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Nutritional and biochemical attributes of present juice and *Gur* produced from date palm trees

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Abstract
Investigation of nutritional, biochemical analysis and mineral contents of *Phoenix sylvestris* L. juice and *gur* is an important issue. Five different protectors; control (No protection), bamboo net, nylon net, nylon & bamboo net and plastic chot were used during juice collect from pate palm plant. *Gur* samples were collected from a variety of sources, including *gur* prepared by SAU machines, contact growers by traditional method, and Jashore and Khulna local markets. The results revealed that juice collected from plants using protector showed better performance compared to plant using no protectors. The maximum juice quantity was recorded in the plants protected with bamboo + nylon net, which also had the highest levels of total soluble solids, potassium, phosphorus, pH, and phenol and the least amount of bacterial contamination. The *gur* collected from local market of Jashore and Khulna had more sugar and bacterial contamination. However, *gur* produced from SAU-machine had substantially higher total soluble solids, vitamin C, titratable acidity and total phenol. *Gur* generated by the SAU-machine contains a significant level of K (756.33 mg/100 g), Ca (262.06 mg/100 g), and P (231.69 mg/100 g), indicating that high-quality gur produced by controlled condition can be a rich source of minerals.

Keywords: Protector, juice, *gur*, phenol, potassium

1. Introduction
In Bangladesh, the most prevalent types of palm trees are date palm, palmyra palm, and coconut palm. The monocotyledonous date palm (*Phoenix sylvestris* L.) is a member of the Arecaceae family. Date palm is widespread throughout Bangladesh, particularly in the districts of Jashore, Faridpur, Kustia, Khulna, and Rajshahi, and is commonly referred to as Khajur or Khajur. Date palm juice (sap) is consumed fresh or processed further for concentrated juice and jaggery production (Barreveld, 1993) [4]. In addition, date palm juice, which is harvested by tapping the tree's delicate trunk, is the main economic output of some remote districts of Bangladesh. About 200-250 L of juice per tree, containing 12-15% sucrose, is harvested during the taping season (Winter), and 25–30 kg of molasses is produced from this juice (Rana *et al.*, 2009) [21]. In addition, it was mentioned that date palm juice, a favorite wintertime drink for soothing one's thirst, contains 9–14% sugar, a minor quantity of organic acid, some trace elements, and some volatile substances (Dalibard, 1999) [7].

Trees naturally produce sap and juice that is essential for relieving our thirst and supplying essential nutrients. Date palm juice contains beneficial bioactive and functional ingredients (Younas *et al.*, 2020) [28]. Walkowiak-Tomczak (2007) [26] has found that the antioxidant activity of juice concentrate was decreased during storage due to an increase in pH, and temperature. Due to the high levels of reducing sugars and total sugars in date palm juice (sap), it has a significant propensity to lose flavor, vitamins, color, and minerals when kept out in the open (Ahmad *et al.*, 2021) [1].

Due to the longer chains of sucrose that make up jaggery instead of sugar, it is far more complicated. As a result, it releases energy more gradually than sugar and not instantly. This gives off energy for a longer period of time and is healthy for the body. Jaggery, without a doubt, is enriched with the goodness of nature and is packed with nutrients, like protein, iron, potassium, and magnesium, to name a few. *Gur* quality is significantly impacted by smoke, ash contamination, and other unhealthy contaminants. By emitting smoke and greenhouse gases, this boiling process also harmed the environment.

It is crucial to make high-quality food that appeal to consumers of all ages. In Bangladesh, the season for collecting date palm sap also happens to be when the Nipah virus (NiV) infection is most prevalent. In Bengali culture, drinking raw date palm sap is considered a delicacy. Fruit bats with the NiV may occasionally contaminate the sap with their saliva and urine if they get access to it for drinking (Nahar *et al.*, 2010) [14]. According to *gachhis*, bats provide a problem for the successful collection of high-quality sap since they consume and feces into the sap, significantly reducing its worth. Insects, rats, birds, snakes, and other pests can contribute to pollution. Using various protectors is crucial to preventing access by bats and other pests. Therefore, the objectives of this research was to determine the most effective protective material for preventing insect and animal access during juice collection and to evaluate the nutritional quality and biochemical properties of juice and *gur* producing from date palm trees.

