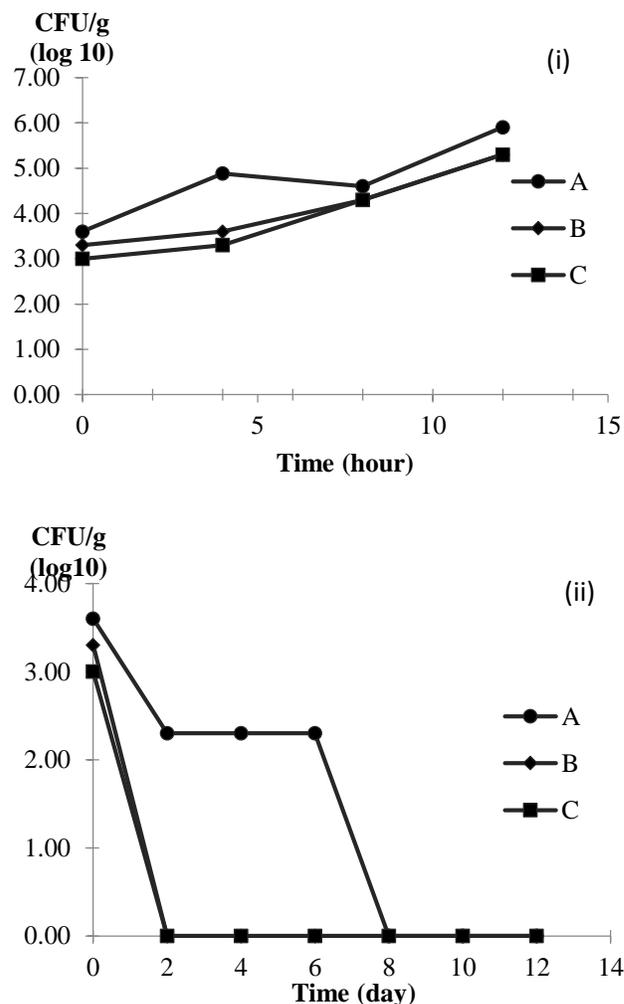


Fig. 5. *Staphylococcus aureus* counts of different samples of kerabu manga stored at (A) room temperature 28°C ± 2°C and (B) chill temperature 5°C ± 1°C

However, there was significant difference ($P < 0.05$) between storage time and *S. aureus* counts. The biological environments of *S. aureus* are relatively frequent contamination in foods but they compete poorly with the spoilage of flora of most foods that have high water activity (a_w) (Narang, 2004). Thus,

even after 12 hours of storage, *S. aureus* count was still considerable low. It was not significantly different of storage between drying treatment of samples and counts of *S. aureus* although there was reduction in treated samples. The results indicated that drying treatment did not significantly affected the *S. aureus* count and could possibly be due to the water activity level after drying which was 0.874. However, it must be highlighted that the initial *S. aureus* count could also be contributed by the raw ingredients used in this study.

Furthermore, a significant reduction ($p < 0.05$) in *S. aureus* count was recorded when the “Kerabu Mangga” was stored at chilling temperature. The number of *S. aureus* in all three samples decreased rapidly from 3.0-3.6 CFU/g to 0-2.2 CFU/g just after 2 days of storage at 5°C (Figure 5ii). This could be due to the combined effect of low temperature injury and water activity lower than the optimum for growth. Similar observation was reported by Kinsella et al. (2006); chilling process caused cell injury resulted from the combined stressed effect of low temperature and low water activity (a_w). The low temperature caused cell to experience cold shocked and low water activity (a_w) caused cells to experience osmotic shocked.

Sensory analysis

Samples of “Kerabu Mangga” made with mango shredded dried at different conditions and stored at 28°C and 5°C were subjected to sensory analysis and the result is shown in Table 1.

