Chapter 1: Introduction

Date palm (*Phoenix dactylifera*) is one of the oldest cultivated trees and its fruit has been a dietary staple around the world for many centuries (Al-Hooti *et al*., 2007). Date palm is traditional fruit of Saudi Arabia. They are well known for its nutritive value and are widely used as traditional food to maintain the health and improve the health of diseased one. The *Phoenix dactylifera* is a monocotyledonous woody perennial belonging to the *Arecaceae family*, which comprises 3000 species and 200 genera (Jassim and Naji, 2010). Palm trees were taken from Saudi Arabia to other countries, which were attracted by their charm, beauty and endless generosity. More than 2000 varieties of dates are grown worldwide, and date palm is an important crop in arid and semi-arid area. Based on the climatic conditions and environmental features the fruits are produced from the flowers of the palm tree within a period of 5 to 6 months. The taste, nutritive value and visual appeal of fruit mainly depends on the cultivational lands that are adequate for the better growth of palm tree (Lee, 2008; Al-Hooti *et al*., 2007).The final factor that determines the date fruits nutritional value are fruiting stages which include kimri, khalal, rutab and tameer. Kimri is the initial stage of the fruit that contains high moisture content of about 85% with increased fruit weight. Khalal is second stage of fruit ripening where the fruits look fresh and hard (Gad *et al*., 2010; Tang *et al*., 2013). Rutab is the third stage where the fruits are at ripe stage and tends to have crispy and succulent nature. The final stage, tameer is the tender, succulent ripe stage of the fruit that is used as edible part on processing all over the world. Based on the nature of the fruit stages all the biochemical parameters differ accordingly due to changes in the ripening enzymes (Mayo-Wilson *et al.,* 2011).

Palm date fruits consist of three essential parts: date flesh which constitutes between 85% to 90% of date fruit weight (Amira *et al.,* 2011; Chaira *et al*., 2007), date seed or pit which constitutes about 6 to 12% of the total weight of the mature date and skin which is a thin layer surrounding the fruit to protect the fleshy part (El Sohaimy and Hafez, 2010; Shafiei *et al.,* 2010). Dates are rich in carbohydrates, comprising 70–80% in the form of glucose and fructose. Date fruit also contains fiber, vitamins and minerals, as well as polyphenols, a class of bioactive compounds, especially phenolic acids (Al-Farsi *et al*., 2007; Mattila *et al*., 2006). The carbohydrate, fiber and phenolic

acid content depends on the date cultivar and ripening stage of the fruit (Al-Shahib *et al*., 2012) as well as environmental conditions (Tang and Aleid , 2013). The crude protein reduces as the fruit mature; it is 5.5- 6.4% at the kimri stage and gradually decreases to 2.0- 2.5% at the tamr stage (Al-Hooti *et al*., 2007). Although dates are not a rich source of protein, they considered an important nutritional source because they contain essential amino acids (Al-Farsi and Lee 2008). The protein content of fresh and dried dates is 1.50 and 2.14 g/100 g, respectively. Increased amino acids content in dried dates are due to water reduction (Al Shahib and Marshall, 2013; Al-Farsi and Lee, 2008). Many date varieties were shown to contain *p*-coumaric acid, ferulic acid, sinapic acid and cinnamic acid derivatives, and isomers of 5-*O*-caffeoyl shikimic acid; while other date varieties were found to contain ferulic acid, caffeic acid, *p*-coumaric acid and *o*-coumaric acid, the concentration of which varied from 0.06 to 0.1477 g/kg in dry dates (Al-Farsi *et al*., 2008). Flavonoids, also present in dates, are another important group of phenolic compounds that include flavonoid glycosides and anthocyanins (Mansouri *et al*., 2005; Al-Farsi et al., 2007).

Epidemiological studies have consistently shown that high date fruits consumption is associated with a reduced risk of several chronic diseases such as hepato-protective activities, coronary heart disease, cardiovascular disease, cancer, atherosclerosis, neurodegenerative disease, tumor (El-Beltagy *et al*., 2009; Gad *et al.,* 2010). Extracts of the dates provided to the women after childbirth stimulate their immune system (Gad *et al*., 2010). On the other hand, a polysaccharide isolated from dates presented an antitumor activity (Ishurd and Kennedy, 2005).The date fruit is used in folk medicine to treat the different infectious diseases probably because of their anti-bacterial ability, immune modulatory activity and antifungal property (Baliga *et al.,* 2011; El-Beltagy *et al*., 2009). The presence of pharmacological properties could be due to the presence of high concentrations of minerals and a variety of other phyto-chemicals of diverse chemical structure (Baliga *et al.,* 2011). Furthermore, aqueous extracts of dates were shown to have potent antioxidant activity, because they inhibit in vitro lipid and protein oxidation and possess free radical scavenging capacity (Al-Farsi and Lee, 2008 ; Vinson *et al*., 2005).

Chemical composition of date fruits depends on geographical distribution, composition of soil, available nutrients present in soil, rainfall, absorbance capacity of water by soil. The chemical composition of soil and geographical location of

Bangladesh are different then Middle east countries. The chemical composition analysis of date fruits cultivated in Bangladesh is the main theme of the research.

Aims and Objectives of the study

- To determine the chemical composition of experimental date fruits cultivated in Bangladesh as well as dates imported from abroad.
- To analyze the macro-mineral and sugar content of experimental date fruits cultivated in Bangladesh.
- To make a comparison of chemical parameters of dates.
- To give encourage to the farmers about cultivation of date fruits in Bangladesh.

Chapter-02: Review of Literature

2.1 History of date fruit production

Al-Madinah Al Munawarah is considered the first producer of dates in Saudi Arabia. It has been used as food for 6000 years (Al-Shahib and Marshall, 2013). There are over 600 kinds of dates based on the shape and organoleptic properties (Baliga *et al.*, 2011). Date fruits are a significant component of the diet in the majority of the Arab countries with low cost. Food and Agriculture Organization reported in 2009, Saudi Arabia is the second producer of dates in the world. For Muslims, dates are of religious value and have been mentioned several times in the Quran. They are usually breaking their long day fasting with dates in the month of Ramadan (Al-Farsi and Lee, 2008; Baliga *et al.* 2011). It has been established as an important food crop in the desert regions of Arabian countries and has become the basis of survival of many ancient nomads (Mohammed *et al*., 2011). The fresh date markets embrace Bangladesh, Canada, Denmark, Germany, India, Indonesia, Malaysia, Sri Lanka, USA and UK whereas the dried dates are traded to Afghanistan, Bangladesh, Canada, Denmark, Germany, India and Japan (Amin *et al.*, 2007). During the colonial period, a number of Arabian date palm varieties were introduced in Multan and Muzaffargarh, in Punjab during 1910-12 from Basra (Iraq) by the British Indian Government (Milne, 1918). The importance of date palm culture for its high nutritive, economic and social values is well recognized, especially in the arid and semi-arid areas, where it plays an important role. Global production, utilization and industrialization of dates are increasing continuously (Bruck et *al*., 2011); its world production expanded from 2.8 million tons in 1981 to 5.4 million tons in 2011 with an annual expansion of about 5%. Local date palm (*Phoenix sylvestris* Rox b.) in Bangladesh is the main source of only jaggary (gur) as its fruit quality is poor. So, every year Bangladesh spends huge foreign currency to import date palm from the Middle-East. Millions of date palm trees got lost within one decade in North Africa due to different natural disasters (Bardia *et al*., 2008). That event suggests that large numbers of traditional cultivars in many countries may be lessening. Therefore urgent conservation efforts are needed worldwide (Chaira *et al*., 2007). Introduction of new varieties from the native places to check their adaptability under varied environments is of an utmost importance. Recently high quality date production in Bangladesh

conveys an excellent message for this country as a glimps of success. The planted palm species exhibited good growth at the early stage in the foreshore coastal lands (Islam *et al*., 2014).

2.2 Nutritional composition of date fruit

2.2.1Moisture

The moisture content of fresh date is 42.4 g/100 g and it is 15.2 g/100 g on dried dates (Al-Farsi and Lee, 2008). Moisture content of the date palm fruits are high to 85% at kimri stage and reduce to 13.35% in tameer stage of date variety like Davee. The average moisture content of popular varieties of the date fruit as collected from all literature support is 17.65%. Reduced moisture content of the date fruit makes it suitable as staple energy food (Tang and Aleid, 2013). It can store more calories that can serve better during the fasting period. The dryness of the date fruit prevents them from infestation and loss of nutrients due to contamination. Tameer stage of the date fruits is good to store and use them as energy rich food for a good life span of time for about 1 year (Alhussein, 2009).

