Metabolomics profiling and antimicrobial activity of fermented date fruit (Khastawi) used as functional ingredients for making Asian confectionary (Dodol)

Belal J. Muhialdin, Anis Asyila Marzlanc, Hana Kadum, Brisha Arulrajah, Nursyafiqah Mohamad Asria, Salahaldin Fathallah and Anis Shobirin Meor Hussin

Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, Serdang, Selangor, Malaysia; Halal Products Research Institute, Universiti Putra Malaysia, Putra Infoport, Serdang, Selangor, Malaysia; Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, Serdang, Selangor, Malaysia; Department of Biology, Faculty of Science, University of Al-Muthanna, Al-Muthana, Iraq; Department of Botany, Faculty of Science, Sebha University, Sebha, Libya

ABSTRACT

Date fruit (Phoenix dactylifera) have long history in food application due to the nutritional value, pleasant flavour and biological activity. This study aimed at investigating the antimicrobial activity of date fruits fermented with Lactobacillus plantarum ATCC8014. The fermented date fruit was added as ingredient for confectionary making and evaluated for its effects on the physio-chemical properties and shelf life of toffee-like South Asian product (Dodol). The results showed broad range antifungal activity of fermented date fruit towards Aspergillus niger (90.85%), Aspergillus flavus (92.86%) Escherichia coli (13 mm) and Staphylococcus aureus (15 mm). The identified bioactive metabolites included propylene glycol (0.028 mmol mL⁻¹), lactic acid (0.763 mmol mL⁻¹), acetic acid (0.292 mmol mL⁻¹), acetoin (0.046 mmol mL⁻¹) and gamma-Aminobutyric acid (0.041 mmol mL⁻¹). Fermented date fruit (125 g/kg) significantly (p < 0.05) extended the shelf life of Dodol for 19 days at 25 ± 2 °C in comparison to the control that showed mould growth after 12 days. The microbial growth was significantly reduced in the modified Dodol. A significant influence was observed in the physiochemical properties for modified Dodol such as increasing moisture and water activity and reducing the product firmness. No significant differences (p ≥ 0.05) were observed for the consumer acceptability between traditional and modified Dodol. The results indicated that the high antifungal activity is due to the presence of several bioactive metabolites. Moreover, the findings indicated the promising applications of fermented date fruit as functional ingredient to improve quality and the shelf life stability for confectionaries.

INTRODUCTION

Date fruit (Phoenix dactylifera) are very nutritious and consist of 70% to 80% carbohydrate, mainly glucose and fructose [1]. Date fruit are rich source for proteins, pectin, lipids, salts, minerals and phenolic compounds [2]. Date fruit is globally commercialized as a high value confectionary and usually consumed fresh or applied for the preparation of processed confectionaries and bakery products [3, 4]. The statistics from the Food and Agriculture Organization (FAO) indicated the significant increase for the production and utilization of dates in the world [5]. However, the applications of date fruit have high potential to be expanded in confectionaries for improving their quality. Date fruit demonstrated antioxidant activity and strong antimicrobial activity due to the high content of phenolic and flavonoid compounds [6]. In recent study, fruit snack bar was prepared using date fruit as major ingredient demonstrated high potential to develop functional food with biological functions including antioxidant activity [7]. In addition, fermented date fruit was reported as value-added product that is rich in bioactive compounds such as organic acids, exopolysaccharide, nisin and amino acids [8]. Chandrasekaran & Bahkali, [5] reviewed the high potential for fermented date fruit as ingredients in functional foods. Fermented date fruit have high potential for food applications due to the production

CONTACT Belal J. Muhialdin belal@upm.edu.my Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400, Selangor, Malaysia.
© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
of bioactive compounds and flavouring compounds. Fermentation is inexpensive technology known to enhance the shelf life of foods and increase the bioactivity of raw materials.