Appearance

There were significant differences ($P < 0.05$) for the attributes of appearance among the three samples. A, B and C. Highest acceptability score (7.00 ± 1.00) was obtained for Sample A followed by Sample B and Sample C. The drying process causes the changes in the appearance of dried mango, the slices appeared less juicy and less acceptable by the panellist. The panellists preferred the ‘Kerabu Mangga’ made from freshly sliced mango. Drying process through the application of heat can cause cooked appearance and loss of fresh-like appearance (Lamikanra, 2002). Additionally, drying process caused wound-related

effects and resulting in unattractive product (Toivonen, 2007).

Colour

Colour influences acceptability of a product. It was observed that drying the mango slices at 60°C significantly ($p < 0.05$) for either One or two hours reduced the panellist preference of the “Kerabu Mangga”. The panellist scored highest acceptability 7.00 ± 2.00 for Sample A followed by Sample B and Sample C. The panellists were able to detect the change in colour of mango slices from green-yellowish to brownish as a result of drying. Drying process introduced undesirable changes in appearance and caused modification of the natural ‘balanced’ colour (Nijhuis et al., 1998). Maltini et al. (2003) suggested that the browning rate decreased as the effect of dilution of the reactants in samples with high water content. In this study, sample C had the lowest a_w at 0.874 but the colour changes was from green to brownish. This could be possibly be explained by the reaction of enzymatic reaction that occurs in typical fruits like mango that is rich in polyphenols and highly susceptible to enzymatic browning (Holderbaum et al., 2010). The finding was supported by Maltini et al. (2003) where the maximum browning has been observed in most cases at a_w 0.3-0.7.

Odour

Heating may affect the odour of a product. However, there was no significant different ($P > 0.05$) in odour among Sample A, Sample B and Sample C. Sample A had the highest acceptability score (6.53) followed by Sample B (6.33) and Sample C (6.13). Hui et al. (2010) observed changes in odour profile of mango after the application of heat treatment in compounds such as pentane-2-3-dione, 2-acetyl-1-pyrrolene, butane-2-3-dione and pyrozone compound. However, the panellists were not able to detected differences in odour among the samples. “Kerabu Mangga” consisted a mixture of ingredients including shredded mango, shallots, lemon grass, torch ginger’s eyes, bird chillies, dried shrimps, lime juice, toasted grated coconut and sugar prepared at the same quantity according to the formulation. This may have masked the possible changes in odour as a result of drying the mango slices.



Table 1. Sensory acceptance of different attributes in dried ‘Kerabu Mangga’. Values are median \pm interquartile range followed by different letters in the same column differs significantly ($P < 0.05$). Sample A; without drying, sample B; dried for 1 h and sample C; dried for 2 h.

Sample	Appearance	Colour	Odour	Flavour	Texture	Overall acceptance
A	7.00 \pm 1.00 ^a	7.00 \pm 2.00 ^a	6.53 \pm 1.46 ^a	5.43 \pm 1.83 ^a	6.07 \pm 1.64 ^a	6.00 \pm 2.00 ^a
B	6.00 \pm 2.00 ^b	6.00 \pm 3.00 ^b	6.33 \pm 1.24 ^a	5.17 \pm 1.82 ^a	5.87 \pm 1.57 ^a	6.00 \pm 1.00 ^a
C	4.00 \pm 4.25 ^c	3.00 \pm 5.00 ^c	6.13 \pm 1.66 ^a	5.17 \pm 1.98 ^a	5.60 \pm 1.55 ^a	5.00 \pm 3.00 ^a

Flavour

Kerabu Mangga generally taste refreshing with the combination of crunchy shredded mangoes, along with the zest sharp taste of lime juice with the sweetness of sugar. In the present study, there was no significant different ($P > 0.05$) in the flavour between Sample A, Sample B and Sample C. The panellist preferred Sample A followed by Sample B and Sample C. Chang et al. (1998) in their study revealed that there were significant differences in flavour an eating quality when eating fresh and dried longan fruits. Hence, since kerabu manga is eaten with fresh mangoes, and the water activity in all three samples were above 0.85, the flavour of kerabu mangga samples in this study might not be significant to the panellist as stated in the result (Table 1).