2.2.2 Sugar

Sugars in dates are the most prevalent compounds (Mayo-Wilson *et al.,* 2011) as they provide a rich source of energy to humans. The average energy of fresh and dried dates is 213 and 314 kcal/100 g, respectively (Al-Farsi and Lee 2008). Types of carbohydrates in dates are glucose, fructose, sucrose, mannose, maltose, small amounts of cellulose and starch (Al-Shahib and Marshall, 2013). The total sugars increase as the fruit mature. It is ranging from 33-38 % at the kimri stage and 78-79.39% at the tamr stage. The sucrose contents increased rapidly as the fruits grown from the kimri to the khalal stage then it decreased at the tamr stage to a non-detectable level. The increase of the concentration of sugars from stage 1 to stage 4 is linked to the decrease in the water content of date during these stages (Al-Shahib and Marshall, 2013).

Table 2.1 Average quantification of nutrients from the reported date varieties

Nutrient	Average quantity	Nutrient	Average quantity
Protein (%)	2.61	Cu (mg/100 g)	0.31
Carbohydrates (g/100 g)	77.13	Zn (mg/100 g)	0.57
Lipid (%)	0.35	A Retinol (IU)	23.85
Ash (%)	1.68	B_1Thiamine (mg/100 g)	78.67
Moisture (%)	17.66	B_2 Riboflavin (mg/100 g)	116.5
Fat (%w/w)	7.08	B_3 Niacin (mg/100 g)	0.1442
Total sugar (g/100 g)	59.88	B_6 Pyridoxal (mg/100 g)	0.207
Fibre (%w/w)	3.98	B_9 Folate (µg/100 g)	53.75
Dry matter (%)	82.63	Ascorbic (mg/100 g)	0.39
Nitrogen (g/100 g)	0.48	Fe (mg/100 g)	1.72
Fructose (g/100 g)	29.39	Phenolics (mg/100 g)	239.51
Glucose (g/100 g)	30.41	Mn (mg/100 g)	106.76
Sucrose (g/100 g)	11.65	K (mg/100 g)	373.89

2.2.3 Protein

Protein content in various date varieties are comparatively high due to the presence of various amino acid content (Al-Farsi and Lee 2008). Nitrogen content and water reduction may be reason for high protein content in date on comparing to other fruits like apple, banana and orange (Al-Shahib and Marshall 2013). The average protein content changed from 2.0% to 6.4% that differs accordingly to the ripening stages of the date fruit (Al-Mamary *et al*., 2011). The present analysis revealed an average protein content of about 2.6%.Nitrogen was estimated in the range of 0.25–0.5g/100g. Nitrogen is an essential element to form amino acids and hence the amino acids were reported to be high at ripening stages and were significantly more in dried dates to 2.14 g/100g. These amino acids in turn play vital role in protein synthesis and metabolism that are essential for ripening of date fruits. Dates were reported to be rich in glutamic and aspartic acid (Al-Shahib Marshall 2013). The protein of dates contains 23 amino acids at high concentration. These amino acids also serve to act as

precursors for proteins, receptors, hormones that involve in cell signalling, gene expression nutrient transport and immunity for the growth, metabolism and normal function of healthy human body (Yeh *et al.*, 2008).

2.2.4 Fat

Fresh and dried dates contain 0.14 and 0.38 g/100 g respectively, of fat contents (Al-Farsi and Lee 2008). Fat content decreased as the fruit ripen. The fatty acids in dates are constituted of saturated oleic acid (50.10% of fatty acids) and linoleic acid (19.23%) and unsaturated acids lauric acid (10.24% of fatty acids), palmitic acid (9.83%), myristic acid (7.51%) and stearic acid (1.66%). Drying of dates increased fat contents (Al-Farsi and Lee, 2008).

2.2.5 Vitamin

Vitamins are important for synthesis of DNA and essential for metabolism of carbohydrates, fat and protein (Baliga *et al.*, 2011). Dates are regarded as a reasonable source of vitamins (Al-Farsi and Lee, 2008). It is considered a moderate source of riboflavin, niacin, pyridoxal and folate as 100 g of dates provide over 9% of the daily (RDA/AI) for adults (Al-Farsi and Lee, 2008; Baliga *et al.*, 2011). Thiamin, retinol and ascorbic acid found in low concentrations in dried dates, as 100 g of dates provide less than 7% of the daily RDA (Al Farsi and Lee, 2008).

2.2.6 Mineral

Dietary minerals play essential role in all major functions of human body. Date palm fruits varieties serve as one such dietary food to prevent regulate and treat the diseases that are caused due to the minerals imbalance. Some of the mineral reported in the date fruits are calcium, phosphorus, sodium, potassium, magnesium, iron, zinc, copper, manganese, cobalt etc. Date palm fruits were reported as the richest source of dietary minerals and vitamins (Vayali 2012). The date varieties have shown significant changes among the mineral contents both qualitatively and quantitatively that were earlier reported to be attributed to genetic difference time of harvest, ripening stages, place of cultivational parameters like water, soil minerals and environmental factors (Amira *et al*., 2011; Marzouk and Kassem 2011). The average mineral quantities at dried stage were reported in the Table 2.1 for most varieties reported. Some major findings that can be enumerated includes, overall all mineral

content was comparatively less in dried date fruits (1.7%) as described by Al-Shahib and Marshall, 2013), than any stage of fresh date fruit. The potassium content was reported to be high with sodium constituent in low level. It also contains higher level of iron followed by other trace elements like selenium and fluoride were reported controversy in many date varieties. Selenium and fluorides are not reported in all the popular date varieties but were reported to have high industrial valorization due to the presence of selenium (Al-Farsi and Lee 2008). Some minerals like iodine and fluoride were not reported in many of the date varieties (Vayalil 2012).Date fruits contribute as a moderate source of vitamins with a total of ten enzyme presence where, vitamin A is detected in lower quantities. It is rich in water soluble vitamins and play major role in vital function of the human body. Vitamin C is reported to protect liver by (Al-Mamary *et al*., 2011)

Mard *et al.,* (2010) reported that 100 g of dates provides over 15% of the daily RDA for selenium, magnesium, copper and potassium and over 7% of manganese, iron, phosphorus, and calcium. Selenium has a role in the protection of body against oxidative stress; it acts as a coenzyme for the antioxidant enzyme glutathione peroxidase. Importance of dietary fiber in health had been shown for more than 30 years as low fibers are associated with increased incidence of constipation, colon cancer, diabetes, heart disease and other disease (Al-Shahib and Marshall, 2013; Mohammad and Habibi, 2011).The crude fibers contents of the dates are decreased as fruit ripen; it was highest at the kimri stage (13.7%) and decreased rapidly to (3.6%) tamr stage (Al-Hooti *et al.,* 2007).

2.2.7 Fibre

Date palm varieties excel as a richest source of dietary fibres. The widely consumed tamer stage of date fruit contains 3% of dietary fibre, it meets 32% of fibre with 100 g consumption as recommended by RDA 25g/day. The dietary fibres contain small proportion of soluble and large amounts of insoluble polysaccharides, lignins and tannin components that are widely indigestible. Soluble polysaccharides in date dried fruits are pectin and hydrocolloids that are decreased in dried dates. The insoluble polysaccharides include cellulose, hemicellulose and lignin.The highest ratio of insoluble polysaccharides therefore are reported to involve in increasing faecal transit time. The dietary fibre plays a vital role in reducing the availability of soluble

carbohydrates by involving them in matrix formation and as well as bulking properties. It induces satiety value and contributes much to glucose metabolism by improving insulin sensitivity, secretion of gut hormones and other metabolic and inflammatory markers associated with metabolic disorder and syndrome like lactose intolerance and irritable bowel syndrome. Altogether fibre consumption regulates glucose absorption by optimal insulin secretion with decreased Hb A1C level in diabetes (Mohammad and Habibi 2011; Jenkins *et al*., 2008). Hence date fruits are reported to be potential factor to prevent the development of diabetes and its progression (Vayalil 2012). In addition, the dietary fibre also reduces the availability of toxic compounds that induces hepato toxicity by low faecal transit time, which also reduces constipation by serving as laxative (Al-Farsi and Lee 2008). Dietary fibre reduces the risk of intestinal, bowel and colon cancer (Mokhtari *et al*., 2008). This property of date fruit are mainly attributed to two anti-neoplastic glucans namely (1-3)- β-D glucan with various (1-6) linked mono, di and trisaccharide branches and (1-3)-β-D glucopyranosyl residues (Ishurd and Kennedy 2005; Ishurd *et al*., 2007).

