# CHAPTER 6

# RESULTS AND DISCUSSION: EFFECT OF WASHING ON DATE FRUIT'S NUTRITION VALUE

## 6.1 Introduction

The influence of wash treatments on the quality characteristics of date fruits is of particular interest because the wash treatment is something that date processors and customers may do themselves. Post-harvest treatments and storage of fruits and vegetables have a significant impact on the nutritional quality of the product (Laurila & Ahvenainen, 2002). Unfortunately, only a few research have investigated the effect of wash treatments on the quality criteria of date fruits. Therefore, this study was required to investigate the influence of current wash treatments on total sugars (TS), total phenolics (TP), and antioxidant activity (AC), and finally to suggest optimal wash treatment settings suitable for date fruits. Determination of washing effect on date fruit's nutrition value was examined through comparing the TS, TP, and AC of the washed samples with that of control samples (unwashed samples) the method is described in sections 3.7 - 3.7.4.

## 6.2 Determination of Washing Effect on Total Sugars

### 6.2.1 Introduction

Date fruits are rich in simple sugars. Consuming of 100 g of dates provides approximately 18 % of the daily needs of carbohydrates (Ahmed, et al., 2018). For over 85 % of the carbohydrate content dates of dates are glucose and fructose. In a particular date fruits variety, the sugar contents can be highly vary depending on the cultivar, soil

conditions, fruit maturity, and climate, which can have a big effect on sugar contents. Date sugars are including glucose, fructose, and sucrose which is depending on the fruit maturity stage and mostly disappearing in Tamar stage, while the overall ratio of the other two sugars (glucose, fructose) is mostly equal. Studies showed that the fruit becomes rich in sugar after the Khalal stage. Al-Noimi and Al-Amir (1980) reported that, in the early stages of development, sucrose content exceeds glucose and fructose content, and sucrose begins to convert to glucose and fructose until sucrose content drops to less than 5 % in the Tamar stage. The rate of sugar conversion is influenced by the temperature and relative humidity of the storage area, as well as the physiological activities of the fruit (Al-Farsi & Lee, 2008).

### 6.2.2 Determination of Total Sugars in Date Fruit

The total sugars in (TS) of date fruit samples were determined as described in Section 3.7.2 as glucose equivalent (mg/g) using the equation obtained from the glucose calibration curve (Figure 6.1).

The washing effect on total sugars (TS reduction %) was calculated from the following equation:

[TS control- TS washed sample /TS control] *100

(6.1)

Depending on the washing solution and experimental settings, all treatments showed detrimental effect on total sugars. The mean TS content in control (unwashed) sample was 775.7±29.14 mg/g fresh weight.

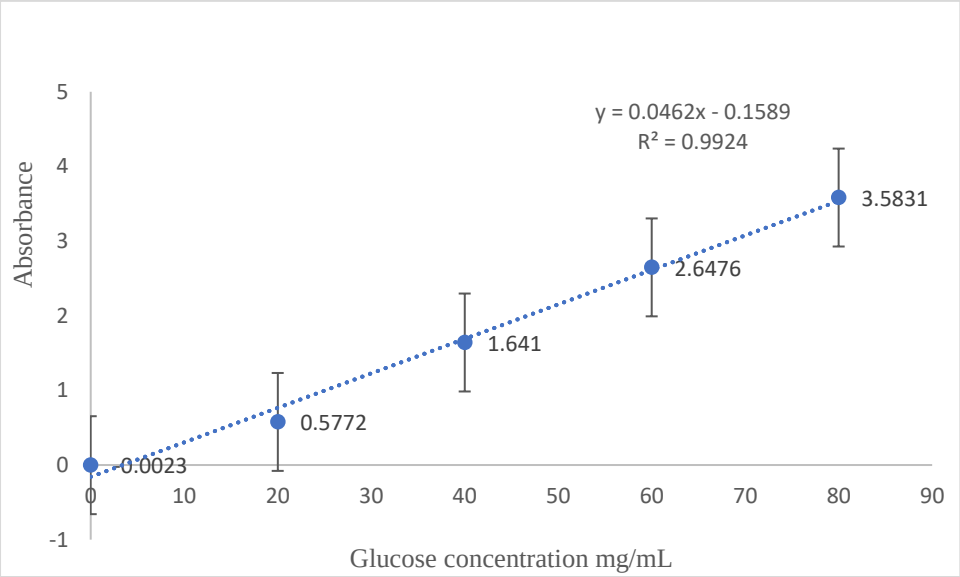


**Figure 6.1:** Calibration Curve of Total Sugars as Glucose Equivalent

### 6.2.3 Effect of Tap Water on Total Sugars Contents of the Washed Dates Samples

The effect of tap water on total sugars contents (TS) of washed date samples is shown in Fig 6.2, data Appendix 2 Table B1. Washing with tap water at 25°C and 37°C for 2 min exerted reduction in total sugars contents ranged from 10.8 % - 19.32 %, while washing for 5 min causes reduction in TS contents ranged from 21.80 - 32.13 % compared with control. The result indicates that temperature and washing duration have a significant effect in TS reducing rates ($p < 0.05$). This result also in agreement with that reported by Osman et al. (2014), who revealed that the loss of sugars from date fruits was increased by extending the duration of washing. Increasing the temperature and washing duration was found to strongly accelerate losing of the soluble sugars from date fruits fleshes.

### 6.2.4 Effect of 1 % Dishwashing Detergent solution (DWD) on Total Contents of the Washed Dates Samples

Effect of 1 % DWD solution on total contents (TS) of washed dates samples is shown in Fig 6.2, data Appendix 2 Table B1. Sample washed by 1 % detergent solution at 25°C and 37°C for 5min showed TS reducing rate of 12.11 % and 25.59 % respectively. The effect of detergent solution on TS enhanced significantly by increasing the temperature from 25°C to 37°C ($p < 0.05$). A detergent solution is mostly made up of ionic surfactants, which work to reduce the surface tension between two liquids, a gas and a liquid, or a liquid and a solid (Awad & Awad, 2022) and this explain the ability of detergent solution on dissolving the sugars.