On the other hand, Dodol is a traditional Malaysian toffee-like confectionary prepared by mixing coconut milk, glutinous rice flour, table sugar and palm-based sugar. Dodol has a broad range of flavours depending on the ingredients added such as durian, pandan and sweet potato [9]. This confectionary is popular in Asian countries including Malaysia, Indonesia, Philippines, Singapore, India and Sri Lanka. Dodol process is very simple and involves gelatinization of starch at temperatures in the range of 57–65 °C [10]. The pH of Dodol is 5-6, and it contains 38.2 g of starch per 100 g [11]. These conditions made this confectionary highly susceptible to spoilage by bacteria, yeast and moulds. The applications of the fermented date fruit are very limited in food industry to produce wine, alcohol, vinegar and organic acids [12]. Thus, fermented date fruits have promising applications as functional ingredient to improve the taste and shelf life stability of confectionaries. To the best of our knowledge, this is the first study aiming to determine the potential applications of fermented date fruit for improving the shelf life of confectionaries. In addition, to evaluate the antifungal activity of fermented date fruit, and identify the bioactive compounds using proton nuclear magnetic resonance (1H-NMR) analysis.

Materials and methods

Date fruit fermentation

Date fruit (8 kg) named Khastawi that is originally cultivated in Iraq was purchased from a local supplier in Kuala Lumpur. The date fruit variety selected for this study is due to their abundance and low-cost. The seeds were removed from the fruit and weighted to determine the weight lost due to the seed removals. Briefly, 200 g of whole date fruit (28.5%) were mixed with 500 mL filtered water (71.5%) and subjected to heat treatment at 100 °C for 45 min for sterilization. The starter culture strain was grown in MRS broth at 37 °C for 48 h, then washed twice using 1% saline; the cells were suspended in the saline and the colony forming units (CFU) were adjusted to 10^6-10^7. The inoculant was added to the date fruit and water mixture (40 °C) at 5% v/v and incubated at 37 °C for 72 h in shaker incubator. The pH was measured using a pH meter at 0 h and 72 h to observe the pH changes. The pH values were determined using a pH meter (3505 pH meter, Jenway, UK) at 28± 2 °C. The fermented samples were blended to prepare a paste and subjected to heat treatment at 100 °C for 15 min to inactivate the fermentation. Samples were prepared in triplicate and subjected to freeze drying.

Water soluble extracts

The water-soluble extract of fermented date fruit was prepared by mixing 100 mg of the freeze dried sample with 10 mL distilled water and filtrated using 0.45 μm pore size syringe filter.

Antifungal activity evaluation by microtiter assay

Aspergillus niger and Aspergillus flavus grown on potato dextrose agar (PDA) were obtained from the Bioprocess laboratory, Faculty of Food Science & Technology, Universiti Putra Malaysia. The conidia suspension was prepared following the method described by Muhialdin et al. [13]. Briefly, the PDA plates with the mature mould growth were flooded by 20 mL of 0.1% peptone water and the surface was gently scratched to release the conidia. The suspension (1 mL) was transferred to 20 mL malt extract broth (MEB) and the conidia concentration was adjusted to 10^6 conidia mL⁻¹ using a haemocytometer as described in a previous study [14]. Fermented Date Fruit (FDF) extract was tested for antifungal activity in 96 wells micro-titter plates assay at different concentrations including 25, 50 and 100 μL against 100 μL of MEB containing 10^6 conidia mL⁻¹. The plates incubated at 37 °C for 72 h and the antifungal activity was evaluated at 600 nm using ELISA reader (Bio-RAD 170-6930, California, USA). The control was 200 μL of MEB growing without the aqueous extortion of FDF. The antifungal assay performed in triplicate and the inhibition percentage was calculated as:

\[ \text{Inhibition\%} = \frac{\text{Absorbance at OD600 (72 h control) - 0 h control}}{(72 h sample - 0 h sample)} \times 100 \]  

\[ = \frac{(72 h control - 0 h control)}{(72 h control - 0 h sample)} \times 100 \]  