2.2.8 Bio active compound

Phytochemicals are non-nutrient bioactive component that are mainly responsible for scavenging the toxic radicals through antioxidant formation after oxidative stress, which is the major causative for most of the chronic diseases (Al-Harrasi *et al.,* 2014). Some of the phytochemicals of date fruits that are reported to act as bioactive components are phenols, phenolic acids, carotenoids, isoflavons, lignans, flavonoids, tannins and sterols. Among this phenols and phenolic acids, the most predominant phenol reported to be high in detection and quantification is ferrulic acid (Vayalil 2012). The phenolic contents in varieties were reported as non-stable (Karasawa et al. 2011). They play vital role in antioxidant activity, which also varied from 40% to 80% (Al-Harrasi *et al*., 2014). Studies on the factors affecting the total phenolics should be implemented to produce varieties with stable estimate of phenolics and antioxidant activity. Flavanoids are also important phenolic compounds and were widely studied in different varieties and stages (Chaira et al. 2009).

Mansouri *et al.,* (2005) analyzed the phenolic profile of seven varieties of date and observed that they contain p-coumaric, ferulic and sinapic acids. Comparative studies with fresh and dried dates have shown that a significant increase in phenolic content

ensues on drying, possibly due to the degradation of tannins and maturation of degradative enzymes at higher temperatures (Mansouri *et al.,* 2005).

2.2.9 Antioxidant

Dates are considered as a good source of antioxidants (Al-Farsi and Lee, 2008). Al-Farsi reported that drying reduced the antioxidant content loss from 29.7% to 42.5% of antioxidants. This loss may be due to the breakdown of natural antioxidants after drying. Carotenoids act as antioxidants, which protect the cell from the deleterious effects of free radicals, and it is considered as an important source of vitamin A. Compared to other dried fruits dates can be assumed as a moderate source of carotenoids (Al-Farsi and Lee, 2008). Fresh date contains 913 mg/100 gm of carotenoids where is dried contains 973 mg/100 gm. Average of anthocyanins is 0.87 mg/100 g. It is only found in fresh date especially the red color varieties.Tannin content is high at the kimri stage it is ranged between 1.8% and 2.5% and decreased as the fruit ripen to 0.4% at the tamr stage (Al Hoot *et al.,* 2007). Phenolics can scavenge free radicals and stimulate the immune system (Al-Farsi and Lee, 2008). Phenolics increased after drying. Fresh date contains 193.7 mg /100 g of phenolics where is dried contains 239.5 mg /100 g because that dates can be considered as a good source of phenolics.

2.3 Health effects of dates

2.3.1 Hepato-protective activity of date fruits.

Liver diseases are one of a global problem and the major threats to public health, with high endemicity in developing countries (Adewusi and Afolayan, 2010). The majority of the hepatotoxic chemicals damage liver cells by inducing lipid peroxidation and other oxidative damages (Adewusi and Afolayan, 2010). Liver plays an essential role in transforming and clearing metabolites and xenobiotics, and is susceptible to the toxicity from these agents (Hrvoje *et al.,* 2009). According to Muslims believe that who eats seven dates every morning will not be affected by poison or magicon the day he eats them (Bastway*et al.,* 2008; Jassim and Naji, 2010; Al-Qarawi *et al.,* 2004).

Several studies assess the ability of date flesh and pits in prevention or treatment of some of the toxic actions of different substances such as carbon tetrachloride, thioacetamide and dimethoate poisoning on the liver of rats. Which are mode for

acute viral hepatitis, induced hepatotoxicity, elevation in plasma enzyme and bilirubin concentration and increase significantly serum glucose level (Al-Qarawi *et al.,* 2004; Bastway *et al.,* 2008; Pitsch *et al.,* 2010).

Studies showed that feeding rats with the aqueous extracts of date flesh or pits reduce significantly the levels of the hepatic markers enzymes (alkaline phosphatase, transaminases, gamma-glutamyl transferase), hepatic levels of malondialdehyde and concomitantly increased the levels of antioxidant enzymes (Bastway *et al.,* 2008). In addition, date pit extract shown its ability to restore the normal functional status of the poisoned liver, and protect against subsequent carbon tetrachloride hepatotoxicity on the liver of rats (Jassim and Naji, 2010, and Mohammad and Habibi, 2011). Moreover, Studies confirmed that selenium, ferulic acid, anthocyanin, caffeic acid,quercetin, chlorogenic acids, β-carotene, apigenin and luteolinare the date constituents which have all been reported to acquire hepato protective effects against the CCl_4-induced hepatic damage in rodents (Pitsch *et al,.* 2010).

Similarly, Al-Qarawi *et al.,* (2004) showed that the daily oral consumption of an aqueous extract of dates was protective agonist CCl_4 poisoning by 80% for flesh and 70% for pits of dates. In many other studies illustrated that the mechanism of hepato protective effects is possibly related to polyphenolic compounds (Al-Qarawi *et al.,* 2004 and Bastway *et al.,* 2008) and trace elements (selenium, zinc, copper and manganese). In addition, the content of vitamin C in the date flesh and pits (0.179% and 0.137%, respectively) may also play a role in hepato protection (Al-Mamary *et al.,* 2011). Logically assume the existence of these compounds may contribute for the hepato-protective effects of the date extract (Baliga *et al.,* 2011). However, the accurate mechanism by which the date flesh induces its hepato protective activity is uncertain (Bruck *et al.,* 2011; Bastway *et al.,* 2008). Likely that the mechanism of antioxidants in aqueous date fruit extract may be related to the ability of its active compounds to detoxify free radicals and to inhibit lipid peroxidation in the liver and protein oxidation. It is clear also that the anti-inflammatory effect of polyphenols through its ability to inhibit the production of nitric oxide and tumor necrosis factor α (TNF-α) to help in hepato protective ability. It is suggested that the flavonoids in date palm fruit can also contribute to the hepato protective ability through inhibition of cytochrome P-450 aromatase (Al Qarawi *et al.,* 2004; Bastway *et al.,* 2008).

2.3.2 Harmful lipid eliminating activities of dates

Atherosclerosis is a disease of the large arteries; it is the primary cause of heart disease and stroke. Epidemiological studies have revealed that it is the underlying cause of about 50% of all deaths in the world. The decreasing of the concentrations of high density lipoprotein cholesterol and increasing of low-density lipoprotein cholesterol are the major cause of Coronary heart disease (Baliga *et al.*, 2011). Studies showed that feeding rats with diet containing defatted date seed flour at 1.5%, 2.5% and at 5.2% concentration caused decreasing in plasma triglycerides, total cholesterol and low density lipoprotein (Al-Maiman, 2005).

Rock *et al.*, (2009) investigated that after 4 weeks Medjool or Hallawi dates consumption, the VLDL-cholesterol levels tended to be reduced (by 8 or 15%, respectively, with value of $0.1 > p > 0.05$). As well as in human, the dietary fiber feeding reduces blood cholesterol concentration. The findings of these studies suggested that diet based on date seed fiber had a good major source of dietary fiber. Date Plant leaves (DPL) extracts could have a protective effect against hyperlipidemia through improvement of lipid profile (Abuelgassim, 2010). However, the total lipids in the date decreased with the maturity stage progressing (Amira *et al.*, 2011). The fat component of the date skin plays a potential protective role for the date contents (Shafiei *et al.*, 2010).

2.3.3 Action of dates on diabetes

El-Mougy *et al.*, (2001) and Gilbertson *et al.*, (2001) showed that consuming low GI diet improved glycaemic control and quality of life for children with type 1 diabetes. Dates can be classified as low (GI) that reduces HbA1c (Jenkins et al., 2008 and Alkaabi et al. 2011). Low (GI) likely to be due to the high fructose in dates (Miller *et al.*, 2003).There is evidence to support dates benefits when mixed with meals in terms of glycaemic control (Gilbertson *et al.*, 2001). Composition of various types of dates alone or in mixed meals with plain yoghurt may be of benefit in glycemic control in diabetic patients (Miller *et al.*, 2003). There does not result in significant postprandial glucose excursions (Alkaabi *et al.*, 2011). Diabetic patients cannot be worrying for consumption of six to eight tamer and eight to 10 rutab dates (Miller *et al.*, 2003). Dietary fiber content of date changes during ripening (Al-Shahib and Marshall, 2013).

Fiber consumption helps in regulation of glucose absorption and insulin secretion and decreased HbA1c (Jenkins *et al.,* 2008). So high-fiber diets are recommended for diabetic patients (Mohammad and Habibi, 2011). Magnesium and zinc in dates stimulate the synthesis and secretion of insulin. Manganese also mimics insulin properties, which lead to hypoglycemic effect (Mokhtari *et al.*, 2008).