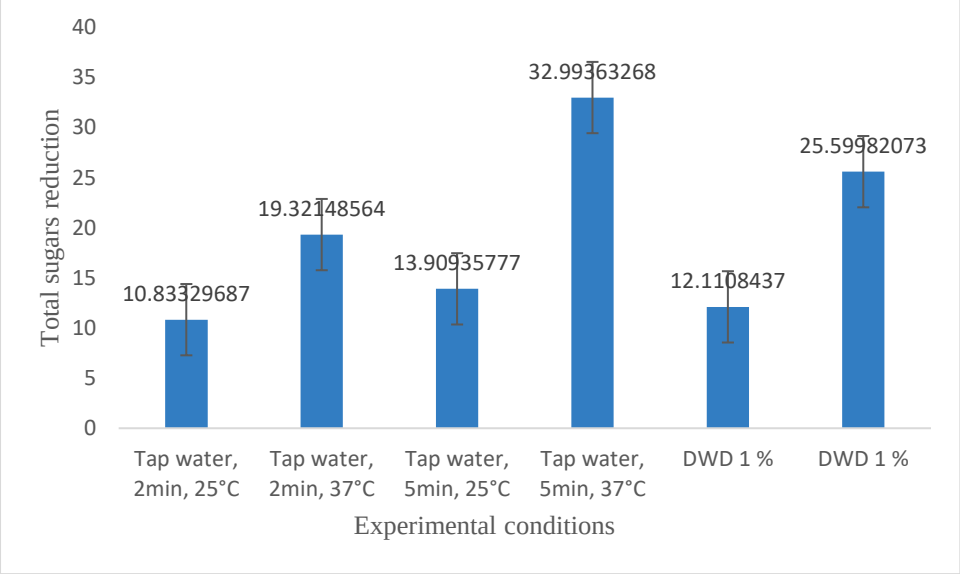


**Figure 6.2:** Percent Reduction of Total Sugars by Tap Water and 1% Detergent Solutions at 25°C and 37°C for 2 and 5 min Compared to Control Sample (Data in Appendix 2 Table B1)

### 6.2.5 Effect of Sodium Chloride Solutions on Total Sugars Contents of the Washed Dates Samples

The effect of sodium chloride (NaCl) solutions on TS contents is shown in Fig 6.3, data Appendix B Table2. Samples washed with 1% sodium chloride solutions for 5 min showed reduction in TS contents of 7.34 % and 17.8 % at 25°C and 37°C respectively, compared to control sample. While sample washed with 2% NaCl showed TS reduction of 9.96 % and 11.76 % at 25°C and 37°C, respectively. Samples washed with 3 % NaCl showed TS reduction of 18.22 % and 18.65 % at 25°C and 37°C respectively. Increasing in washing temperature resulted in a very significant reduction in TS contents of the samples ($p < 0.01$) except in case of 3% NaCl. This may be attributed to the fact that heat enhances dissolving and hydrolysis of soluble sugars in dates tissues.

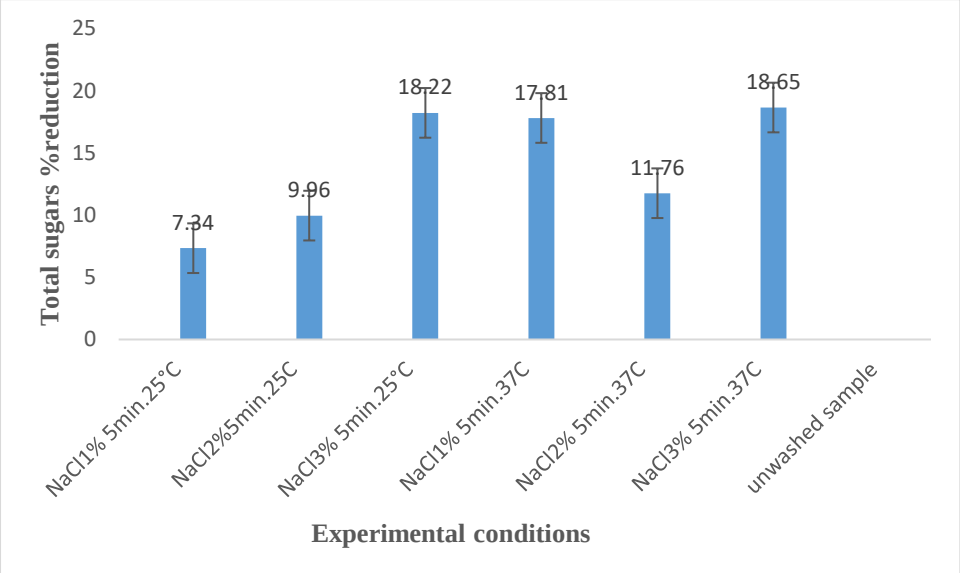


**Figure 6.3:** Total Sugars % Reduction in Samples Washed with different concentrations of NaCl (1 %, 2 % and 3 %) Solutions at 25°C and 37°C for 5 min Compared with Control Sample (Data in Appendix 2 Table B1)

### 6.2.6 Effect of Sodium Bicarbonate Solutions on Total Sugars Contents of the Washed Dates Samples

The effect of $NaHCO_3$ solutions on total sugars contents (TS) of the washed dates samples is shown in Table 6.1. Washing with sodium bicarbonate, exerted very little effect on TS contents of the examined samples. The effect slightly increased with increasing the temperature, contact time, and the solution concentration. The TS reduction rates ranged from 0. 39 % for 1 % concentration at 25°C and 2 min washing duration to 7.5 % for 3 % concentration at 37°C and 10 min washing duration. Because sodium bicarbonate is an amphoteric compound, aqueous solutions are mildly alkaline due to the formation of carbonic acid and hydroxide ions (Housecroft & Sharpe, 2008). Sodium bicarbonate has a pH of 9 can work as surfactant to increase water ability to penetrate date fruit's surface. Increasing washing temperature enhancing sugar solubility in water.

### 6.2.7 Effect of Acetic Acid Solutions on Total Sugars Contents (TS) of the Washed Dates Samples

As shown in Table 6.1, washing with acetic acid (AA) resulted in very little effect on TS contents. Decreasing in TS contents of washed samples gradually increased with increasing in temperature, contact time and the solution concentration from 0.75 % - 4.92 %. Acetic acid has shown a strong attitude in removing pesticide residues because acetic acid has more power as a chelating agent (Amir, et al., 2019) and also can enhance hydrolysis of sugars.