(1)
Antibacterial activity

The pathogenic bacteria including Escherichia coli ATCC12229 and Staphylococcus aureus ATCC6538 were obtained from the Faculty of Food Science & Technology, Universiti Putra Malaysia and cultured at 37 °C for 24 h in a nutrient broth. The cell counts were adjusted to 10² CFU mL⁻¹ using turbidity measurement (OD 600 nm) and plate count on nutrient agar. The bacterial suspension (100 μL) at different concentrations (25, 50 and 100 μL) was inoculated on nutrient agar plates and swapped using sterilized cotton swap. A total of 30 μL of the FDF extract was placed on blank 6 mm paper discs (Whatman No.2) and the discs were placed in the inoculated agar plates [15]. The triplicate plates were incubated for 24 h at 37 °C. The positive controls were tetracycline (30 μg) and ampicillin (10 μg). The antibacterial activity was determined by measuring the diameter for the clear zone around the discs. The experiment was done in triplicate and the results were reported for the mean and standard deviation (±SD).

Metabolites identification

The metabolites identification was carried out using ¹H-NMR analysis following the method described by Muhialdin et al. [16]. Briefly, 10 mg of FDF was mixed with 0.375 mL CH₃OH-d₄ and 0.375 mL KH₂PO₄ buffer in D₂O (pH 6 adjusted with 1 N NaOH), and TSP (0.01%, w/v) was used as the internal standard. The mixture was vortexed for 1 min and subjected to sonication at 30 °C for 10 min. The solution was centrifuged for 10 min at 12225 x g (Eppendorf® microcentrifuge 5424, Frankfort, Germany), and 600 μL of the supernatant was transferred to the NMR tubes. The ¹H-NMR chemical shifts were determined using 500 MHz NMR spectrometer (Varian Inc., California, USA). The residuals of methanol region (δ 3.28 to 3.33) and water region (δ 4.70 to 4.96) were removed before the data analysis. ¹H-NMR PRESAT spectrum was obtained after 4.30 min with 64 scans and relaxation delay of 2.0 s, while the spectral width was set to 10 ppm. The spectral region δ = 0.52–10.00 were automatically fitted and the compounds identified using Chenomx NMR Suite 8.5 (Chenomx Inc., Edmonton, Alberta, Canada).

Dodol preparation

Traditional Dodol was prepared following the traditional recipe described by Rosniyana et al. [17] with some modifications. The ingredients used included water (240 g), palm sugar (240 g), coconut milk (240 g), white sugar (125 g), glutinous rice flour (140 g) and wheat flour (15 g). The modified Dodol was prepared by replacing the 125 g white sugar with 125 g fermented date fruit paste. Briefly, water, palm sugar and sugar were mixed in cooking vessel and boiled for 10 min next, coconut milk added to the mixture and followed by adding glutinous flour and wheat flour. The mixture was subjected to cooking at 90 °C for 30 min with continuous stirring until the batter became thick and sticky. After cooling, the Dodol (1000 g) was packed in plastic containers and kept at 4 °C for further analysis. The samples prepared in triplicate.

Moisture content and water activity

The moisture content for the Dodol samples was determined using an oven at 110 °C based on the differences between the initial weight and constant final weight. The water activity (a_w) was determined using water activity meter (AquaLab 3TE, USA) after days 1 and 2 of incubation. All the analyses were carried out in duplicate.

Determining the effect on texture

The samples firmness was measured using a TA-XTplus Texture Analyser (Stable Micro Systems, Surrey, UK). The centre of the sample was compressed with the probe (36-mm cylindrical probe) at 30% strain using a 5-kg load cell. The testing parameters were pre-test speed (2.0 mm s⁻¹), test speed (1.7 mm s⁻¹), post-test speed (10.0 mm s⁻¹), distance (6.2 mm), time (5.0 s), trigger force (20.0 g). Firmness was reported as the force (in g) required to compress the original sample width by 25%. The experiment was carried out in triplicate.