In 2009, Budin found that palm oil to cotrienol-rich fractions reduced the blood glucose level in streptozotocin induced diabetic rats whereas the alcoholic extract of seeds of dates decreased the blood glucose in male diabetic rats (Mokhtari *et al.*, 2008). Treatment with date palm leaf extract had great raise concentration of plasma insulin in alloxan induced diabetic rats. The release of insulin from the pancreas results in anti hyperglycaemic activity. The mechanism of action of the dates could be similar to that of hypoglycaemic sulphonyl ureas, as closure of K^{+} ATP channels. This result in membrane depolarisation and increased Ca^{2}+ influx, this will be an initial step in insulin secretion (Mard *et al.,* 2010).

2.3.4 Cancer preventive action of date fruit

Saafi *et al.,* (2011) found that the aqueous date palm fruit extract have protective activity against oxidative damage. It is possible that polyphenolic compounds (flavonoids, anthocyanins and phenolicacids), and trace elements (selenium, copper, zinc and manganese), in addition to vitamin C present in the date palm fruit are the responsible compounds for this protection. In fact, Vayalil (2012) proved the antioxidant and the anti-mutagenic activity of the aqueous date palm fruit extract, monitored by the inhibition of lipid per-oxidation and protein oxidation and by the aptitude to scavenge superoxide and hydroxyl radicals *in vitro.*

2.3.5 Dates as an Antioxidant

For several years, a special interest has been paid to oxidative stress; situation of an excessive production of reactive oxygen species in the organism (Saafi *et al.,* 2011). A large number of experimental and epidemiological studies have indicated that the reactive oxygen species contribute to organ injury and in many systems (Pitsch *et al.*, 2010). The increased oxidative stress in subjects with type 2 diabetes is a result of several abnormalities, including hyperglycemia, insulin resistance, hyper insulinemia, and dyslipidemia (Folli *et al.,* 2011).Therefore, a great deal of attention has focused

on the naturally occurring antioxidant phytochemicals as potential therapy for cardiovascular diseases (Das and Das, 2007).

Antioxidants are compounds that can delay or inhibit the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reaction. Cellular antioxidant status determines the susceptibility to oxidative damage and is usually altered in response to oxidative stress (Biglari, 2009). The cellular antioxidant pool comprises antioxidant free radical scavenging enzymes like catalase, superoxide dismutase (SOD) and glutathione peroxidase. The cellular as well as their high capacity in scavenging free radicals related to various diseases hydroxyl radical which are particularly reactive and are known to be a biological product in reducing molecular oxygen (Biglari *et al.,* 2009). An antioxidant, which can reduce reactive free radicals, can prevent the oxidation of other molecules. Therefore, have health-promoting effects in the prevention of degenerative diseases (Sanzari *et al.,* 2011). Cocktail supplementation of antioxidants may have beneficial effects on diabetic nephropathy through discriminating reduction of blood glucose levels and inflammatory response (Das and Das, 2007). Beside the previous result, use of oral antioxidants in infertile men could improve sperm quality and pregnancy rates (Ross *et al.,* 2010). Beta carotene supplementation appeared to increase cancer incidence and cancer mortality among smokers, whereas vitamin E supplementation had no effect, Selenium supplementation might have anti-carcinogenic effects in men (Bardia *et al.,* 2008). Antioxidants can be classified into two groups according to their solubility; hydrophilic antioxidants (water-soluble), such as the majority of phenolic compounds and ascorbic acid, and lipophilic antioxidants (fat-soluble) such as carotenoids and vitamin (Al hussein, 2009 and Al Farsi *et al.,* 2005). The results presented here strongly suggest that date fruit contains compounds with potent antioxidant and anti-mutagenic activity (Vayalil, 2012) and have proved the crucial role of nutritional antioxidants to prevent the damage caused by toxic compound (Pitsch *et al.,* 2010). The primary free radical in most biological systems is the superoxide radical, which is in equilibrium with its protonated form hydroperoxyl radical.

In general, this study reports that palm dates syrups can be a good source of natural antioxidant (Farag, 2011). Which act by several mechanisms, such as removal of free radicals, scavengers of NO, OH and H_2O_2, chelation of Fe^{2+} ion, the ability to reduce

transition metals and the ability to prevent lipid peroxidation (Al Mamary *et al.*, 2011). Aqueous date extract (1.9 mg/mL) was found to inhibit significantly the lipid peroxidation in a dose dependent manner (Vayalil, 2012). Dates have higher caloric content and more essential minerals and vitamins than most other fruits. There are at least 15 minerals in dates (boron, calcium, copper, fluorine, iron, potassium, phosphorous, sodium, zinc and selenium). Selenium present in dates mainly in the form of selenocysteine residues that are an integral constituent of ROS-detoxifying seleno enzymes (GPx, thioredoxin reductase and selenoprotein (Steinbrenner and Sies 2009).

In vivo studies by Yeh *et al*., (2008) have also shown that oral feeding of pcoumaric acid present in date increase the expression of antioxidant enzyme genes in rat.

Chapter-03: Materials and Methods

3.1 Location of the experimental area

The experiment was conducted during January to April 2019 in the laboratory of Department of Applied Chemistry and Chemical technology, Chittagong Veterinary and Animal Sciences University (CVASU).

3.2 Collection of commercial date fruits

Samples of different branded date fruits were collected from different departmental shops in Chittagong metropolitan area where there was abundance of various brands of date fruits. A total of 5 date fruits samples as packed date fruits were collected. The collected samples were Sample A (Bangladeshi cultivated date varieties) that had collected from Gazipur Horticulture, Bangladesh and date fruits B (Ajwa), date fruits C (Mariam), date fruits D (Safawy) and date fruits E (Burni) are the commercial samples respectively. The experiment was done using 5 samples with 3 replicates in each sample.

3.3 Proximate analysis of the experimental samples

The five date fruits samples were analyzed for moisture, crude protein, crude fat, total carbohydrate, energy content and ash content. All the determinations were done in triplicate and the result were expressed as the average value.

3.3.1 Moisture content

Moisture content was determined adopting AOAC (2005) method 14.004.

Procedure

5g date fruit sample was taken in a pre-weight crucible (provide with cover) which was previously heated to 130^0C. The sample was dried for 1 hour in an air oven maintained at temperature 130 ± 3^0C. The crucible was while still in oven then transferred to dessicator and weighed immediately after reaching at room temperature. The loss of weight from sample was determined and the percent of moisture was calculated as follows:

$$\% \text{ Moisture content } = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.3.2 Protein

Protein content was determined using AOAC (2005) method 2.049. The method was as follows:

Reagent required

- Concentrated sulphuric acid (nitrogen free) 20 ml.
- Digestion mixture
- Potassium sulphate =100gm
- Copper sulphate = 10 g
- Selenium di-oxide = 2.5g well mixed in mortar and kept in a dry place.
- Boric acid solution = 2% solution in water.
- Alkali solution = 400g sodium hydroxide in water and dilute to 1 litre.
- Mixed indicator solution: Bromocresol= 0.1g and methyl red= 2g dissolved in 250 ml ethyl alcohol
- Standard HCL : 0.1 N

Procedure

5g digestion mixture was weighed accurately and transferred into a dry 300ml Kjeldahl flask. A suitable quantity of the sample (1g for each) was transferred into the flask. 20ml of sulphuric acid was added, heated continuously until frothing ceased and then simmered briskly. The solution became clear in 15-20 min., continued heating for 45 min. After cooling, 100ml water was added, and transferred quantitatively to a 1 litre round- bottom flask; the final volume was about 500 ml. Added gently sown the side enough sodium hydroxide solution to form a participate of cupric hydroxide and immediately connected the flask to steam-trap and condenser. Then 50ml of boric acid solution, 50ml distilled water and 5 drops of indicator solution were added to a 500ml conical receiving flask. Positioning the condenser distillation was carried out for 4 to 5 minutes or until about 250 ml of distillate was attained, the contents of the receiving flask were titrated with 0.1 N hydrochloric acid, the end point was marked by a brown color. A reagent blank as also determined and deducted from the titration. One milliliter of 0.1N hydrochloric acid is equivalent to 1 mg of nitrogen. A protein

conversation factor was to calculate the percent protein from nitrogen determination. Percentage of nitrogen and protein calculated by the following equation:

$$\% \text{ Nitrogen } = \frac{(\text{Ts } - \text{Tb}) \times \text{ N of HCL} \times \text{ 14 } \times \text{Vol. made up the digest} \times \text{ 100}}{\text{Wt. of sample (gm)} \times \text{Aliquot of the digest taken } \times 100}$$

Where,

T_s = Titre volume of the sample (ml)

T_b = Titre volume of the blank (ml)

% Protein = % Nitrogen ×Protein factor

3.3.3 Crude Fat

AOAC (2005) method using Soxhlet apparatus was used to determine crude fat content of the samples.