2. Materials and Methods

2.1 Date palm juice and *gur*

The experiments were conducted at Khajura, Jashore and Sher-e-Bangla Nagor, Dhaka, Bangladesh during the juice tapping period (December 2020 to February, 2021). In each trial, twenty date palm plants of identical ages were used with various types of protections. The experiment was laid out with 5 numbers of treatments (Protectors) with 4 replications. Five different protectors were used in this experiment i.e. control (No protection), bamboo net, nylon net, plastic chot, and nylon + bamboo net (Figure 1).

Patali *gur* was made by traditional method (Figure 2A) and SAU machine (Figure 2B) and its quality and pollutant levels were tested. *Gur* was collected from different sources as follows:

R_1: SAU machine (Improved ways of *gur* manufacturing with protected condition).

R_2: Traditionally prepared by contact growers (*Gur* processing in open condition).

R_3: Collected from the Jashore district's local market.

R_4: Collected from Khulna district's local market.

2.2 Measurement of biochemical Parameters

2.2.1 Total Soluble Solids (TSS) Content

The TSS content of date palm juice was ascertained using a digital refractometer (MA871; Bucharest, Romania). A juice drop was placed on the refractometer prism using a dropper. The refractometer showed the total soluble solids.

Fig 1: Different protectors used to extract quality date palm juice

Fig 2: *Gur* prepared by contact grower in Khajura, Jashore (A) and SAU machine (B)

2.2.2 pH Determination

The juices from the various treated plants were separated using different filters, and the pH was determined using a digital pH meter (HI 2211; Bucharest, Romania).

2.2.3 Titratable Acidity (TA %)

For the purpose of determining the TA, five ml samples were filtered, and water was added to create a volume of 100 mL. In a conical flask, 10 mL of stock solution was added along with 2 drops of phenolphthalein. With 1N NaOH, the solution was titrated three times. When the pink color started to show, the titration was stopped.

2.2.4 Vitamin C Determination

The method developed by Tee *et al.* (1988) [24] was used to determine the vitamin C content of juice. A 5 ml sample

was strained using Whatman No. 1 filter paper. The volume was increased by adding 5% oxalic acid solution to make 100 ml. With the dye solution 2, 6-dichlorophenol indophenol, titration was carried out. The amount of dye required to oxidize an unknown concentration of a particular amount of L-ascorbic acid solution was calculated using the mean observations and the L-ascorbic acid standard. The final point of titration, which remained for 10 seconds and was shown by the pink color, was reached using a 5 mL solution each time.

2.2.5 Total sugar
After filtering the juice through two layers of cloth, the tissue was ground up and re-extracted for three minutes in hot 80% alcohols, using 2 to 3 ml of alcohol per ml of samples. The extract was run through two layers of cotton after cooling. Whatman No. 41 filter paper was used to filter both extracts. The extract was reduced in volume by 25% using a steam bath, after which it was chilled. The needed volume of distilled water was added to the concentrated extract before being transferred to a volumetric flask with a 100 ml capacity.

2.2.6 Reducing sugar
Each test tube was filled with a 3ml aliquot of the extract and 3ml of DNS reagent, which were then thoroughly mixed. For five minutes, the test tube was heated in a bath of boiling water. 1ml of 40% Rochelle salt was added to the tubes' contents while they were still heated after the color had developed. Next, the test tubes were cooled under running water from the faucet. By mixing 3 ml of distilled water and 3 ml of DNS reagent in a tube and treating them equally, a reagent blank was created. In a colorimeter, the solution's absorbance was determined at 575 nm.

2.3 Nutrient Analysis
Using an atomic absorption spectrophotometer (AAS) and the proper hollow cathode lamp and wavelength for each of the metals, the mineral elements (P, Ca, Fe, and K) were identified.

2.4 Bacterial count
By scraping the surface of packaged jaggery cubes that had been stored, one gram of sample was obtained. The powdered 1 ml sample was thoroughly mixed with 10 ml of autoclaved distilled water in a test tube to create serial dilutions. The suspension was used for serial dilution by adding 1 ml from the tube to 9 ml of the sterile, distilled water used as a blank. Dilutions were made up to six times for each sample. The 90 mm petri dishes were sanitized, and 20 milliliters of medium were added. After the media had solidified, 0.1 ml of each diluted sample was aseptically taken out of the dilutions and placed in triplicate on an agar petri plate's surface. After that, samples were dispersed by the spreader, and plates were incubated at 28 °C for two to three days. Colony Forming Units per ml (CFU/ml) were measured for each *gur* sample. Each petri plate's four equally sized colonies were counted, and the total number of colonies in each plate was then determined.