Determining the colour

The colour of the Dodol samples was determined using calibrated Hunter Lab UltraScan PRO colorimeter attached with EasyMatch QC software (Hunter Associate Laboratory Inc., Reston, USA) and expressed as L (lightness; 0 = black, 100 = white), a (−a = greenness, +a = redness) and b (−b = blueness, +b = yellowness).
Traditional and modified Dodol samples were placed in petri dishes and kept at room temperature and observed for fungal growth. Moreover, another set of samples was inoculated with a mixture of 20 μL A. niger and 20 μL A. flavus containing 10⁶ conidia/mL for each mould. The plates were placed at 25 ± 2°C to determine the shelf life stability at room temperature. Fungi growth was observed visually, and the spore count was determined using a haemocytometer, while the pathogenic bacteria were counted using nutrient agar plates. The experiment was carried out in triplicate.

Evaluating the consumer acceptability

The consumer acceptability evaluation for traditional and modified Dodol was performed following the method described by Rosniyana et al. [17] with modifications. A total of 116 random consumers (24 males and 92 females, 21-44 years old) evaluated the samples based on 7 attributes namely taste, aroma, acidity, colour, texture, appearance and sweetness. Untrained consumers were students and staff recruited at the Faculty of Food Science and Technology, University Putra Malaysia. The consumers were briefed about the evaluated samples and the scoring record was explained to avoid confusion. The scores were recorded based on the hedonic scale method where 9 is ‘like extremely’ and 1 is ‘dislike extremely’. The samples (15 g) were served to the consumers, and drinking water served after every sample to avoid the inaccuracy due to high similarities of the samples.

Statistical analysis

The obtained data subjected to one-way analysis of variance (ANOVA) and Tukey’s test for evaluating the significance differences at α = 0.05 using Minitab (Version 18, Minitab Pennsylvania, USA) statistical software. The test results were expressed as the mean of triplicate values with standard deviations (±SD).

Results and discussion

Antifungal activity of fermented date fruit

In this study, the seeds of the date fruit were removed before the fermentation and caused a reduction of the weight by 17.5 ± 0.13%. The pH of the date fruit was 6.23 ± 0.04 at 0 h fermentation and dropped to pH 3.48 ± 0.26 after 72 h fermentation. The antifungal activity and antibacterial activity of fermented date fruit (FDF) was dose-dependent (Tables 1 and 2). The high concentration (100 μL) demonstrated the highest antifungal activity and growth inhibition towards A. niger (90.85%) and A. flavus (92.86%). The antibacterial activity showed similar results, the highest extract concentration showed strong inhibition zones against E. coli (13 mm) and S. aureus (15 mm). The high antifungal and antibacterial activities of date fruit extract could be a result of their high content of free and bound phenolics [19]. Date fruit extract was reported for it is strong antimicrobial activity due to the high phenolic compounds content determined using 1H-NMR analysis [20]. However, very limited studies investigated the potential applications of date fruit as functional ingredient in making bakeries and confectionaries. Parn at al. [7] produced date fruit snack bars and observed increased phenolic compounds content and biological activities. Tang et al. [8] reviewed the production of bioactive compounds in fermented date fruit such as organic acids, amino acids and nisin, while there are no reports on using fermented date fruit as functional ingredients. The results of this study indicated the high antifungal and antibacterial activities of FDF extract and the high potential for applications as functional ingredient for making confectionaries.

Bioactive metabolites

The 1H-NMR spectra were analysed with Chenomx software to identify and quantify the bioactive metabolites of fermented date fruit (FDF). A total of 20 metabolites were identified in the FDF belonging to different chemical regions (Table 3). The results

| Table 1. Antifungal activity of fermented date fruit at different concentrations against the selected moulds. |
|-----------------------|-----------------|-----------------|
| Moulds                | Treatment       | Growth inhibition (%) |
|                       | 25 μL           | 50 μL           | 100 μL          |
| Aspergillus niger     | 40.06 ± 0.58a   | 52.03 ± 0.25b   | 90.85 ± 0.22a   |
| Aspergillus flavus    | 51.93 ± 0.18a   | 63.71 ± 0.31b   | 92.86 ± 0.31a   |
| Mean values ± Standard deviation of triplicate readings. |
| Small letters represent significant differences within the column (p<0.05). |