Procedure

The dried sample was transferred from weighing machine to a thimble and plugged the top of the thimble with a wood of fat free cotton. The thimble was dropped into the fat extraction tube attached to a Soxhlet apparatus. Approximately 75ml or more of anhydrous petroleum ether was poured through the sample in the tube into the flask. Top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hours or longer on a water bath at 70-80^0 C. At the end of extraction period, the thimble from the apparatus was removed and distilled of the petroleum ether by allowing it or collected in Soxhlet tube. When the petroleum had reached small, it was purer into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask was rinsed and filtered thoroughly using petroleum ether. The petroleum ether was evaporated on steam bath at low temperature and was then dried at 100^{0}C for 1 hour, cooled and weighed. The difference in the weight gave the ether soluble materials present in the sample. The percent of crude fat was expressed as follows:

$$\% \text{ Crude fat } = \frac{\text{Weight of petroleum ether soluble material}}{\text{Weight of sample taken}} \times 100$$

3.3.4 Total carbohydrate

Total carbohydrate content of the sample was determined as total carbohydrate by difference, that is by subtracting the measured protein, fat, ash and moisture from 100 (Pearson, 1970).

3.3.5 Energy content

The energy content of the date fruits was determined by calculating the amount of protein, fat and carbohydrate of respective food items and by using the following equation (Parvin *et al.,* 2014).

Energy = (Protein × 4.1) + (Fat × 9.3) + (Carbohydrate × 4.1).

3.3.6 Ash

AOAC method 14.006 (2005) was used to determine the total ash content.

Procedure

5gm date fruit sample was weighed into clean, dry porcelain ashing dish which burned until white smoking stopped. The sample was then ignited with a gas burner until white smoking stopped. The sample was then placed in a muffle furnace at 550^0C and ignited until light gray ash resulted (or to constant weight). The sample was then cooled in desiccators and weighed. The ash content was calculated by the following expression:

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

3.3.7 Determination of mineral content in the experimental date fruits samples

The mineral content of date fruits were measured by atomic absorption spectrophotometry.

3.3.7 .1 Atomic spectroscopy

This technique is applicable to most gas phase elements over a wide range of concentrations and involves detecting, measuring and analyzing radiation that is either absorbed or emitted from the atoms or ions of the element of interest (McMahon, 2007). It involves three techniques: Absorption, emission and fluorescence. In all the above, the sample is decomposed by intense heat into hot gases consisting of free atoms and ions of the element of interest (McMahon, 2007). As atoms are the simplest and purest form of matter and cannot rotate or vibrate as a molecule does when subjected to high energy radiation, electrons within the atom undergo transitions.The high energy radiation is commonly produced by

a. Flame in flame atomic absorption spectroscopy(FAAS)
b. Electrothermal furnace in flameless graphite furnace atomic absorption spectroscopy (GFAAS)
c. Plasma in inductively coupled plasma-optical emission spectroscopy (ICPOES)
d. X-ray in X-ray fluorescence spectroscopy(XRF)((Lajunen and Paavo, 2007))

The above four belong to one of three major types of atomic spectroscopy namely absorption, emission and fluorescence ((Lajunen and Paavo, 2007).

3.3.7.2 Principle of AAS

An atom is made up of positively charged nucleus surrounded by a number of negatively charged particles necessary to provide neutrality. These atoms occupy discrete energy levels but it is possible for an electron to be moved from one level to another by introduction of energy. Such transitions will only occur if the available energy is equal to the difference between the two levels. Energy levels and the energies associated with electron transitions are unique for each element.

When light (energy) of a characteristic wave length enters an analytical system, outer shell electrons of corresponding atoms within the light path will be excited as energy is absorbed. The amount of light transmitted through the system from a source to the detector will be less. The loss of light is proportional to the number of atoms. The

measurement of the radiation transmitted (using Beer-Lambert's law) in such a transition form the basis of AAS. Beer- Lambert's law relates absorbance, a to the concentration of metallic atoms in the atom cell, c as follows

$\text{Log } T^{-1} = a\ b\ c$

Where

a is the absorptivity in grams per litre-centimetre

b is the atom width in centimeters

c is the concentration of atoms

3.4 Statistical analysis

Data were compiled in MS Excel. Raw data related to Moisture, Protein, Fat, Carbohydrate, Energy Content, Ash, Minerals, Sugar were tested for normality by using normal probability plot and analyzed for one way ANOVA by using STATA (2017). Means showing significant differences were compared by Duncan's New Multiple Range Test (Duncan, 1955). Statistical significance was accepted at $p \leq 0.05$ for F-test.

Chapter-4: Results

The experimental date fruits collected from Gazipur Horticulture as Bangladeshi variety was designated as sample A and the collected samples also designated as date fruits B (Ajwa), date fruits C (Mariam), date fruits D (Safawy) and date fruits E (Burni).

4.1 Proximate composition of date fruit

Table 4.1: Comparative chemical analysis of date fruit

Parameters	Sample (g/100 g dry weight) of date flesh					Sig
	A	B	C	D	E	
Moisture	25.4±.2^{a}	21.8±0.1^{ab}	18.5 ± 0.1^{b}	22.6 ±.3^{ab}	23.4 ± 0.1^{a}	*
Protein	3.38 ±.01^{a}	2.81 ± .02^{bc}	3.32 ± .03^{ab}	2.36 ±.02^{b}	2.40 ± .04^{b}	*
Fat	.41 ±.004^{ab}	.37 ± .001^{b}	0.28 ±.004^{a}	.22 ±.003^{b}	.57 ± .001^{a}	*
Carbohydrate	68.37±.39^{bc}	71.02±.54^{a}	73.83±.32^{a}	72.49±.44^{a}	71.41±.89^{b}	*
Energy (kcal)	298.86±1.4	304.92±2.0^{b}	318.06±1.1	308.3±1.7^{a}	309.9±3.8^{a}	*
Ash	2.23 ±.01	2.33 ±0.01^{a}	2.32 ± .04	1.58 ±.01	2.01 ± 0.01	NS

A= Experimental date fruit (Bangladeshi cultivated), B =Ajwa, C= Mariam, D= Safawy and E= Burni collected from local market; SEM= Standard error of mean, *= Significant at 5% level; NS = Non significant at 5% level, Means with different superscripts in the same row differ significantly ($p<0.05$).

4.1.1 Moisture

The result revealed that there was significant variations ($p<0.05$) in moisture among date fruit. Considering the data on moisture, the highest observed score was in case of date fruit A (25.4 %). The lowest preference in terms of moisture was in case of date fruit C (18.5%).

4.1.2 Protein

It is apparent from the result that there was significant difference ($p<0.05$) in terms of protein of experimental date fruits. The result (Table- 4.1) indicates that the protein of the date fruit A was in highest position (3.38 %). The lowest preference in terms of

protein was in case of date fruit D (2.36%). The experimental date fruit contains 3.38%) protein that was found in the comparative study with other date fruit.

4.1.3 Fat

No significant fat differences were revealed among the date fruit (Table- 4.1).The fat preference was conducted and the finding suggested that the dates A, B, and E were equally acceptable. It shows that, sample E (0.57%) possesses highest score in case of fat and the lowest score was obtained the sample D (0.22%).

4.1.4 Carbohydrate

In case of carbohydrate preference among the date fruit showed that the date fruits were no highly significantly different ($p< 0.05$). The data shows that, date fruits C (73.83%) possesses highest score in case of carbohydrate and the lowest score was obtained the sample A (68.37%).

4.1.5 Energy

No significant energy differences ($p<0.05$) were revealed among the date fruit samples (Table- 4.1). The energy preference was conducted and the result revealed that date fruits C contained higher energy level than others. The energy score of date fruit C (318.06kcal) was the highest score among the samples of the date fruits while date fruit A (298.86 kcal) obtained the lowest score among the date fruits.

4.1.6 Ash

No significant ash differences were revealed among the experimental date fruit, Ajwa, Mariam, Safawy and Burni (Table- 4.1).The ash preference was conducted and the finding suggested that the dates A, B, C, D and E were equally acceptable. The ash score were almost similar that does not differ significantly in the experiment. The ash content ranged from 1.58 g/100 g dry matter in Safawy to 2.33g/100 g in Ajwa.