### 6.2.8 Effect of Hydrogen Peroxide Solutions on Total Sugars Contents (TS) of the Washed Dates Samples

The effect of hydrogen peroxide ($H_2O_2$) on TS contents of washed sample is shown in Table 6.1. Washing with hydrogen peroxide $H_2O_2$ solutions exerted a higher effect on TS content than $NaHCO_3$ and AA solutions. The effect increased with increasing washing duration and concentration from 4 % for concentration of 1% at 25°C and 2 min washing duration to 12.3% for concentration of 3% at 25°C and 10 min washing duration. The increasing in temperature from 25°C to 37°C seemed to reduce the TS reduction rates, this may attribute to exothermic nature of $H_2O_2$ reaction because $H_2O_2$ is exothermic reaction increasing temperature slowing down the or reversing it to the opposite direction.

### 6.2.9 Effect of Potassium Permanganate on Total Sugars Contents of the Washed Dates Samples

Effect of potassium permanganate ($KMnO_4$) solutions on TS contents is shown in Table 6.1. $KMnO_4$ solutions showed lower effect of TS content than that of $H_2O_2$ at 2 and 5 min (0.45 %,0.6% respectively) but the effect become greater (14-33 %) with increasing of the solution concentration, the washing duration, and temperature to cause the maximum % reduction of 33% when 3% solution was used for duration of 10 min at 37°C.

On the other hand, $H_2O_2$ and $KMnO_4$ at 3% concentrations, had a more dramatic effect on total sugar levels. By increasing the contact time, the sugars loss from date fruits was increased. According to the findings, acetic acid, hydrogen peroxide, and potassium permanganate had a minor negative effect on total sugars, with the exception of $H_2O_2$ and $KMnO_4$ at a concentration of 2 %, which had a significant effect on the

total sugar contents of washed date fruit samples. Soluble sugars are easily dissolved in washing solutions and are continuously lost from dates. Time and temperature are important considerations in the washing process (Osman et al., 2014).

**Table 6.1:** Total Sugars Contents and Reduction % in Samples Washed by Different Concentrations (1 %, 2 %, and 3%) of Sodium Bicarbonate, Acetic acid, Hydrogen peroxide and Potassium permanganate at 25C° and 37°C for 2, 5 and 10 Minutes. (Values are mean ±SD)

| Experimental conditions | $NaHCO_3$ | | Acetic acid | | $H_2O_2$ | | $KMnO_4$ | |
|---|---|---|---|---|---|---|---|---|
| | TS | Rd % | TS | Rd % | TS | Rd % | TS | Rd % |
| **1 %, 2min, 25°C** | 772.59 | 0.39 | 769.80 | 0.76 | 744.40 | 4.03 | 772.13 | 0.46 |
| **1 %, 5min, 25°C** | 768.50 | 0.92 | 763.56 | 1.56 | 741.34 | 4.43 | 770.68 | 0.65 |
| **1 %, 10min, 25°C** | 755.50 | 2.6 | 754.36 | 2.75 | 738.23 | 4.83 | 767.80 | 1.02 |
| **1 %, 2min, 37°C** | 769.77 | 0.76 | 762.66 | 1.68 | 756.37 | 2.49 | 753.48 | 2.86 |
| **1 %, 5min, 37°C** | 762.04 | 1.76 | 757.41 | 2.36 | 762.04 | 1.76 | 752.66 | 2.97 |
| **1 %, 10min, 37°C** | 751.80 | 3.08 | 749.53 | 3.38 | 770.58 | 0.66 | 740.27 | 4.57 |
| **2 %, 2min, 25°C** | 770.14 | 0.71 | 765.81 | 1.28 | 733.94 | 5.38 | 719.52 | 7.25 |
| **2 %, 5min, 25°C** | 765.79 | 1.28 | 765.47 | 1.32 | 730.80 | 5.79 | 716.38 | 7.69 |
| **2 %,10min, 25°C** | 753.45 | 2.88 | 759.88 | 2.05 | 725.92 | 6.42 | 711.49 | 8.28 |
| **2 %, 2min, 37°C** | 767.11 | 1.10 | 760.88 | 1.91 | 740.34 | 4.56 | 725.91 | 6.42 |
| **2 %, 5min, 37°C** | 763.70 | 1.55 | 759.733 | 2.06 | 718.97 | 7.32 | 707.44 | 8.80 |
| **2 %, 10min, 37°C** | 748.90 | 3.45 | 753.69 | 2.84 | 715.07 | 7.82 | 700.65 | 9.68 |
| **3 %, 2min, 25°C** | 758.79 | 2.18 | 756.60 | 2.46 | 686.48 | 11.5 | 680.71 | 12.24 |
| **3 %, 5min, 25°C** | 731.10 | 5.75 | 754.58 | 2.72 | 681.38 | 12.16 | 666.94 | 14.02 |
| **3 %, 10min, 25°C** | 738.04 | 4.85 | 742.22 | 4.32 | 680.39 | 12.28 | 658.75 | 15.08 |
| **3 %, 2min, 37°C** | 746.95 | 3.71 | 750.92 | 3.19 | 717.35 | 7.52 | 558.62 | 27.98 |
| **3 %, 5min, 37°C** | 723.73 | 6.69 | 745.81 | 3.85 | 712.75 | 8.12 | 551.28 | 28.93 |
| **3 %, 10min, 37°C** | 717.53 | 7.5 | 737.47 | 4.93 | 701.98 | 9.50 | 514.39 | 33.68 |

## 6.3 Washing Effect on Total Phenolic Contents of Date Fruits Samples

### 6.3.1 Introduction

Phenolic compounds are valuable antioxidants and free radical scavengers, as well as reducing agents (Aryal, et al., 2019). Among the phenolic contents of date fruits are ferulic, sinapic and cinnamic acids, along with various cinnamic acid derivatives, coumaric acid, vanillic acid, syringic acid, gallic acid, protocatechuic acid, p-hydroxybenzoic acid and caffeic acid. Apparently, after it had been dried, it is said that the phenolic content increased because of the removal of tannins, but this is yet to be substantiated (Alfaris et al., 2021).