2.5 Statistical analysis
The SAS 9.4 (SAS Institute Inc., Cary, NC, USA) application was used to calculate the means and standard deviations for the data shown in the table. The Duncan test was used to conduct additional tests for degrees of significance between groups, and a p-value of 0.05 was chosen as the acceptable level of significance.

3. Results and Discussion
3.1 Measurement of quality parameters and quantity of juice
Date palm juice production and quality is affected by several biotic and abiotic factors. Different protected and non-protected conditions influenced insects and animal access in juice collection pot (Table 1) and quantity of juice, TSS, titratable acidity and pH (Table 2). The highest quantity of juice was recorded in the bamboo + nylon net protected plant (3.01L) and the lowest was found in the control condition using no protection (2.31L). The findings show that using various protectors when collecting juice encourages *gachis* to use them and may reduce the risk of human NiV infection in Bangladesh by preventing access by bats and other pests. Drinking polluted sap can expose people to the highly fatal NiV (Luby *et al.*, 2006) [12]. If effective measures have not been implemented to prevent bat access to the sap during collecting, fresh date palm sap should not be consumed (Rahman *et al*., 2012) [2].

Table 1: Visual evaluation of date palm juice using various protection methods to protect insects, animals and birds

Types of Protectors	Insects	Animals	Birds
Control	Not protected	Non protected	Non protected
Bamboo	Partial protected	Protected	Protected
Bamboo + Nilon net	Protected	Protected	Protected
Nilon Net	Protected	Non protected	Partial protected
Plastic Chot	Partial protected	Partial protected	Protected

The total soluble solids (TSS) content of the date palm juice responded differently to the different protected conditions (Table 2). TSS were the maximum in the juice obtained from the plants protected with Bamboo + Nylon Net (13.5 ^{o}Brix), whereas a minimum was recorded from the plants with no protection (12 ^{o}Brix). The highest vitamin C was found in the plants protected with Bamboo + Nylon Net (7.84 mg/100 g), followed by plastic chot and bamboo net both in approximately (7.68 mg/100 g) and the lowest vitamin C was found in the juice that collected using no protection (5.76 mg/100 g) (Table 2). With low average temperatures during juice collection contributing to enhanced enzymatic activity and thus raising vitamin C and other bioactive substances in the fruit juice. Vitamin C level decreases when microbial load increases and enzymes in the juice are inactivated (Barros *et al*., 2011) [5]. The highest pH was found in juice when protected with Bamboo + Nylon Net (6.71) and the lowest pH was found in the juice that collected using no protection (5.2) (Table 2). The results show that increasing acidity in juice may be the cause of the decreased pH levels. The drop in pH signifies deterioration in quality of the product (Okudu and Ene-Obong, 2015) [16].

Table 2: Quality attributes of date palm juice using different protectors

Parameters	Quantity of Juice (L)	Total soluble solid (°Brix)	pH	Vitamin C (mg/100 g)	Titratable acidity (%)
Control	2.31e	12 b	5.2c	5.76c	0.19b
Bamboo Net	2.87b	12.1b	6.41b	7.68a	0.16c
Nylon Net	2.69c	13.4a	5.4c	6.76b	0.19b
Bamboo + Nylon Net	3.01a	13.5a	6.71a	7.84a	0.13d
Plastic Chot	2.42d	12.5ab	5.34c	7.68a	0.20a
LSD (0.05)	0.1	1.11	0.22	0.31	0.01
CV (%)	2.13	4.65	2.09	2.38	3.3

3.2 Biochemical attributes of date palm juice

The highest phenol content was found in juice protected with Bamboo + Nylon Net (8.29 mg/g) and the lowest phenol was found in the juice that collected using no protection (2.12) (Table 3). The antioxidant effect was directly facilitated by the phenolic components. Among the bioactive chemicals, phenolic compounds are particularly important since their properties are directly or indirectly related to juice quality, influencing its color and astringency (Girard and Mazza, 1998) [10]. The higher total sugar content was found in the juice that was collected using no protection (4.10 mg/100 ml) and the lowest total sugar content was found in juice protected with Bamboo Net (2.19 mg/100 ml) followed by and Bamboo + Nylon net (2.20 mg/100 ml) and nylon net (2.27 mg/100 ml).