Table 4.2: Sugar content of date flesh

Parameters	Sample (g/100 g dry weight) of date flesh					Sig
	A	B	C	D	E	
Total sugar	73.3±1.0[a]	81.33±3.9[ab]	75.93±1.7[b]	71.46±1.1	82.7±1.8[bc]	*
Reducing sugar	70.2±.66[ab]	77.7±.36[a]	72.2±.10[bc]	67.7±0.1[a]	78.83±.35	*
Sucrose	3.1±.17	3.53±.05[a]	3.33±.05[a]	3.56±.11	3.5±0.10	NS
Fructose	47.9±.75	48.26±.15[b]	46.8±.60	45.7±.55	48.23±.60	NS
Glucose	48.76±.37[b]	52.03±1.45	49.23±.568	46.43±.70[a]	51.8±.52	NS

A= Experimental date fruit (Bangladesh cultivated), B =Ajwa, C= Mariam, D= Safawy and E= Burni collected from local market; SEM= Standard error of mean, *= Significant at 5% level; NS = Non significant at 5% level, Means with different superscripts in the same row differ significantly ($p<0.05$).

Dates contains high sugar that is the main source of energy. The range of total sugar (71.46- 82.7%). The level of reducing sugar is high 78.8% in Burni dates. Total sugar composed of reducing sugar and sucrose. The sugar content was lower than those in commercial dates with high sensory quality. Statistical analysis showed no significant difference in fructose, glucose and sucrose content between Experimental date fruits, Ajwa, Mariam, Safawy and Burni.

Table 4.3: Mineral composition of date flesh

Parameters	Sample(mg/100 g dry weight) of date flesh					Sig.
	A	B	C	D	E	
Calcium	143.33±1.0^{b}	179.2±.72^{ac}	141.36±.7	125.43±.6^{b}	161.8±.34^{b}	*
Phosphorus	18.26±.61^{ab}	25.66±1.5^{a}	17.33±.57	14.5±.81^{a}	20.63±1.0	*
Sodium	6.7±.26^{b}	8.1±.66^{b}	7.24±.08^{bc}	5.20±.56^{a}	8.40±.04^{a}	*
Potassium	440.66±1.52^{a}	494.6±1.52^{b}	482.6±1.5	380±1.00	418.3±.57^{ac}	*
Magnesium	124.66±1.1^{ab}	148.56±1.2^{a}	135.63±1.	84.36±.77	104.6±.65^{b}	*

A= Experimental date fruit (Bangladesh cultivated), B =Ajwa, C= Mariam, D= Safawy and E= Burni collected from local market; SEM= Standard error of mean, *= Significant at 5% level; NS = Non significant at 5% level, Means with different superscripts in the same row differ significantly ($p<0.05$).

Table-4.3 showed that dates fruit contained significant amounts of minerals. The potassium concentration was the highest (380–494 mg/100 g dry matter), followed in descending order by calcium (125–179 mg/100 g), magnesium (84.36–148.56 mg/100 g), phosphorus (14.5–25.66 mg/100 g) and sodium (5.20-8.1 mg/100 g. Most of the analyzed minerals showed significant difference among the different varieties, especially in potassium. The variations in magnesium and sodium contents could be explained by factors such as variety and soil type.

Chapter-5: Discussion

5.1 Chemical composition of date flesh

Table 4.1 it was showed that the average chemical composition of date flesh from the experimental point of view. The moisture content at the final stage ranged from 18.5 to 25.4%. The date flesh of experimental sample A had the highest moisture content (25.4%) and Mariam C (18.5%) the lowest, with no significant difference between Ajwa, Safawy and Burni. The results are comparable to those reported previously (Ahmed *et al*., 1995 Sawaya, *et al*., 1983; Elleuch, *et al*., 2008) with some differences related to date variety and agro-climatic and environmental conditions (Ahmed *et al*., 1995; Al-Hooti *et al*., 2007).

The protein content ranged from 2.36g/100g dry matter in the Sample D (Safaway) to 3.38g/100g in sample A, indicating relatively little protein it has been reported previously that dates are not a good source of protein (Al-Hooti *et al*., 2007).
The protein content of the experimental date flesh was 3.38g/100g whereas date sample B, C, D and E contained 2.81g/100g, 3.32g/100g, 2.36g/100g and 2.40g/100g, respectively. The protein content of the experimental date flesh was not degraded from the level that followed by the commercial imported date company available in the market. The experimental date flesh contains 3.36% protein that meet the desired level of diet chart formulation. The protein rich fruit is essential for the children in case of protein energy malnutrition. The high level of protein of the experimental date flesh would play an important role to fulfill the protein requirement. The proximate result of the experimental dates was agreed with the reported by (Al-Farsi and Lee 2008; Al-Shahib and Marshall 2013; Al-Mamary *et al*., 2011)

The date flesh samples also had a very low fat content, from 0.22 g/100 g dry matter in Safawy to 0.57 g/100 g in Burni, which are similar to those reported previously for dates produced in Saudi Arabia (Sawaya *et al*., 1983) and in the United Arab Emirates (Ahmed *et al*., 1995) but lower than those in some Iranian varieties (0.4–0.9% of fat). No significant difference in fat content was found in Ajwa, Mariam, Safawy dates. The fat content of the experimental date flesh was 0.41/100 g and the commercial date flesh B, C, D and E contain 0.37/100g, 0.28/100g, 0.22/100g, 0.57/100g, respectively. From the result, it was apparent that the fat content of the experimental date flesh and the commercial brands date were same. Food sample with high fat content is more

liable to spoilage than one with a lower fat content (Al-Farsi and Lee, 2008). The proximate result of the experimental dates was agreed with the reported by (Al-Farsi and Lee, 2008; Al-Mamary *et al*., 2011).

The ash content of the dates gives an idea of the mineral content. The experimental dates had appreciable level of ash contents (2.23/100g) and sample B (2.33/100g) and C (2.32/100g) also had approximately the same level of ash content.

The carbohydrate content of the experimental date fruit was 68.37g/100g whereas date fruit B, C, D and E contain 71.02g/100g, 73.83g/100g, 72.49g/100g and 71.41g/100g, respectively. The experimental date fruit contains the medium carbohydrate content than imported commercial date fruit. This is because the soil condition, weather tropical conditions of the country. (Mayo-Wilson *et al.,* 2011) reported that carbohydrate and sugar content of date fruits mostly depends on quality and types of soil. The result of the experimental date fruit was agreed with the reported by Al-Farsi and Lee, 2008.

5.2 Sugar present in date fruits

The dates had a highest carbohydrate content (73.83%) in sample C. It is well known that dates are important sources of sugar, and the total sugar content was similar to that reported previously: 81.6–88.4% (Ahmed *et al*., 1995; Al-Hooti *et al*., 2007), 72.8–79.1% (Elleuch, *et al*., 2008) and 78.3–87.6% (Mayo-Wilson *et al.*, 2011). No significant difference in total sugar content was found between Experimental date fruits, Ajwa, Mariam Safawy and Burni. The main sugars found in the date flesh samples were fructose, glucose and sucrose (Table 4.2); the reducing sugars (glucose and fructose) were the major sugars in all cultivars. The richness of these varieties in reducing sugars suggests the existence of pronounced invertase activity, which considerably reduces its sucrose content (Elleuch, *et al*., 2008). The sugar content was lower in sample A than those in commercial dates with high sensory quality. It is because the soil condition, tropical weather condition of the country. Elleuch *et al*. (2008) reported that sugar loss in date by-products could be explained by non-enzymatic browning during storage (Maillard reaction) and rinsing of date flesh samples. Statistical analysis showed no significant difference in fructose, glucose and sucrose content between Experimental date fruits, Ajwa, Mariam Safawy and Burni.

5.3 Mineral composition of date flesh

Date fruits contained significant amounts of minerals (Table-4.3). The potassium concentration was the highest (380–494 mg/100 g dry matter), followed in descending order by calcium (125–179 mg/100 g), magnesium (84.36–148.56 mg/100 g), phosphorus (14.5–25.66 mg/100 g) and sodium (5.20-8.1 mg/100 g). Similar results were reported by Al-Hooti *et al*. (2007) and our results are in close agreement with those of many other studies, which show that dates contain suitable concentrations of calcium, potassium and phosphorus, which are important for metabolism in human cells (Sawaya *et al*., 1983; Amira *et al*., 2011; Marzouk and Kassem 2011). Magnesium and calcium are essential for healthy bone development and for energy metabolism, and iron is essential for red blood cell production. The high potassium and low sodium contents of dates are suitable for people with hypertension (Vayali 2012). Most of the analyzed minerals showed significant difference among the different varieties, especially for potassium. The variations in magnesium and sodium contents could be explained by factors such as variety, soil type and amount of fertilizer.