### 6.3.2 Determination of Total Phenolic Contents of Date Samples

The phenolic contents (TP) of date fruit samples were determined by the method described in Section 3.7.3 based on gallic acid equivalent using the equation obtained from the gallic acid calibration curve Figure 6.4. The washing effect on TP contents was calculated from the following equation:

[TP control - TP washed sample / TP control] *100

(6.2)

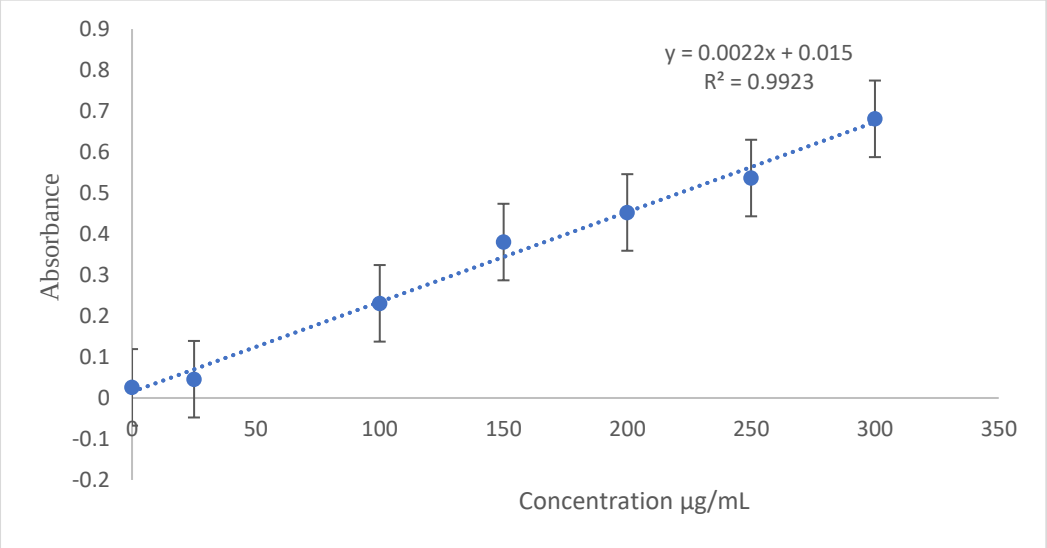


**Figure 6.4:** Calibration Curve of Total Phenolic Gallic Acid Equivalent

### 6.3.3 Effect of Washing with Tap Water on Total Phenolic Contents

Reduction in total phenolic contents of 4.02 % and 7 % at 25°C and 37°C, was observed in the sample washed by tap water for 2 min. The result Table 6.2 indicated significant effect of the temperature configurated to significantly decrease TP contents during washing ($P<0.05$). The samples washed by water for 5 min showed reduction of TP by 9.42 % and 12.89 % at 25°C and 37°C respectively, which is significantly different ($P < 0.05$) from TP contents of sample washed for 2 min at 25°C and 37°C. Increasing the washing temperature and duration causes very significant decrease in TP contents ($p < 0.001$) and vice versa. The temperature and washing duration are essential factors that enhancing the dissolving and hydrolysis rates of the dates constituents into rinsing water which continuously decreases their mounts in the dates' flesh.

**Table 6.2:** Effect of Water and Detergent Solution at 25°C and 37 °C on Total Phenolic Contents for Washing Duration of 2 and 5 Min

| Sample | TP. Contents (µg/g) | % Reduction |
|---|---|---|
| Control sample | 1.64 ± 0.05 | - |
| Tap water, 2min, 25°C | 1.574 ± 0.15 | 4.02 |
| Tap water, 2min, 37°C | 1.525 ± 0.09 | 7.00 |
| Tap water, 5min, 25°C | 1.48 ± 0.06 | 9.42 |
| Tap water, 5min, 37°C | 1.43 ± 0.03 | 12.86 |
| Detergent 1%, 5min, 25°C | 1.53 ± 0.07 | 6.74 |
| Detergent 1%, 5min, 37°C | 1.28 ± 0.01 | 21.54 |

### 6.3.4 Effect of DWD solution on Total Phenolic Contents

The effect of DWD solution on TP contents is shown in Fig 6.2, data Table 6.2. Samples was washed by DWD solution for 5 min at two different temperature 25°C and 37 °C. Washing at 25°C reduced the TP contents by 6.74 % compared to control, which is significantly different from that of sample washed at 37°C (21.54 %). Increasing of washing temperature causes a very significant decrease in TP contents even for the same time duration ($P<0.001$). Detergent contains surfactants that increase water ability to penetrate dates' peel and dissolves constituents in the flesh, while heat ease dissolving the constituents in the date peel and flesh, allowing the water or detergent to easily dissolve sugars and draw them away into the rinse water.

### 6.3.5 Effect of Sodium Chloride Solution on Total Phenolic Contents

Effect of NaCl solutions on TP contents is shown in Table 6.3. Samples washed by 1 % NaCl solution for 5 min at 25°C showed total phenolic reduction ranged from 2.41 % - 3.6 %. TP reduction rate increased gradually with increasing of solution concentration.

Samples washed by 1 % NaCl solutions for 5 min at 37°C showed total phenolic reduction ranged from 5.2 % - 6.8 %. It is noted that the increasing in solution concentration at 37°C do not have a significant effect in TP reduction because the temperature effect is dominant. The activity of NaCl may refer to its acidic nature (pH 5.76) which catalyzing dissolution and dissolving of phenolics and other nutrition in dates tissues.

**Table 6.3:** Effect of Differrent Concentrations of NaCl Solutions ( 1 %, 2 % and 3 %) at 25°C and 37°C for 5 Min on Total Phenolic Content

| Washing | | TP µg /g | % Rd |
|---|---|---|---|
| Unwashed sample | | 2.50 | - |
| 1 % NaCl | 5min, 25°C | 2.41 | 3.6 |
| 2 % NaCl | 5min, 25°C | 2.39 | 4.4 |
| 3 % NaCl | 5min, 25°C | 2.37 | 5.2 |
| 1 % NaCl | 5min, 37°C | 2.33 | 6.8 |
| 2 % NaCl | 5min, 37°C | 2.33 | 6.8 |
| 3 % NaCl | 5min, 37, °C | 2.31 | 7.6 |

### 6.3.6 Effect of Sodium Bicarbonate Solutions on Total Phenolic Contents

Effect of sodium bicarbonate solution shown Table 6.4. The effect of washing increased with increasing of washing duration, temperature, and concentration of $NaHCO_3$ solution. Percentage of TP reduction gradually increased from 0.32 % by concentration 1 % at 25°C and 2 min washing duration to reach the maximum reduction rate of 4.15 % by 3 % concentration at 37°C for 10 min duration. When concentration of 1 % $NaHCO_3$ at 25 °C was used, washing duration do not exert a significant effect on TP reduction rate, while at 37°C there was a significant reduction ($P<0.05$) in TP contents by achieving reduction of 0.74, 1.54, 3.69 % for washing duration of 2, 5 and 10 min. The effect of $NaHCO_3$ became more drastic by using concentration of 3 % at

37°C. Decreasing of TP contents of dates by washing was reported by Osman et al. (2014).