Table 3 shows that when date palm juice was collected without protection, minerals (P and K) were reduced compared to juice collected with protection (except plastic chot). This could be due to the higher temperature of the juice generated by the usage of chot. The minerals content of the date palm juice responded differently to the different protected conditions (Table 3). The highest P and K were found in plants protected with Bamboo + Nylon Net (4.5 µL/100 ml) and (48.03 µL/100 ml) respectively, and the lowest P and K were found in juice collected using plastic chot (3.5 µL/100 ml) and (42 µL/100 ml) followed by using no protection (4.0 µL/100 ml) and (43.45L/100 ml) respectively (Tab. 3). The elemental composition of juice is critical for consumer safety and protection (Demir *et al.*, 2020) [8]. Aside from the vital elements delivered to the human body by juice drinking, there is a risk of harmful materials being introduced, causing disturbance of the consumer's biological processes (Todorovska and Popovski, 2012) [25].

According to *Gachhis*, bats provide a problem for the successful collection of high-quality sap since they consume juice and feces into the sap, significantly lowering its value (Nahar *et al.*, 2010) [14]. Preventive measures are taken to guarantee the sap's quality and the cultural and economic significance of collecting sap. *Gachhis* appreciate sap quality because it provides the best price for raw sap or molasses, and good sap is sweeter and cleaner. The results indicate that a proper protector might be useful for juice collection to avoid polluted sap and to guard against bats and other pests.

Different protected and non-protected conditions influenced on bacterial count (Table 3). The maximum number of bacteria counted in juice that were collected using no protection (1156 cfux10^6) and the minimum number were counted in juice that were collected using Bamboo + Nylon Net protection (272 cfux10^6) (Table 3). Spoilage fruit juice generally resulted from the growth of bacteria, yeasts or molds. Early detection of spoiling will occur if there are large levels of bacteria present in the juice materials, which means that using juice of lower quality. NiV is transmitted by date palm sap (Nahar *et al.*, 2017) [15]. Date palm trees are frequently visited by bats during sap collection, contaminating the sap with their saliva and urine (Khan *et al.*, 2012) [11].

Table 3: Biochemical attributes of date palm juice using different protectors

Parameters	Phenol (mg/g)	Total sugar (mg/100 ml)	Reducing Sugar (%)	Phosphorus (µL/100 ml)	Potassium (µL/100 ml)	Bacterial Count (cfux10^6)
Control	2.12e	4.10ab	3.20c	4.0ab	43.45b	1156a
Bamboo Net	7.49b	4.19ab	3.95a	4.2a	47.89a	536d
Nylon Net	2.6d	4.27a	3.06d	4.3a	46.98a	696c
Bamboo + Nylon Net	8.29a	4.20ab	3.36b	4.5a	48.03a	272e
Plastic Chot	5.66c	4.08b	3.20c	3.5b	42.0c	748b
LSD (0.05)	0.2	0.18	0.11	0.61	1.42	48
CV (%)	2.05	2.39	1.88	7.98	1.65	7.62

3.3 Measurement of biochemical parameters of *gur*

3.3.1 pH and Titratable Acidity

The lowest titratable acidity (0.13%) was found in in *gur* prepared by SAU machine and the highest titratable acidity was found in the *gur* collected from Jashore (0.36%) market (Figure 3A). The higher pH was found in *gur* that made by SAU machine (6.77), and the lower pH was found in *gur* collected from Jashore market (6.40) (Figure 3B). The main element influencing the clarification process is pH. According to Mandal *et al.* (2006) [13], it is crucial to the stability and storage quality of the jaggery. The pH level's retention is a sign of a high-quality product (Tamuno and Onyedikachi, 2015) [23].