| Table 2. Antibacterial activity* of fermented date fruit extract at different concentrations. |
|----------------------------------|-----------------|-----------------|
| Treatment                        | Pathogenic bacteria |
|                                  | E. coli         | S. aureus       |
| Extract 25 μL                    | 10.00 ± 0.80c   | 12.00 ± 0.10c   |
| Extract 50 μL                    | 11.00 ± 0.65c   | 12.00 ± 0.35c   |
| Extract 100 μL                   | 13.00 ± 0.40b   | 15.00 ± 0.15ab  |
| Tetracycline (30 μg)             | 16.00 ± 0.14a   | 17.00 ± 0.70a   |
| Ampicillin (10 μg)               | 10.00 ± 0.12c   | 14.00 ± 0.22bc  |
| Mean values ± Standard deviation of triplicate readings. |
| Small letters represent significant differences within the column (p<0.05). |

*The diameter for the clear zone was measured and expressed as (mm).
showed high presence of several sugars at high concentrations in sugar region (δ = 3.3-6.0). Fructose, xylose, erythritol, and arabinose were determined at high concentrations (Figure 1). The amino acids identified in the FDF including alanine, arginine, proline, cystine, lysine and β-alanine. In addition, 5 out of the 20 identified metabolites were well known for their antimicrobial activity namely propylene glycol.

| Compound              | Chemical shifts ppm | Concentration (mmol mL⁻¹) |
|-----------------------|---------------------|----------------------------|
| Propylene glycol      | δ 1.13 (d)          | 0.028                      |
| Lactic acid           | δ 1.32 (d), δ 4.1 (q)| 0.763                      |
| Alanine               | δ 1.46 (d)          | 0.013                      |
| Arginine              | δ 1.61 (m)          | 0.075                      |
| 4-Hydroxybutyrate     | δ 1.76 (m)          | 0.026                      |
| Lysine                | δ 1.89 (m)          | 0.051                      |
| Acetic acid           | δ 1.96 (s)          | 0.292                      |
| Acetoin               | δ 2.21 (s)          | 0.046                      |
| Dimethylamine         | δ 2.52 (s)          | 0.024                      |
| N-Acetyl-L-tyrosine   | δ 2.94 (dd)         | 0.078                      |
| gamma-Aminobutyric acid | δ 3.00 (d)       | 0.041                      |
| β-Alanine             | δ 3.17 (t)          | 0.867                      |
| Proline               | δ 3.33 (dt), δ 3.41 (dt)| 0.452                     |
| Cystine               | δ 3.38 (dd)         | 0.404                      |
| Xylose                | δ 3.31 (dd), δ 3.42 (dt), δ 4.57 (d), δ 5.19 (d)| 1.054                     |
| Glucose               | δ 3.524 (m), δ 3.728 (m), δ 3.824 (m) | 1.724                     |
| Fructose              | δ 3.577 (m), δ 3.695 (m), δ 4.005 (m) | 1.940                     |
| Erythritol            | δ 3.61 (m)          | 0.188                      |
| Arabinose             | δ 3.95 (m), δ 4.02 (m)| 0.751                     |
| Choline               | δ 4.056 (dd)        | 0.103                      |