Drying process affects the volatile compounds that are responsible for flavours of a product. In mango, the volatile compounds detected present were monoterpene hydrocarbons including 3-carene (Hui, 2006). However, the panellist were not able to detect any differences in flavour as a result of drying the mango slices. This might be due to the influences of other ingredients that present in similar amount within all samples and caused panels unable to recognize the differences.

Texture

It was observed that in terms of texture the panellists rated Sample A as more acceptable followed by Sample B and Sample C, although there was no significant different ($P > 0.05$) in texture among the samples of “Kerabu Mangga”. It was noted that the panellists were not able to detect differences in texture of mango slices between the freshly sliced mango and the dried mango. The temperature used (60°C) was not high enough to influence the texture. It could also be

that addition of other ingredients which were prepared fresh influenced the overall texture of the salad. However, Chong et al. (2008) noted that the texture of fruit was affected by temperature used during drying process.

Overall acceptance

There was no significant different ($P > 0.05$) in overall acceptability among all the samples of ‘Kerabu Mangga’. This showed that drying the shredded mango at 60°C did not affect the overall acceptability of ‘Kerabu Mangga’ as evaluated by the untrained panellists. Additionally, the presence of other ingredients at same quantity according to the formulation caused the panels unable to recognize the differences.

Proximate analysis

For the proximate analysis of the samples, there was no significant difference ($P > 0.05$) in moisture content, ash, crude protein, crude fat and crude fiber content of “Kerabu Mangga” made either from fresh or oven dried mango slices (Table 2).

Moisture analysis

There was no significant different ($P > 0.05$) in moisture content among all samples of ‘Kerabu Mangga’. Sample A had the highest moisture content (80.97%) followed by Sample B (80.24%) and Sample C (77.78%). This result showed clearly the reduction of moisture in all samples, in line with the time of drying used. Based on the previous study by Chang et al. (1998), rapid reduction in fruit weight during drying process was due to the evaporation of water from fruit shell, flesh and seed that lead to the loss in moisture content.



Table 2. Proximate analysis of dried kerabu manga. Values are mean \pm standard deviation followed by different letters in the same column differs significantly ($P < 0.05$). Sample A; without drying, sample B; dried for 1 h and sample C; dried for 2 h.

Sample	Moisture	Ash	Crude fiber	Crude protein	Crude fat	Carbohydrate	Vitamin C
A	80.97 \pm 0.99 ^a	0.74 \pm 0.22 ^a	0.32 \pm 0.08 ^a	1.43 \pm 0.26 ^a	11.95 \pm 0.25 ^a	4.91 \pm 1.28 ^b	2.98 \pm 0.38 ^a
B	80.24 \pm 1.33 ^a	0.71 \pm 0.16 ^a	0.32 \pm 0.10 ^a	1.31 \pm 0.17 ^a	9.17 \pm 1.72 ^a	8.57 \pm 0.72 ^a	1.76 \pm 0.19 ^b
C	77.78 \pm 1.86 ^a	0.68 \pm 0.07 ^a	0.14 \pm 0.20 ^a	1.34 \pm 0.29 ^a	8.92 \pm 1.61 ^a	11.28 \pm 0.61 ^a	1.36 \pm 0.38 ^b

Ash

In ash analysis, there was no significant different ($P > 0.05$) of ash content in all 'Kerabu Mangga' samples. Sample A which contained fresh shredded mango had the highest ash content (0.74%) followed by Sample B (0.71%) and Sample C (0.68%). Based on previous study by Mota et al. (2009), drying process at temperature of 30°C, 40°C, 50°C and 70°C on fresh onions did not affect the content of ash. However, in the present study, there was still a slight reduction of 0.06% in the content of ash. Based on the data obtained from Latifah et al. (1996), the value of ash in raw mango was 0.70% which was quite similar to ash content in control Sample A and sample B of 'Kerabu Mangga'.

Crude fiber

There was no significant different ($P > 0.05$) of crude fiber content in all samples of 'Kerabu Mangga'. In general, drying for an hour did not the crude fiber content and for Sample C, it contains the lowest crude fiber content. Based on study by Guine et al. (2010) on drying process of pumpkin, the comparison between fresh pumpkin and dried pumpkin at 30°C perceived that drying operation reduction of 36% in crude fiber content.