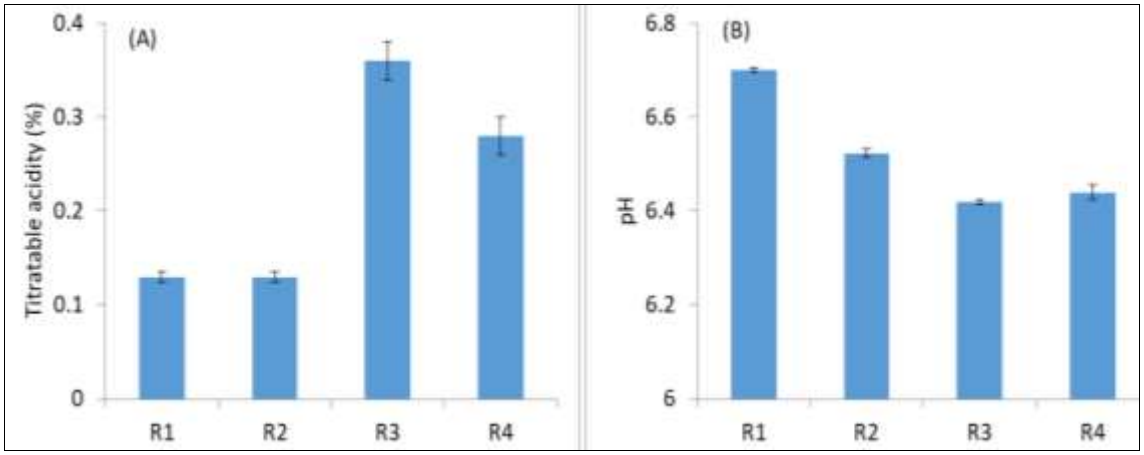

Fig 3: Average contents of titratable acidity (A) and pH (B) of date palm *gur* collected from different sources. Values are mean ±standard error. R_1: *Gur* prepared by SAU machine; R_2: *Gur* Prepared by contact grower in Jashore; R_3: *Gur* collected from Jashore market; R_4: *Gur* collected from Khulna market.

3.3.2 Vitamin C, Total sugar and Phenol Content

The highest ascorbic acid content was found in the *gur* made by SAU machine (8.62 mg/100 g) and the lowest ascorbic acid was found in the *gur* collected from Jashore (3.84 mg/100 g) (Figure 4A). Depending on the *gur* collection region, there were considerable variations in the overall sugar concentration. The lowest amount of total sugar was found in *gur* made by SAU machine (11.27%), while the highest amount was found in *gur* collected from Jashore (16.32%) (Figure 4B). Sucrose is a non-reducing sugar that is frequently employed as a sweetener in food formulations and it is possible that the gur collected from Jashore and Khulna has been adulterated with it. This could account for why it has the highest concentration of sucrose (White *et al.*, 2015) [27]. Jaggery's texture and stability during storage are impacted by its increased hygroscopicity when there is a significant concentration of reducing sugars (Patil and Adsule, 1998) [17]. The higher total phenol content (9.89 mg/100 g) was found in *gur* prepared by SAU made machine and the lower phenol content was found in the *gur* collected from Jashore (3.47 mg/100 g) followed by Khulna (3.60 mg/100 g) market (Figure 4 C). The highest concentration of phenolic components was found in *gur* that has been prepared by SAU machine. Jaggery protects phenolics and other phytochemicals that have potent biological effects, like antioxidant activity (Prasad *et al.*, 2010) [18].