### 6.3.7 Effect of Acetic Acid Solutions on Total Phenolic Contents

Effect of acetic acid solution on TP contents of the washed samples shown is in Table 6.4. The effect of AA solutions on TP reduction was ranged from 1.4 % for 1 % concentration, and duration of 2 min at 25°C to 14.17 % by 3 % concentration and washing duration of 5 min at 37°C. From result in Table 6.3, changes in temperature, contact time and solution concentration resulted in a significant reduction ($P > 0.05$) in TP contents. Temperature and contact time enhance water to penetrate into dates' tissues and dissolve the phenolics what significantly contribute to the loosing of TP form dates' tissues.

### 6.3.8 Effect of Hydrogen Peroxide Solutions on Total Phenolic Contents

The effect of hydrogen peroxide solutions on TP contents is shown in Table 6.4. 1 % $H_2O_2$ solution for washing duration of 2 min at 25°C, exerted unsignificant increasing in TP. While washing for 5 min showed strong effect on TP reduction ranging from 11.3 % for 1% concentration of 1% and washing duration of 5 min at 37°C to 38.14 % at concentration of 3% and washing duration of 10 min at 37°C. The results indicated that increasing in temperature, contact time and $H_2O_2$ concentration increases the TP % reduction. Changing any of the examined factors resulted in significant decreasing ($p < 0.05$) in TP contents.

### 6.3.9 Effect of Potassium Permanganate Solutions on Total Phenolic Contents

The effect of potassium permanganate solutions on TP contents is shown in Table 6.4. $KMnO_4$ showed the highest reduction effect on total phenolic contents. The reduction of TP contents ranged from 13 % when the solution concentration was 1 % at 25°C and washing duration was 5min to 50.66 % when the concentration was 3 % and washing duration was 5 min at 37°C. The results also indicate that increasing in $KMnO_4$ concentration, solution temperature and contact time mostly resulted in significant decreasing of TP contents and increasing the % reduction of TP during washing process. The result revealed that the 3 % solution at 37°C has drastic effect on TP (55.66 % reduction) what strongly reduces the nutrition value of the washed dates fruits.

These results are agreeing with some findings of that reported by Osman et al., (2014) who illustrated that washing date fruits with running water, acetic acid, citric acid, hydrogen peroxides and potassium permanganate tended to decrease TP contents by increasing the contact time.

**Table 6.4:** Total Phenolic Contents (μg/g ) and Total Phenolic Reduction % in Date's Samples Washed by (1 %, 2%, and 3%) $NaHCO_3$, AA, $H_2O_2$ and $KMnO_4$ Solutions at 25°C and 37 °C for 2, 5 and 10 Min Compared to Unwashed Sample

| Washing solution | $NaHCO_3$ | | AA | | $H_2O_2$ | | $KMnO_4$ | |
|---|---|---|---|---|---|---|---|---|
| | TP | Rd% | TP | Rd% | TP | Rd% | TP | Rd % |
| 1 %, 2min, 25°C | 2.19 ± 0.05 | 0.32 | 2.19±0.06 | 1.4 | 2.2± 0.12* | 0 | 1.91±0.12* | 13.02 |
| 1 %, 5min, 25°C | 2.2 ± 0.05 | 0.46 | 2.12±0.04* | 4.53 | 1.95±0.03* | 11.3 | 1.63±0.012* | 25.87 |
| 1 %, 10min, 25°C | 2.12 ±0.20* | 0.360 | 2.09±0.02* | 4.95 | 1.67±0.20* | 24.06 | 1.53±0.0.03* | 30.42 |
| 1 %, 2min, 37°C | 2.18 ± 0.04 | 0.74 | 2.12±0.09* | 4.51 | 1.55±0.02* | 29.36 | 1.79±0.02* | 18.37 |
| 1 %, 5min, 37°C | 2.17± 0.16 | 1.54 | 2.11±0.07* | 4.12 | 1.55±0.03* | 29.44 | 1.46±0.02* | 33.62 |
| 1 %, 10min, 37°C | 2.12±0.01* | 3.69 | 2.09±0.10* | 5.07 | 1.47±0.01* | 33.01 | 1.43±0.03* | 35.05 |
| 2 %, 2min, 25°C | 2.18±0.04 | 1.86 | 2.17±0.07* | 2.25 | 1.51±0.01* | 31.15 | 1.54±0.01* | 29.97 |
| 2 %, 5min, 25°C | 2.18±0.05 | 1.09 | 2.105±0.2* | 4.32 | 1.37±0.09* | 37.86 | 1.3±0.01* | 39.12 |
| 2 %,10min, 25°C | 2.12±0.04* | 3.69 | 2.04±0.09* | 7.06 | 1.35±0.01* | 38.7 | 1.29±0.09* | 41.42 |
| 2 %2, min, 37°C | 2.18±0.035 | 1.89 | 2.06±0.05* | 6.35 | 1.32±0.02* | 39.87 | 1.35±0.01* | 38.59 |
| 2 %, 5min, 37°C | 2.15±0.046* | 2.03 | 2.043±0.15* | 7.11 | 1.34±0.01* | 37.98 | 1.32±0.01* | 39.89 |
| 2 %, 10min, 37°C | 2.11±0.004* | 4.15 | 2.02± 0.11* | 8.34 | 1.33±0.20* | 39.44 | 1.23±0.01* | 43.98 |
| 3 %, 2min, 25°C | 2.17±0.04 | 1.07 | 2.055±0.15* | 6.57 | 1.32±0.03* | 39.89 | 1.35±0.02* | 38.59 |
| 3 %, 5min, 25°C | 2.11±0.04* | 3.91 | 2.02±0.12* | 8.01 | 1.36±0.01* | 37.98 | 1.32±0.03* | 39.9 |
| 3 %, 10min, 25°C | 1.78±0.01* | 19.25 | 1.96±0.13* | 11.75 | 1.33±0.03* | 39.27 | 1.27±0.01* | 42.03 |
| 3 %, 2min, 37°C | 1.73±0.01* | 21.18 | 2.03±0.13* | 7.57 | 1.355±0.01* | 40.17 | 1.29±0.01* | 41.41 |
| 3 %, 5min, 37°C | 1.65±0.01* | 24.98 | 2.02±0.13* | 8.23 | 1.37±0.03* | 37.62 | 1.20±0.05* | 45.28 |
| 3 %, 10min, 37°C | 1.62±0.07* | 26.24 | 1.88±0.10* | 14.17 | 1.36±0.01* | 38.14 | 1.08±0.04* | 50.66 |