Crude protein

For the analysis of crude protein, again, there was no significant different ($P > 0.05$) of crude protein content in Sample A, Sample B and Sample C. Sample A contained the highest crude protein content (1.43%) followed by Sample B (1.31%) and Sample C (1.34%). Drying process caused the reduction of 14% crude protein in pumpkin and the heat provided during drying process causes crude protein denaturation (Guine et al., 2010). In this study, there was only slight reduction in crude protein content after drying process. This result could possibly be supported by the fact that crude protein may not be influenced by the moderate temperature of less than 50°C (Mota, 2009),

Crude fat

There was no significant different ($P > 0.05$) of crude fat among all 'Kerabu Mangga' samples although there was reduction in crude fat content through drying treatment. Sample A contained the highest crude fat followed by Sample B and Sample C. Based on Latifah et al. (1996), crude fat content in fresh mango was only 1.8 g per 100 g mango. The results obtained in this study were relatively higher, due to the presence of other ingredient in 'Kerabu Mangga' such as toasted grated coconut or 'kerisik' which has high crude fat content.

Carbohydrate

There were significant differences ($P < 0.05$) among control Sample A, Sample B and Sample C. Since mango was the major ingredient in 'Kerabu Mangga', carbohydrate content based on study by Malik (1996) recorded 15.6 g of carbohydrate in every 100 g of mango flesh. Shredded mango was a major ingredient in 'Kerabu Mangga' and contributes the highest carbohydrate content in 'Kerabu Mangga'.

Vitamin C

There was significant difference ($P < 0.05$) between treated samples which were Sample B and Sample C with the control Sample A. The result showed that drying process caused significant reduction in vitamin C content in 'Kerabu Mangga' especially from mango since it was the major ingredient in 'Kerabu Mangga'. The loss in vitamin C depend on the degree of heating, temperature, surface area that exposed to water and oxygen, pH, presence of transition metals and any other factors that facilitate oxidation (Eitenmiller and Laden, 1999).

Conclusion

The principle of drying is to lower the water activity (a_w) until become undesirable to support the microbial growth. Results obtained showed that the drying treatments were able to reduce the water activity (a_w)



from 0.994 in control sample to 0.953 for Sample B and 0.874 for Sample C. In sensory analysis, the appearance and colour attributes play a significant role while in proximate analysis, only carbohydrate and vitamin C content showed differences among treatments. For the microbiological analysis, the interaction of sample treatments and time of storage upon the microbial load only presented in chilling temperature storage for Aerobic Plate Count (APC), *Enterobacteriaceae* and *Staphylococcus aureus*. All the samples stored at room temperature showed no interaction between treatment and time of storage upon the microbial load. There was no significant difference between drying treatments applied in microbial loads in all microbiological analysis except the *Enterobacteriaceae* and *Staphylococcus aureus* that stored at chilling temperature. However, there were significant differences between storage upon microbial load in all microbiological analysis since the microbial load increased significantly from its initial load. Finally, it can be concluded that the drying treatment applied was unable to reduce the water activity (a_w) to the level that can inhibit the microbial growth. Furthermore, the microbial source in 'Kerabu Mangga' might potentially come from other ingredients of 'Kerabu Mangga' that might present in raw without further treatment applied. However, it is interesting to mention that the shelf life of 'Kerabu Mangga' stored at chilling temperature was longer compared to room temperature storage due to preservation through temperature and not due to the drying treatment applied.

Contribution of Authors

Lani MN: Responsibility for supervising research and principal investigator of the financial support for the project.

Adnan NA: Conducting the research and investigation process, specifically data and evidence collection

Nurmahani MM: Managing and coordinating of research activities leading to this publication. Responsible for the final submission of manuscript.

Ibrahim R: Co-Supervisor and technical expert for chemical analyses

Hassan Z: Mentoring, guiding the research ideas and final proof read of the manuscript.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

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