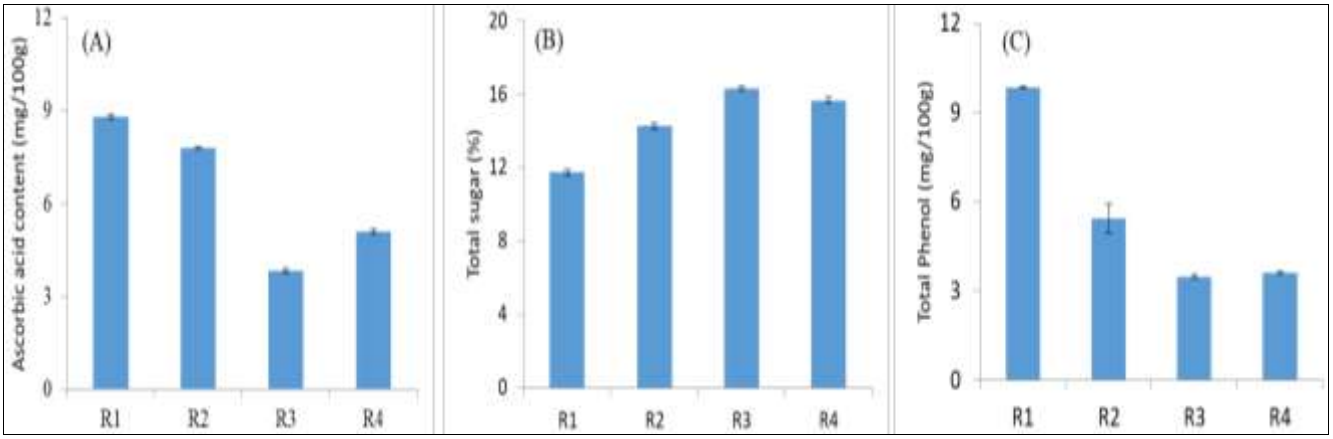

Fig 4: Average contents of ascorbic acid (mg/100 g) (A), total sugar (mg/100%) (B) and total phenol (mg/100 g) (C) of date palm *gur* collected from different sources. Values are mean ±standard error. R_1: *Gur* prepared by SAU machine; R_2: *Gur* Prepared by contact grower in Jashore; R_3: *Gur* collected from Jashore market; R_4: *Gur* collected from Khulna market.

3.3.3 Total soluble solid and bacterial count

The total soluble solids content of the *gur* responded significantly different in different *gur* collection area (Figure 5A). The total soluble solids were maximum in the *gur* obtained from SAU made machine (45.3 ◦Brix), whereas a minimum was recorded in the *gur* collected from Jashore market (34.2 ◦Brix). The increase in the content of soluble solids is a good indicator of *gur* quality.

The *gur* that was procured from Jashore market had the highest (788 cfu x 106) level of bacterial contamination. The amount of bacteria (251 cfu x 106) in the *gur* made with the SAU machine was relatively low (Figure 5B). It can be because the pH is lower than those of other collected *gurs*. The amount and types of bacteria that can survive or grow in *gur* are severely constrained by its low pH (Prescott *et al.*, 2002) [19].

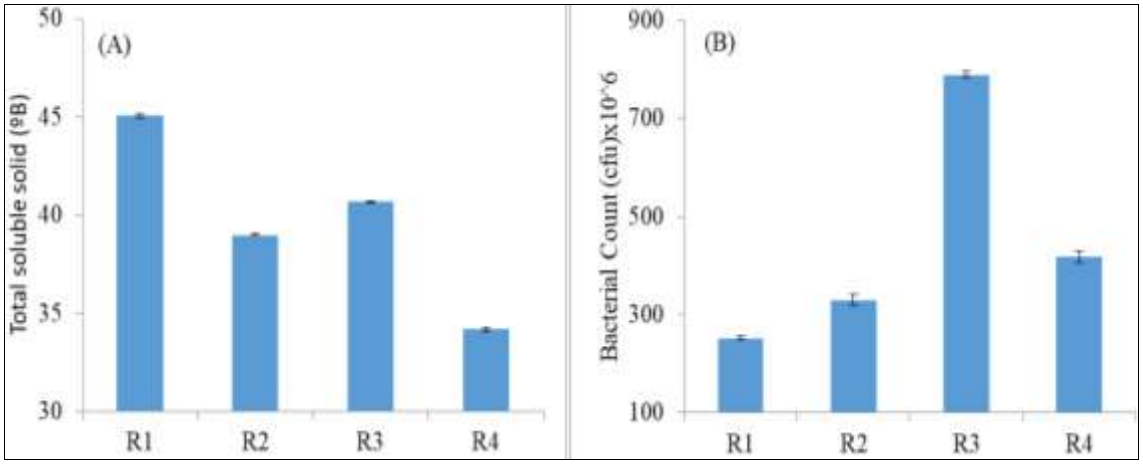

Fig 5: Average contents of total soluble solid (ºBrix) (A) and bacterial count (B) of date palm *gur* collected from different sources. R_1: *Gur* prepared by SAU machine; R_2: *Gur* Prepared in researched field of Jashore; R_3: *Gur* collected from Jashore market; R_4: *Gur* collected from Khulna market. Values are mean ± standard error.