* Values are significantly different ($p < 0.05$) from control (unwashed sample)

## 6.4 Determination of Antioxidants Activity (Free Radical Scavenging Activity) of the Washed Date Sample

### 6.4.1 Introduction

Date fruits has long been thought to be a healthy source of antioxidants. Antioxidants prevent the oxidative processes that cause degenerative diseases like heart disease, brain dysfunction, and arthritis (Mohd & Makpol., 2019). Many studies reported that an aqueous extract of date flesh has an important free radical scavenging activity against superoxide ($O^{\bullet-}$) and hydroxyl ($OH^{\bullet}$) free radicals which known as

reactive oxygen species (Vayalil 2002; Esteban et al., 2005). The same extract also prevented lipid peroxidation and protein oxidation which led to macromolecular damages in living cells. DPPH has the advantage of being unaffected by such side reactions that may cause by enzyme inhibition and metal-ion chelating (Amarowiczet al., 2004). A newly prepared DPPH solution has a deep purple color and a maximum absorption at 517 nm. When an antioxidant is present in the medium, the purple color usually disappears. Thus, an antioxidant molecule can quench DPPH free radicals by contributing hydrogen atoms or electrons, possibly through free radical attack on DPPH molecules and converting them gradually to a noncolored products i.e., (2,2-diphenyl-1- hydrazine, or a substituted analogous hydrazine) resulting in gradual decrease in UV absorbance at 517 nm. As a result, the faster absorbance decreases, the greater the antioxidant activity of the measured sample (Yamaguchi et al., 1998).

### 6.4.2 Determination of DPPH Inhibition Activity of Date Fruit Extracts

DPPH inhibition activity of date fruit extracts was evaluated by the method described in Section 3.7.4.

### 6.4.3 Effect of Washing with Tap Water on DPPH Inhibition Activity

Effect of tap water on DPPH inhibition activity is shown in Table 6.5. Samples washed in tap water for 2 min showed reduction in DPPH inhibition activity ranging from 7.20 % to 16.09 % at 25 °C and 37 °C, respectively compared to DPPH inhibition activity of the control (unwashed sample). While samples soaked for 5 min showed reduction percent ranged from 11.50 % to 19.90 % at 25 °C and 37 °C, respectively. Increasing of water temperature from 25°C to 37°C, resulted in significant decreasing

in DPPH inhibition activity, this may attribute to the fact that hot water reduces the TP contents of date fruits.

### 6.4.4 Effect of DWD Solution on DPPH Inhibition Activity

The effect of detergent solution on DPPH inhibition activity is shown in Table 6.5. Sample washed by 1 % DWD solution at 25°C for 5 min showed DPPH inhibition activity of 82.67 % with reduction rate of 3.47 % compared with the inhibition activity of unwashed sample. While, at 37°C, DPPH inhibition activity was dropped to 69.84 % with reduction rate of 18.45 %. However, increasing the washing temperature from 25°C to 37°C, significantly reduced the DPPH inhibition activity of the washed sample ($P< 0.05$). It well known the antioxidant activity of fruits and vegetables is corresponding its phenolic contents which could be continuously lost by washing solutions and this process is strongly accelerated by heat. Although water gives the lowest % removal for pesticides, it has less effect on nutrition value of date fruits.

**Table 6.5:** DPPH Inhibition and Inhibition Reduction % of Samples Washed by Tap Water Detergent Solution, and Control (Unwashed Sample) at 25°C and 37°C for 2 and 5 Min (Mean ± SD)

| Sample | Inhibition % | Rd% |
|---|---|---|
| Tap water, 2 min, 25°C | 83.34 ± 2.50 ⁎ | 2.70 |
| Tap water, 2 min, 37°C | 71.87 ± 4.10 ⁎ | 16.09 |
| Tap water ,5 min, 25°C | 75.80 ± 1.95 ⁎ | 11.50 |
| Tap water, 5 min, 37°C | 68.60 ± 3.83 ⁎ | 19.90 |
| Detergent at 25°C | 82.67 ± 2.89 ⁎ | 3.47 |
| Detergent at 37°C | 69.84 ±1.32 ⁎ | 18.45 |
| Unwashed sample | 85.65 ± 3.43 ⁎ | - |

Note: Values with (⁎) are significantly different ($p < 0.05$).

### 6.4.5 Effect of Sodium Chloride Solutions on DPPH Inhibition Activity

The effect of NaCl solutions on DPPH inhibition activity of date samples was examined using three concentrations, 1 %, 2 % and 3 % at 25°C and 37°C. As shown in data Table.6.6, sample washed with NaCl solutions at 25°C showed reduction in DPPH inhibition activity as the following 3.97 %, 4.89 %, 5.86 % for the solution concentration of 1 %, 2 %, and 3 % respectively compared with unwashed sample. Increasing in NaCl concentration exerted small effect on DPPH inhibition activity (< 2%). Washing at 37 °C exerted strong effect on DPPH inhibition activity and caused reduction of 12.31 %, 11.84 %, 11.51 % for the three concentrations, respectively. The differences in antioxidant activities within samples washed by different concentrations at fixed temperature (25°C or 37°C) were insignificant ($P > 0.05$), while there were significant differences ($P < 0.05$) in DPPH inhibition activities between samples washed at different temperature which indicated that the temperature is the dominant factor rather than the concentration in the case of NaCl solutions. The effect of NaCl solutions may refer to its acidity (pH 5.76) which can help in dissolution of phenolics from date's tissues into rinsing water.