Figure 1. Representative ¹H nuclear magnetic resonance (NMR) spectrum of fermented date fruit from 1 ppm to 6 ppm with the identified metabolites.
lactic acid, acetic acid, acetoin, and gamma-Aminobutyric acid (GABA). Secondary metabolites were found at relatively low concentrations such as 4-Hydroxybutyrate, dimethylamine, and N-Acetyl-L-tyrosine. Lactic acid and acetic acid were the major antimicrobial compounds and their antimicrobial mechanism heavily depends on causing cell membrane hydrolysis leading to death of spoilage microorganisms [21]. In addition, propylene glycol mechanism of action was suggested as cell membrane function interference that can reduce the pathogens surface tension [22]. The presences of several antimicrobial compounds that have different mechanisms of action indicate that the antimicrobial activity of FDF is synergistic mechanism. In previous study, some of the compounds were found in Deglet Nour date variety which explained the suggested bioactivities [19]. 1H-NMR analysis was applied for the profiling of metabolites in fermented foods and beverages [16]. Majority of the compounds were amino acids, organic acids and sugars. Moreover, gamma-Aminobutyric acid (GABA) was determined at high concentration. The results of this study agree with previous studies, as the major metabolites produced during lacto-fermentation are organic acids and amino acids. The bioactive metabolites present in FDF are functional ingredients with high potential to improve the shelf life of Dodol. In addition, FDF is a suitable replacement for sugar in Dodol production due to the high concentration and variety of mono- and disaccharides determined using NMR analysis.

**Dodol shelf life stability**

The shelf life of the traditional and modified Dodol was determined at room temperature via the observation for fungal growth. The fungal growth was observed after 12 days on the traditional samples, but after 19 days on the modified samples. The results indicated that the shelf life of the Dodol was extended by 58% when date fruit was added as an ingredient. On the other hand, Dodol samples inoculated with A. niger and A. flavus showed fungal growth after 7 days for traditional samples and 18 days for modified samples at 25 ± 2 °C (Figure 2). The two fungi were selected in this study because they are commonly associated with spoilage of foods in Malaysia and cause high health risk to the consumers [23]. The spores count for fungi and cell count for pathogenic bacteria demonstrated significant (p<0.05) reduction in the growth of fungi and pathogenic bacteria in modified Dodol (Table 4). The results indicated that FDF has high potential as a functional ingredient with the ability to extend the shelf life of confectionaries. The presence of the antimicrobial compounds including lactic and acetic acids in FDF plays an important role to prevent the growth of the fungi and extend the shelf life. On the other hand, the synergistic antimicrobial activity of the other bioactive compounds in the FDF can contribute to prevention of fungal growth. The applications of lactic acid bacteria (LAB) were reported as an inexpensive method to extend the shelf life of bakery products [24, 25]. In a previous study, LAB were suggested as potential antifungal biocontrol agents to inhibit the spore germination of Colletotrichum gloeosporioides and/or prevent fruits spoilage [26]. In another study, fermented kefir was added to bread as a functional ingredient and the shelf life of bread was extended for 10 days compared to the control bread [27]. To the best of our knowledge there are no studies reporting the use of fermented date fruit for the preservation of confectionaries. In this study, fermented date fruit enhanced the resistance to fungal growth for modified Dodol.

**Physicochemical properties**

The physicochemical properties for Dodol samples were significantly influenced by adding the FDF as ingredient (Table 5). The moisture content and water activity were significantly (p<0.05) high for the modified Dodol. Nevertheless, the firmness of the traditional Dodol was significantly (p<0.05) higher than that of the modified sample. On the other hand, the modified Dodol demonstrated darker colour compared to the traditional sample. The changes in the physicochemical properties are the result of adding FDF including the increasing of moisture content and the water activity due to the high-water content at the fermentation process [28]. Moreover, the addition of the FDF to the Dodol caused reduction in the firmness, while caused darker colour for the product. The findings of this study are in line with a previous study that reported the influence of adding rice bran on Dodol physiochemical properties such as increased moisture content and reduced firmness for the texture [17]. Traditional Dodol ingredients are mainly carbohydrates including glutinous rice and wheat flour and they are responsible for the high firmness [11]. In this study, the addition of FDF that contains organic acids influenced the texture firmness and high phenolic compounds caused the darker colour. The results of this study indicated a significant influence of the FDF on the physiochemical properties of Dodol.
Consumer preference

The results of this study demonstrated high acceptability for the modified Dodol in comparison to traditional Dodol (Table 6). There were no significant differences (p < 0.05) for the 7 attributes evaluated in the study. The colour and appearance received the highest scores for both samples. Acidity was recorded as the lowest scores which was 5.72 ± 2.95 and 5.59 ± 2.64 for traditional and modified Dodol, respectively.