3.3.4 Foreign matter and mineral composition of date palm *gur*

Foreign matters are as non-animal objects such as metal, plastic, rubber, glass, wood, ash, etc. Generally, *gur* was manufactured in open conditions, and the juice was boiled with fuel such as rice bran, straw, dried leaves, woods, clothing materials, and so on, resulting in cash or other debris polluting the prepared *gur*. Pollutants have a number of negative effects on the product, including decreased demand, negative health effects, and so on. However, Date palm *gur* is manufactured in a machine that is covered or shielded, thus no pollutants were found in the *gur* that was produced (Table 4). Thus, pure *gur* can be made from the machine.

Tab. 4 illustrates the concentration of the mineral elements P, K, Fe and Ca. The sequence of concentrations is as follows: K > Ca>P > Fe for all samples. The potassium concentration is high indicating that date palm juice can be a rich source for K. The highest potassium (K^+) content was found in the *gur* made by SAU machine (756.33 mg/100 g) and the lowest K^+ content was found in the *gur* collected from Jashore (336.32 mg/100 g) (Table 4). The most prevalent element is potassium followed by calcium and phosphorus (Cheikh-Rouhou *et al.*, 2006) [6]. Potassium is abundant in date palm sap, while the other minerals are in extremely small amounts (Souli *et al.*, 2014) [22]. The higher Ca content (262.05 mg/100 g) was found in *gur* prepared by SAU made machine and the lower Ca content was found in the *gur* collected from Khulna (124.01 mg/100 g) market (Table 4). Calcium plays an important role for healthy bones development (Assirey, 2015) [2].

The higher P content (231.69 mg/100 g) was found in *gur* prepared by SAU made machine and the lower P content was found in the *gur* collected from Jashore (110.73 mg/100 g) followed by Khulna (125.1 mg/100 g) market (Table 4). Phosphorus plays key roles of energy transfer and storage, acid-base balance and cell membrane structure among other biologically significant substances (Gropper *et al.*, 2012) [9].

The higher Fe content (4.01 mg/100 g) was found in *gur* prepared by SAU made machine and the lower Fe content was found in the *gur* collected from Jashore (2.0 mg/100 g) market (Table 4). Calcium plays an important role for healthy bones development (Assirey, 2015) [2]. For the creation of blood and tissue respiration, iron is essential (Abbaspour, 2014) [3]. Date palm *gur* is therefore regarded as a healthy food that has a rich supply of minerals and plays a crucial part in the human immune system's development because it contains these necessary components.

Table 4: Nutrient composition of date palm *gur* collected from different sources

Treatments	Foreign matter (%)	Phosphorus (mg/100 g)	Calcium (mg/100 g)	Iron mg/100 g)	Potassium (mg/100 g)
Prepared by SAU machine	0.03±0.00^d	231.69±2.72^a	262.06±2.88^a	4.01±0.11^a	756.33±2.33^a
Prepared from Farmers	0.20± 0.01^c	188.00±2.31^b	199.00±3.17^b	2.88±0.12^b	629.96±1.73^b
Jashore market	1.20±0.05 ^{b}	110.73±2.45^d	126.60±2.92^c	2.00±0.57^c	336.33±2.90^d
Khulna market	1.90± 0.05^a	125.10±2.88^c	124.02±2.30^c	2.20±0.11^c	354.96±2.88^c

4. Conclusion

Results revealed that Juice collected from protected plants showed the best performance compared to non-protected plants. Juice collected from the plants protected with bamboo + nylon net produced the highest amount of juice and had more TSS and less amount of bacterial contamination compared to other protections. Furthermore, *gur* produced from SAU machine had substantially more total soluble solids, vitamin C, titratable acidity and total phenol. However, the *gur* collected from local market of Jashore and Khulna had more sugar and bacterial contamination. Finally, the plant needs to be protected properly for quality juice and *gur* production with higher production rate of juice from each plant and *gur* need to be prepared through pollution free process.

5. Acknowledgement

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6. Conflicts of Interest

The authors declare no conflict of interest.

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