**Table 6.6:** Effect of Different concentration of Sodium Chloride Solutions (1 %, 2 % and 3 %) at 25°C for time duration of 5 Min on Antioxidant Activity (DPPH Assay) Compared to Unwashed Sample

| Sample | Inhibition % | Rd% |
|---|---|---|
| 1 % NaCl, 25°C | 71.27 ± 1.95 a | 3.97 |
| 2 % NaCl, 25°C, | 70.52 ± 3.83 b | 4.89 |
| 3 % NaCl, 25°C | 69.87 ± 2.89 c | 5.86 |
| 1 % NaCl, 37°C | 65.08 ± 1.15 d | 12.31 |
| 2 % NaCl, 37°C | 65.08 ± 2.23 d | 11.84 |
| 3 % NaCl, 37°C | 65.67 ± 1.76 e | 11.51 |
| Unwashed sample | 74.22 ± 1.17 f | - |

Note: Rows with different letters are significantly different ($p > 0.05$)

### 6.4.6 Effect of Sodium Bicarbonate on DPPH Inhibition Activity

The effect of sodium bicarbonate ($NaHCO_3$) solutions on DPPH inhibition activity of date samples was examined using three concentrations ,1 %, 2 % and 3 % at 25°C and 37°C. Result is shown in Table.6.7. Samples washed with 1 % $NaHCO_3$ solution at 25°C showed reduction in DPPH inhibition activity ranged from 2.3 % - 3.56 %. There was no significant difference between DPPH inhibition activities of the washed samples at 25°C through all time intervals and the inhibition activity of the control ($p > 0.05$). While at 37°C, the DPPH inhibition reduction rates of the washed samples ranged from 11.44 - 13.38 %, inhibition activities of samples were significantly decreased ($p < 0.05$) compared to control sample. But there was no significant difference in inhibition activities within those samples regarding the deference in washing duration ($p > 0.05$).

Washing with 2 % $NaHCO_3$ solution at 25°C showed significant decreasing in DPPH inhibition activity compared with control ($p < 0.05$) ranged from 12.26 - 16.33 %. The inhibition activities within 2- and 10-min intervals were significantly different from each other ($P<0.05$). Washing at 37 %, exerted reduction in DPPH inhibition activities of the washed sample ranged from 13.97 - 16.2 %.

Samples washed by 3 % $NaHCO_3$ solution at 25°C showed significant decreasing in DPPH inhibition activity compared with control ($p < 0.05$). The reduction rates ranged from 14.28 - 16.26 %. There was significant difference in the effect of washing for 2 and 10 min at 25°C. While at 37°C the reduction of DPPH inhibition activity rates ranged from 19.46 - 23.06 %. However, at 37°C, the decreasing in inhibition activity after 2, 5 and 10 min was very significant ($p < 0.001$) compared to control. The difference in decreasing of DPPH inhibition activity at 25°C and 37°C at 3 % concentration was significant ($p < 0.05$) at all washing durations.

### 6.4.7 Effect of Acetic Acid (AA) Solutions on DPPH Inhibition Activity

The effect of (AA) solutions on DPPH inhibition activity of washed date samples is shown in Table 6.7. Samples washed with 1 % acetic acid (AA) solution at 25°C showed the lowest effect on DPPH inhibition activity of washed samples, the reduction rate ranged from 0.411 % to 7.9 %. While at 37°C the reduction rates of DPPH inhibition activity were ranged from 2.88 - 10.03 % compared to control sample inhibition activity. Though the DPPH inhibition activities of washed samples were significantly different from that of control, there was no significant deference ($P > 0.05$) between the DPPH inhibition activities of the washed samples regarding temperature and washing duration when the AA concentration of 1 %.

2 % acetic acid solution treatment at 25°C revealed reduction of DPPH inhibition activity ranged from 9.3 - 11.26 %. DPPH Inhibition activities of the samples treated at 25°C were significantly reduced compared to control. At 37°C, the DPPH inhibition activities of the washed samples were reduced by 10.08 - 31.8% compared to control sample inhibition activity. Increasing the washing temperature from 25°C to 37°C, mostly resulted in significant drop-in in antioxidant activity of the washed samples. 3 % AA solution at 25°C exerted reduction of antioxidant activity ranged from 21.22 – 29 %. While at 37°C the reduction of antioxidant activity ranged from 30.07- 42.44 %. The difference became more significant when washing was performed at 37°C at all washing duration. It is well known that antioxidant activity of date fruits refers to the water-soluble constituents so, in the presence of acidic solution and heat these constituents will dissolve faster from tissues to the washing solution and this will be led to decreasing in antioxidant activity of the dates flesh extract.

### 6.4.8 Effect of Hydrogen Peroxide ($H_2O_2$) Solutions on DPPH Inhibition Activity

The effect of $H_2O_2$ solutions on DPPH inhibition activity of washed date samples is shown in Table 6.7. Samples washed with hydrogen peroxide ($H_2O_2$) solutions showed strong effect on decreasing the antioxidant activities of the washed samples. The exerted reduction rates of antioxidant activities of washed samples ranged from 9.72 - 50.92 %. The reduction rates were significantly enhanced ($P < 0.05$) by increasing in washing duration and washing temperature. While increasing in $H_2O_2$ concentration do not show significant change in antioxidant reduction rates.

### 6.4.9 Effect of Sodium Permanganate Solutions on DPPH Inhibition Activity

The effect of Sodium Permanganate ($KMnO_4$) solutions on DPPH inhibition activity is shown in Table 6.7. The antioxidant activities of washed samples were significantly reduced by $KMnO_4$ solutions. The reduction rates ranged from 6.15 – 38.89 %. The antioxidant activities of sample washed at 25°C for 10 min were significantly different from that of control ($P < 0.05$). Inhibition activities of samples washed at 37°C for different time intervals, are significantly different from that of control and also significantly efferent from samples treated at 25°C under the same concentration and washing duration. The increasing in any of the measured parameters (solution concentration, temperature and washing duration) resulted in significant reduction in DPPH inhibition activity.

Unfortunately, studies delving effect of washing solutions on nutrition value of date fruits are very limited in literature so, extensive studies should be conducted to explore the effect of chemical and household washing techniques on the nutrition values of fruits and vegetables. The effect of the examined solution on total sugars (TS) for 2-

5 min seemed to be in descending order as follows: $H_2O$ > detergent >NaCl > $H_2O_2$ >$KMnO_4$ >$NaHCO_3$ >AA while, concentration of 3 % $KMnO_4$ at 37°C for 10 min caused destructive effect TS contents ranged from 27.98 – 33.68 %.