Table 4. Spore and cell counts for the traditional and modified Dodol expressed as spore and or CFU g⁻¹.

| Sample          | A. flavus | A. niger | E. coli | S. aureus |
|-----------------|-----------|----------|---------|-----------|
| Traditional Dodol | 9.1 x 10⁵ | 3.7 x 10⁶ | 6.4 x 10⁴ | 2.7 x 10⁴ |
| Modified Dodol   | 7.4 x 10⁵ | 3.2 x 10⁶ | ND      | ND        |

Not detected (ND).

Table 5. Physiochemical properties for the traditional and modified Dodol.

| Parameters       | Traditional Dodol | Modified Dodol |
|------------------|-------------------|---------------|
| Moisture content (%) | 21.50 ± 1.22b     | 29.40 ± 2.74a |
| Water activity (a_w) | 0.81 ± 0.02b      | 0.84 ± 0.06a  |
| Firmness (g)     | 137.66 ± 9.80a    | 97.24 ± 3.48b |
| Colour, L        | 59.95 ± 4.30b     | 73.71 ± 7.90a |
| a                | 6.42 ± 0.29b      | 1.18 ± 0.42a  |
| b                | 18.27 ± 0.80a     | 8.33 ± 1.15b  |

Mean values ± Standard deviation of triplicate readings.
Small letters represent significant differences within the row (p<0.05).

Consumer preference

The results of this study demonstrated high acceptability for the modified Dodol in comparison to traditional Dodol (Table 6). There were no significant differences (p < 0.05) for the 7 attributes evaluated in the study. The colour and appearance received the highest scores for both samples. Acidity was recorded as the lowest scores which was 5.72 ± 2.95 and 5.59 ± 2.64 for traditional and modified Dodol,
respectively. The replacement of sugar with FDF did not show impact on the acceptability of the consumers. In a previous study, rice bran was used as a substitution of rice flour at different concentrations for Dodol preparation. The traditional sample received low overall acceptability compared to the samples prepared using 20, 30 and 40% rice bran [17]. The colour was observed to be darker for the 40% rice bran sample. In another study, the snack bar prepared from date fruit showed low consumer preference to the texture and appearance, but high preference was given to the odour and flavour [7]. Hooper et al. [29] reported that the replacement of certain ingredients in well-known food will have effects on the consumer acceptability. However, the results of this study demonstrated that FDF enhanced the palatability for consumers towards the modified Dodol and showed high potential for application as a functional ingredient to produce confectionaries with high consumer acceptability.

Conclusions

Date fruit fermented with L. plantarum showed strong antifungal and antibacterial activities against A. niger, A. flavus, E. coli and S. aureus. Fermented date fruit have high potential for applications as a functional ingredient for making confectionaries. The antifungal activity was probably due to the presence of several antimicrobial metabolites identified by 1H-NMR analysis. The addition of FDF as a bioactive ingredient showed high potential to extend the shelf life of Dodol, indicated by the reduction of microbial growth in the modified sample. The addition of fermented date fruit demonstrated significant influence on the physiochemical properties of Dodol. Modified Dodol received high consumer acceptability for the tested attributes. The findings of this study recommended the application of fermented date fruit to improve the shelf life of confectionaries. Further study is recommended to optimize the fermentation conditions for date fruit, and to determine the applications of fermented date fruit in different confectionary products.

Acknowledgement

The authors would like to thank the laboratory technicians at the Faculty of Food Science and Technology, Universiti Putra Malaysia (UPM) for their support.