Chapter-5: Conclusion

This study provides baseline information on important date varieties grown in Saudi Arabia and Bangladesh. The experimental date fruits results suggested that dates are nutritious and can play a major role in human nutrition and health. In addition, dates are an important nutritional source of minerals and sugar. Moisture content significantly increased due to presence of moisture in the soil of Bangladesh as geographically the country located in the line of tropic of cancer so heavy rainfall is available that's the main fact of high moisture in date fruits. Energy level of all experimental dates increased as there is presence of more carbohydrate presence in dates. The results show that dates have a high content of sugar (71.2–81.6%) and low concentrations of protein (2.26-3.38%) and fat (0.22–0.57%). The predominant mineral is potassium, and the predominant sugars are glucose and fructose. This product could be an alternative of the imported commercial date fruits to meet the nutritional requirements of the country.

Chapter-7: Limitations of the research

- Microbial analysis of date fruits was not estimated in the study.
- Amino acids contents of date fruits was not observed in the study.
- Heavy metal in the date fruits did not estimate.
- Colorful packaging of the experimental date fruits did not design properly.
- Special preservation technique did not examine.

Chapter-8: Recommendations and Future perspectives

- The experimentally cultivated date fruits in our country have much protein, fat and almost same carbohydrate contents as imported dates are sufficient to meet people's basic demands of nutrients of the least developed Bangladesh.
- There are some amino acids that play an important role such as Alanine, Trypsin, Tyrosine etc. analysis are also important for exact nutritional value.
- The experimentally cultivated date fruits in our country was cheap as there is no import cost.
- The experimental date fruits can be cultivated in the lower area of the country on the experimental point of view.
- An appropriate packaging material for the product can also be selected which will protect the product from physical, chemical and microbial hazards with a cheap cost.

REFERENCES

Abuelgassim AO. 2010. Effect of flax seeds and date palm leaves extracts on serum concentrations of glucose and lipids in alloxian diabetic rats. Pakistan Journal of Biological Science .13:1141-45.

Adewusi EA and Afolayan AJ. 2010. A review of natural products with hepato - protective activity. Journal of Medicinal Plants Research .4:1318-34.

Al-Farsi M A and Lee CY. 2007. Optimization of phenolics and dietary fibre extraction from date seeds. Food Chemistry. 108: 987-985.

Al-Farsi M, Alasalvar C, Morris A, Baron M, Shahidi F. 2005. Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried date varieties grown in Oman. Journal of agricultural and food chemistry. 53(19):7592–95.

Al-Farsi MA and Lee CY. 2008. Nutritional and functional properties of dates: a review. Food Science Nutrition 48: 877-887.

Al-Hooti S, Sidhu JS and Qabazard H. 2007. Physicochemical characteristics of five date fruit cultivars grown in the United Arab Emirates. Plant Foods Human Nutrition. 50:101-13.

Alhussein MA. 2009. Study of penetration curves of solar heat into date fruits as a mean to control insects. Journal of Engineering Science and Technology. 3: 251 –263.

Alkaabi JM, Al-Dabagh B, Ahmad S, Saadi HF, Gariballa S and Ghazali MA. 2011. Glycemic indices of five varieties of dates in healthy and diabetic subjects. Nutritional Journal. 10: 59-59.

Al-Maiman S. 2005. Effect of Date Palm (Phoenix Dactylifera) Seed Fibers on Plasma Lipids in Rats. Volume of Agricultural Science. 12: 117-123.

Al-Mamary M, Al-Habor M and Al-Zubairi AS. 2011. The *in vitro* antioxidant activity of different types of palm dates (Phoenix dactylifera) syrups; Arabian Journal of Chemistry. 10:106 -110.

Al-Nozha M and Al-Kanhal M. 2006. Percentage of famillies consuming food item. Aluation of the nutritional status of the people of Saudi Arabia. 218.

Al-Qarawi A, Mousa HM, Ali BH, El-Mougy SA. 2004. Protective effect of extracts from dates (Phoenix dactylifera) on carbon tetrachloride induced hepato toxicity in rats. International Journal of Veterinary Medicine. 2: 176-180.

Al-Shahib W, Marshall RJ. 2013. The fruit of the date palm: Its possible use as the best food for the future. International journal of food sciences and nutrition. 54(4): 247–59.

Amin M, Zafar MS and Anjum AY. 2007. Potential of Date Export. In: Hortimag Newsletter (June, 2007). Pakistan Horticulture Development and Export Board. 3: 19.

Amira E, Guido F, Behija S, Nesrine Z and Lotfi A. 2011. Chemical and aroma volatile compositions of date palm (Phoenix dactylifera L.) fruits at three maturation stages. Food Chemistry. 127:1744–1754.

AOAC. 2005. Official methods of Analysis, 17th edition. Association of Official Analytical Chemists, Washington, D.C. USA.

Aryangat AV and Gerich JE. 2010. Type 2 diabetes: postprandial hyperglycemia and increased cardiovascular risk. Health Risk Management. 6:145-55.

Asha VV and Pushpangadan P. 2008. Preliminary evaluation of the anti-hepatotoxic activity of Phyllanthus kozhikodianus, Phyllanthus maderspatensis and Solanum indicum. Fitoterapia. 59: 255- 259.

Baliga S, Baliga V, Kandathil S. 2011. A review of the chemistry and pharmacology of the date fruits (Phoenix dactylifera L.). Food Research of International. 44: 1812-22.

Bardia A, Tleyjeh IM and Cerhan JR. 2008. Efficacy of antioxidant supplementation in reducing primary cancer incidence and mortality. Food Chemistry 83: 23-34.

Bastway AM, Hasona AS and Selemain AH. 2008. Protective Effects of Extract from Dates (Phoenix Dactylifera L.) and Ascorbic Acid on Thio-acetamide Induced Hepatotoxicity in Rats. Journal of Applied Sciences Research. 5:160-67.

Biglari F, Abbas FM and Alkarkhi EA. 2008. Antioxidant activity and phenolic content of various date palm (Phoenix dactylifera) fruits from Iran. Food Chemistry, 107: 1636– 1641.

Biglari F, AlKarkhi AFM and Mat EA. 2009. Cluster analysis of antioxidant compounds in dates (Phoenix dactylifera): Effect of long term cold storage. Food Chemistry. 998–1001.

Brand JC, Colagiuri S, Crossman S, Roberts DC and Truswell AS. 2011. Low-glycemic index foods improve long-term glycemic control in NIDDM. Diabetes Care.14: 95-101.

Brand-Miller JC, Petocz P and Colagiuri S. 2003. Meta-analysis of low-glycemic index diets in the management of diabetes: response to Franz. Diabetes Care. 26: 3363-64.

Bruck R, Shirin H and Aeed H. 2011. Prevention of hepatic cirrhosis in rats by hydroxyl radical scavengers. Journal of Hepatology. 35:457-64.

Budin SB, Othman F, Louis SR, Bakar MA, Das J. 2009. The effects of palm oil rich fraction supplementation on biochemical parameters, oxidative stress and the vascular wall of streptozotocin-induced diabetic rats. Clinics 64: 235-244.

Chaira N, Ferchichi A, Mrabet A and Sghairoun M. 2007. Chemical composition of the flesh and the pit of date palm fruit and radical scavenging activity of their extracts. . Pakistan Journal of Biological Science .10: 2202-2207.

Das S and Das DK. 2007. Resveratrol: a therapeutic promise for cardiovascular diseases. Recent Pat Cardiovasc. Drug Discovery .2: 133-138.

Deng Y, Xu Z, Liu W,Yang H and Wei Y. 2012. Effects of Lycopene and Proanthocyanidins on Hepatotoxicity Induced by Mercuric Chloride in Rats. Biological Trace Element Research. 146(2): 213-23.

El-Beltagy AE, Nassar AG, El-Ghobashy AK, Yousef HYM. 2009. Microwave a potent date syrup producing method. Egypt journal of Applied Science. 24 8:454–464.

El-Mougy SA, Abdel-Aziz SA, Al-Shanawany M, Omar A. 2001. The gonadotropic activity of Palmae in mature male rats. Pharmaceuticals Science 5:156–159.