The effect of wash treatments on TP resulted in gradual decreasing in TP contents. The study revealed significant differences ($p < 0.05$) in reduction rates of phenolic content between samples washed for different time intervals different temperatures and different solution concentration, but the effect of temperature and solution concentration is greater than the effect of contact time. In general, the washing solutions effect on TP contents was in descending order as follows: $KMnO_4$ > $H_2O_2$ > AA > NaCl >$NaHCO_3$> detergent > Tap water. At concentrations of 3 %, $NaHCO_3$ showed more distractive effect for TP and caused reduction rates ranged from 19.25 – 26.24 %.

The effect of washing on antioxidant activity (AC) was mostly following a similar trend as TP. Since it is well known that antioxidant activity of date fruits is mainly refer to the presence of constituents with high free radical scavenging activity such as phenolics and flavonoids (Biglari et al., 2008; Osman et al., 2014). Strong correlation between TP contents and antioxidant activity (AC) in date fruits was established and reported by many researchers (Allaith 2008, Biglari et al., 2008).

**Table 6.7:** DPPH Inhibition Activity and Inhibition Activity Reduction % of Samples Washed by Different Concentrations (1 %, 2 % and 3%) of Sodium Bicarbonate, Acetic Acid, Hydrogen Peroxide and Potassium Permanganate Solutions at 25°C and 37°C for 2, 5 and 10 Min Compared with Unwashed Sample Inhibition Activity (74.22 %)

| Washing solution | $NaHCO_3$ | Rd% | AA | Rd % | $H_2O_2$ | Rd% | $KMnO_4$ | Rd% |
|---|---|---|---|---|---|---|---|---|
| **1 %, 2min, 25 °C** | 72.64 | 2.30 | 74.05 | 0.411 | 67.13 | 9.72 | 69.78 | 6.15 |
| **1 %, 5min, 25 °C** | 72.02 | 3.15 | 72.35 | 2.71 | 64.54 | 13.28 | 68.07 | 8.45 |
| **1%, 10min, 25 °C** | 71.72 | 3.56 | 68.46 | 7.90 | 61.11 | 17.67 | 65.31 | 12.17 |
| **1%, 2min, 37 °C** | 65.85 | 11.44 | 72.18 | 2.93 | 60.59 | 18.51 | 65.56 | 11.84 |
| **1%, 5min, 37 °C** | 64.73 | 12.95 | 72.22 | 2.88 | 59.26 | 20.30 | 66.14 | 11.06 |
| **1%, 10min, 37 °C** | 62.36 | 13.38 | 66.90 | 10.03 | 44.19 | 40.56 | 63.64 | 14.42 |
| **2%, 2min, 25 °C** | 65.25 | 12.26 | 67.42 | 9.30 | 65.66 | 11.70 | 66.15 | 11.03 |
| **2%, 5min, 25 °C** | 64.97 | 12.62 | 68.64 | 7.70 | 64.32 | 13.50 | 65.95 | 11.31 |
| **2%, 10min, 25 °C** | 63.22 | 14.8 | 65.98 | 11.26 | 41.15 | 44.66 | 65.94 | 11.31 |
| **2%, 2min, 37 °C** | 61.94 | 13.97 | 66.86 | 10.08 | 59.33 | 20.21 | 62.16 | 16.40 |
| **2%, 5min, 37 °C** | 60.38 | 16.20 | 63.91 | 14.05 | 58.75 | 20.98 | 59.23 | 20.34 |
| **2%, 10min, 37°C** | 60.50 | 15.97 | 50.71 | 31.80 | 38.30 | 48.42 | 56.14 | 24.51 |
| **3%, 2min, 25 °C** | 63.46 | 14.28 | 58.58 | 21.22 | 63.80 | 14.20 | 62.35 | 16.16 |
| **3% 5min, 25 °C** | 62.26 | 16.26 | 57.77 | 22.31 | 61.94 | 16.71 | 58.64 | 21.15 |
| **3%, 10min, 25 °C** | 62.68 | 15.71 | 52.73 | 29.09 | 43.15 | 41.96 | 54.44 | 26.78 |
| **3%, 2min, 37 °C** | 59.89 | 19.46 | 51.99 | 30.07 | 59.33 | 20.21 | 59.27 | 20.29 |
| **3%, 5min, 37 °C** | 58.31 | 21.58 | 46.07 | 38.04 | 57.42 | 22.78 | 56.33 | 24.24 |
| **3%, 10min, 37 °C** | 57.21 | 23.06 | 42.80 | 42.44 | 36.49 | 50.92 | 45.44 | 38.89 |

### 6.4.10 Conclusion

The effect of optimization of washing conditions namely concentration, duration, and temperature on date fruit's nutrition value i.e., total sugars (TS), total phenolic (TP) and antioxidant capacity (DPPH inhibition activity) was studied. The mean contents of total sugars (TS) are reported as glucose equivalent (mg/g) of fresh weight. All washed samples showed a considerable loose on total sugars contents increased according to, concentration, washing duration and temperature. However, $H_2O_2$, $KMnO_4$ and $NaHCO_3$ showed reducing % of total sugars at the concentration of 3 % at 37°C.The effect of washing solutions on TS for 2 and 5 min seemed to be in descending order as follows: $H_2O$>detergent >NaCl >AA>$NaHCO_3$>$H_2O_2$ >$KMnO_4$ while, at 10 min and concentration of 3 % $KMnO_4$ caused the highest decreasing in TS contents (>33 %).

When compared to the control, all treatments resulted in a significant decrease in TP content (unwashed sample). Increasing the duration, temperature, or concentration of the washing solution resulted in a greater decrease in TP content. The results revealed significant differences in phenolic content ($p<0.05$) between samples washed at different time intervals, different temperatures, and different concentrations, but the effect of temperature and concentration was greater than the effect of contact time. In general, the washing solutions effect on TP contents was in descending order as follows: $KMnO_4$ > $H_2O_2$ > AA > NaCl >$NaHCO_3$> detergent > Tap water. However, the effect of washing on antioxidant activity (DPPH inhibition activity) followed a similar trend as TP, which could be due to the fact that AC is mostly refer to total phenolic content. To minimize the effect of washing on the nutritional value of date fruits fruit, washing temperature is the most important factor to consider. Washing should be done at 25°C or lower, with a 1-2 % concentration of the washing solution.