Disclosure statement

The authors have no conflict of interest to be reported

Funding

This study did not receive any fund

ORCID

Belal J. Muhialdin http://orcid.org/0000-0003-4684-536X
Anis Shobirin Meor Hussin http://orcid.org/0000-0002-9702-8856

Data availability statement

The data supporting the findings reported in this study are available from the corresponding author upon reasonable request.

References

[1] Al-Farsi M, Alasalvar C, Al-Abid M, et al. Compositional and functional characteristics of dates, syrups, and their by-products. Food Chem. 2007;104(3):943–947.
[2] Hussain MI, Farooq M, Syed QA. Nutritional and biological characteristics of the date palm fruit (Phoenix dactylifera L.)–A review. Food Biosci. 2020;34:100509.
[3] El Hadrami A, Al-Khayri JM. Socioeconomic and traditional importance of date palm. Emir J Food Agr. 2012;24(5):371.
[4] Sidhu JS, Al-Sager JM, Al-Hooti SN, et al. Quality of pan bread made by replacing sucrose with date syrup produced using pectinase/cellulase enzymes. Plant Foods Hum Nutr. 2003;58(3):1–8.
[5] Chandrasekarani M, Bahkali AH. Valorization of date palm (Phoenix dactylifera) fruit processing by-products and wastes using bioprocess technology - Review. Saudi J Biol Sci. 2013;20(2):105–120.
[6] Taleb H, Maddocks SE, Morris RK, et al. The antibacterial activity of date syrup polyphenols against S. aureus and E. coli. Front Microbiol. 2016;7:198.
[7] Parn OJ, Bhat R, Yeoh TK, et al. Development of novel fruit bars by utilizing date paste. Food Biosci. 2015;9:20–27.
[8] Tang ZX, Shi LE, Aleid SM. Date and their processing byproducts as substrates for bioactive compounds

Table 6. Consumer preference evaluation for traditional dodol and modified Dodol.

| Attributes  | Traditional Dodol | Modified Dodol |
|------------|-------------------|----------------|
| Taste      | 6.55 ± 1.91*      | 6.00 ± 1.77*   |
| Aroma      | 6.20 ± 2.00*      | 6.00 ± 1.85*   |
| Colour     | 7.24 ± 1.53*      | 7.38 ± 1.36*   |
| Appearance | 7.14 ± 1.64*      | 6.86 ± 1.46*   |
| Soursness  | 5.72 ± 2.95*      | 5.99 ± 2.64*   |
| Texture    | 6.72 ± 1.73*      | 6.10 ± 1.48*   |
| Sweetness  | 6.10 ± 2.42*      | 6.14 ± 2.12*   |
| overall    | 6.53 ± 0.50*      | 6.30 ± 0.45*   |

Small letters show significant differences (p < 0.05) and same letters show no significant differences in the row.

Each value in the table is the mean ± SD of triplicates.
production. Braz Arch Biol Technol. 2014;57(5):706–713.

[9] Zähid K, Wahid MA, Ahamad N, et al. Dodol berenzim. Bul Teknol MARDI. 2012;2:113–117.

[10] Chuah TG, Nisah HH, Choong ST, et al. Effects of temperature on viscosity of dodol (concoction). J Food Eng. 2007;80(2):423–430.

[11] Nasaruddin F, Chin NL, Yusof YA. Effect of processing on instrumental textural properties of traditional dodol using back extrusion. Int J Food Prop. 2012;15(3):495–506.

[12] Johnson, DV, Al-Khayri, JM, & Jain, SM. (2015). Introduction: Date production status and prospects in Asia and Europe. In Date palm genetic resources and utilization (pp. 1-16). Dordrecht: Springer.

[13] Muhialdin BJ, Hassan Z, Abu BF, et al. Novel antifungal peptides produced by Leuconostoc mesenteroides DU15 effectively inhibit growth of Aspergillus niger. J Food Sci. 2015;80(5):1026–1030.

[14] Gamba RR, Caro CA, Martinez OL, et al. Antifungal effect of kefir fermented milk and shelf life improvement of corn arepas. Int J Food Microbiol. 2016;235:85–92.