El-Sohaimy SA and Hafez EE. 2010. Biochemical and Nutritional Characterizations of Date Palm Fruits (Phoenix dactylifera L.). Journal of Applied Sciences Research. 6:1060-67.

Farag AA. 2011. Effect of Dates during the Tapering Period on Some Antioxidants, Glucose and Record Level for 50 m Freestyle Young Swimmers. World's Science Journal. (201): 1106-1110.

Folli F, Corradi D and Fanti P. 2011. The Role of Oxidative Stress in the Pathogenesis of Type 2 Diabetes Mellitus Micro- and Macro-vascular Complications: Avenues for a Mechanistic-Based Therapeutic Approach. Current Diabetes Review. 7(5): 313-324.

Fullerton SA, Samadi AA, Tortorelis DG, Choudhury MS, Tazaki H, Konno S. 2010. Induction of apoptosis in human prostatic cancer cells with beta glucan Maitake mushroom polysaccharide. Molecular Urology, 4: 7 13.

Gad AS, Kholif AM, Sayed AF. 2010. Evaluation of the nutritional value of functional yogurt resulting from combination of date palm syrup and skim milk. Journal of Food Technology. 5 (4): 250–259.

Gilbertson HR, Brand Miller JC, Chondros P Werther GA. 2001. The effect of flexible low glycemic index dietary advice versus measured carbohydrate exchange diets on glycemic control in children with type 1 diabetes. Diabetes Care. 24: 1137-43.

Hrvoje J, Cedomila M, Biserka. 2009. Dose- and time dependent effects of luteolin on carbon tetrachloride induced hepatotoxicity in mice Experimental and Toxicologic Pathology. 61: 581-89.

IA. Ahmed, WK. Ahmed RK, Robinson. 1995. Chemical composition of date Varieties as influenced by the stage of ripening. Food Chemistry. 54:305–309.

Ishurd O, Kennedy JF. 2005. The anticancer activity of polysaccharide prepared from Libyan dates (Phoenix dactylifera L.). Carbohydrate Polymer 59: 531–535.

Ishurda O, John FK. 2005. The anti-cancer activity of polysaccharide prepared from Libyan dates (Phoenix dactylifera L.). Carbohydrate Polymers. 59: 531-535.

Islam AS, Miah MA, Habib MA Moula MG. 2014. Performance of some mainland trees and palm species planted in the coastal islands of Bangladesh. Journal of Asiatic Society of Bangladesh, Science. 40(1): 9-15.

Jassim SA and Naji MA. 2010. In vitro Evaluation of the Antiviral Activity of an Extract of Date Palm (Phoenix dactylifera L.) Pits on a Pseudomonas Phage. Based Complement Alternate Medication 7: 57-62.

Jenkins DJ, Kendall CW, McKeown-Eyssen G. 2008. Effect of a low glycemic index or a high cereal fiber diet on type 2 diabetes: a randomized trial. Molecular Urology. 4: 7- 18.

Karasawa K, Uzuhashi Y, Hirota M, Otani H. 2011. A matured fruit extract of date palm tree (Phoenix dactylifera L.) stimulates the cellular immune system in mice. Food Chemistry 59:11287–11293.

Ljubuncic P, Portnaya I, Azaizeh H and Bomzon A. 2005. Antioxidant activity of Crataegus aronia aqueous extract used in traditional Arab medicine in Israel. Journal of Ethnopharmacol. 101: 153-61.

M. Elleuch, S. Besbes, O. Roiseux, C. Blecker, C. Deroanne, H. Attia.2008. Date flesh: chemical composition and characteristics of the Dietary fiber, Food Chem. 11 :676–682.

Mansouri A, Embarek G, Kokkalou E, Kefalas P. 2005. Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit Food chemistry. 89:411–20.

Mansouri A, Embarek G, Kokkalouc E, Kefalas P. 2005. Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit (Phoenix dactylifera). Food Chemistry. 89: 411-420.

Mard SA, Jalalvand K, Jafarinejad M and Naseri M K. 2010. Evaluation of the antidiabetic and antilipaemic activities of the hydroalcoholic extract of phoenix dactylifera palm leaves and its fractions in alloxan-induced diabetic rats.Malays Journal of Medical Science.17: 4-13.

Mattila P, Hellstrom J, Torronen R. 2006. Phenolic acids in berries, fruits, and beverages. Journal of agricultural and food chemistry. (19):7193–97.

Mayo-Wilson E, Imdad A, Yakoob MY and Bhutta Z A. 2011. Vitamin A supplements for preventing mortality, illness, and blindness in children aged under 5: systematic review and meta-analysis. Medical Science.1: 40-53.

Mohammad B and Habibi N. 2011. Date Seeds: A Novel and Inexpensive Source of Dietary Fiber, International Conference on Food Engineering and Biotechnology. Journal of Pharmaceutical Research. 18:189-99.

Mokhtari M, Sharifi A and Sabzevari A. 2008. Effect of palm seed alcoholic extract on the blood glucose and lipids concentration in male diabetic rats. Biotechnology 10(4):8–15.

Ovbiagele B, Markovic, Fonarow GC. 2011. Recent us patterns and predictors of prevalent diabetes among acute myocardial infarction patients. Cardiological Research.14: 561-95.

Pitsch, NT, Witsch B and Baier M. 2010.Comparison of the chloroplast peroxidase system in the chlorophyte Chlamydomonas reinhardtii, the lycophyte Selaginella moellendorffii and the seed plant Arabidopsis thaliana. Plant Biology. 10: 133.

Rock W, Rosenblat M and Borochov-Neori H. 2009. Effects of date consumption by healthy subjects on serum glucose and lipid levels and on serum oxidative status. Food Chemistry. 57: 8010-27.

Ross C, Morriss A and Khairy M. 2010. A systematic review of the effect of oral antioxidants on male infertility. Reproductive Biomedical Online. 20: 711-23.

Saafi EB, Louedi M, Zakhama A, Najjar MF and Achour L. 2011. Protective effect of date palm fruit extract on dimethoate induced-oxidative stress in rat liver. Experimental and Toxicologic Pathology. 63: 433–441.

Sanzari J K, Wambi C, Lewis-Wambi JS and Kennedy AR. 2011. Antioxidant dietary supplementation in mice exposed to proton radiation attenuates expression of programmed cell death associated genes. Radiation Research. 175:650-56.

Sawaya A, Miski JK, Khalil AA, Khatchadourian S,Mashadi. 1983. Physicochemical characterization of the major date Varieties grown in Saudi Arabia, Date Palm Journal. 4 (5): 1–25.

Shafiei M, Karimi K and Taherzadeh MJ. 2010. Palm date fibers: analysis and enzymatic hydrolysis. International Journal of Molecular Science.11:4285-96.

Souhail D, Lobna B, Christophe, Claude A, Hamadi. 2009. Adding value to hard date (*Phoenix dactylifera* L.): compositional, functional and sensory characteristics of date jam. Food Chemistry. 112: 406–411.

Steinbrenner H, Sies H. 2009. Protection against reactive oxygen species by seleno-proteins. Biochimica et Biophysica Acta. 1790: 1478-1485.

Tang ZX, Shi LE, Aleid SM. 2013. Date fruit: chemical composition, nutritional and medicinal values, products. Journal of food and agriculture 93(10):2351–61.

Tapas AR, Sakarkar AM, Kakde RB. 2008. Flavonoids as nutraceuticals: A review. Tropical Journal of Pharmaceutical Research. 7:1089-99.

Vayalil PK. 2012.Antioxidantandant imutagenic properties of aqueous extract of date fruit (*Phoenix dactylifera*). Journal of Agriculture Food Chemistry.50: 610–17.

Vinson JA, Zubik L, Bose P, Samman N and Proch J. 2005. Dried fruits: excellent in vitro and in vivo antioxidants. Journal of Animal Nutrition. 24: 44-50.

Yeh CT, Ching L C, Yen G C. 2008. Inducing gene expression of cardiac antioxidant enzymes by dietary phenolic acids in rats. The Journal of Nutritional Biochemistry, 20: 163-171.

Brief Biography

Kafil Uddin passed the Secondary School Certificate Examination in 2008 and then Higher Secondary Certificate Examination in 2010. He also received Bachelor of Food Science and Technology (BFST) degree from Faculty of Food Science and Technology in 2015, Chittagong Veterinary and Animal Sciences University, Khulshi, Chittagong. Now, he is a candidate for the MS degree in Food Chemistry and Quality Assurance under the Department of Applied Chemistry and Chemical Technology of faculty of Food Science and Technology.

His research interests are in the areas of Product development, improving nutritional value of food, reduction of malnutrition among children.