

CHAPTER II

LITERATURE REVIEW

2.1 Botanical Aspects of the Date Palm

According to Zaid and Jiménez (1999) the botanical name of the date palm, *Phoenix dactylifera* L. is derived from Phoenician word "*phoenix*" which means date palm and "*dactylifera*" a Greek word "daktulos" meaning a finger. This botanical name is also associated with the legendary Egyptian bird "*Phoenix*" that can live until 500 years old and then renew its growth by casting itself into a fire.

The date palm tree has resemblance to the phoenix as it can re-grow after being damaged by fire. Therefore, the date palm shared its name with the majestic *phoenix*. "*dactylifera*" is said to have originated from the Hebrew word "*dachel*" which denotes the shape of the fruit. *Palmaceae* which belongs to *Angiosperms-Monocotyledones* is a family of about 200 genera and 1,500 species. *Phoenix* (*Coryphoideae Phoeniceae*) is one of the genera that consist of a dozen species which are all native to the tropical or subtropical regions of Africa or Southern Asia including *Phoenix dactylifera* L. Jaradat and Zaid (2004) have classified date palm as follows:

Group :	Spadiciflora
Order :	Palmea
Family :	Palmaceae
Subfamily :	Coryphoideae
Genus :	Phoenix
Species	Dactylifera L

2.2 Origin of Date Palm

The exact origin of *Phoenix dactylifera* L. (date palm) is unknown but there is evidence that the date palm has been planted as early as 4000 B.C. as it was utilized in the building of the Temple of the Moon God near Ur in Southern Iraq during the Mesopotamian civilization (Elhoumaizi et al, 2002).

More evidence of the existence of the date palm was found in the Egypt's Nile Valley where by it was used in the Egyptian hieroglyphics to symbolize a year and its frond was used to symbolize a month. Nevertheless, the cultivation of date palm was not important in Egypt until later date in Iraq. According to Chao and Krueger (2007) archaeological research done on ancient historical remains of the Sumerians, Acadians and Babylonians collaborate with the history of date palm. The homes of the ancient civilization had roofs made of palm tree trunks and fronds. The usages of dates for food and medicinal purposes have been documented. Date palm is perhaps the oldest cultivated plant in the world. Date palms and dates have been mentioned in Judaism, Christianity and Islam.

Dates are considered as one of the seven holy fruits and the Jews who celebrate Palm Sunday. The sacredness of dates and date palms have been stressed in Islam. The Holy Quran had mentioned dates and date palms in 17 Suras (chapters) out of the total 114 Suras and in 20 verses out of 6,263 verses. According to the Hadith of the Prophet *Muhammed* the best property a Muslim owns is date palm. Prophet *Muhammed* is reported to mention that dates can cure many disorders and Muslims are urged to consume the dates and cultivate the date palms. Where the date palm originated is still remain unknown. Although date palms are widely cultivated, no truly wild plants have

been discovered. It is believed to have originated from *Phoenix reclinata* Jacq found in tropical Africa or *Phoenix sylvestris* (L) Roxb Found in India or a hybrid between these two. Both these species have palatable, but inferior fruits. In the past century, date palm and its cultivated have spread in two distinct directions namely:-

- a. One that starts from Mesopotamia to Iran reaching Pakistan and the Indus Valley.
- b. Another starting from Egypt towards Libya, the Maghreb and Sahel countries.

Initially the date palm was found in localized area such as Algeria/Souf; Tunisia/Djerid; Oued Rhir, Tidikelt and Saoura; Mauritania/Adrar; Morocco/Tafilalet and Draa Valleys. In the south, it was found in Adrar of Iforas; Mali/Tassili and Hoggar; Niger/Djado-Kaouar and Chad/Borkou-Tibesti (Zaid & De Wet, 1999).

2.3 Date Products

Dates are delicious to consume as a fresh fruits. Dates will add superb taste to the final product if used in baking. Dates are also used in food preparations such as in the production of confectionery, baking products, sweets, snacks, institutional feeding and health foods (Besbes et al., 2009).

A brief summary of products that use dates are as follows:-

a. Home-Made Delicatessen

- i. Bakery pastry, confectionery products and beverages
- ii. Sandwich spreads
- iii. Appetizers, salads and party snacks

b. Semi-Finished Date Products

- i. Whole pitted dates b. Macerated chips
- ii. Date paste and date paste mixtures
- iii. Extruded date pieces and diced dates
- iv. Dehydrated dates, date flour (dietetic baby foods)
- v. Breakfast foods (dates with cereals, almonds, nuts and other dried fruits)

c. Ready For Consume Date Products

- i. Sweets and snacks (date nut roll)
- ii. Stuffed dates (with nuts) and chocolate-coated date
- iii. Date butter or cream and date jams.
- iv. Preserved dates and caramel products
- v. Date desserts (with juice, ice-cream, whipped cream, etc.)

d. Extracted Date Fruit Products (Date Juice and Syrup)

Dates are a source of energy and have nutritional value, exoticism, originality and laxative effect, their level of energy is in the form of invert sugars except for the Deglet Noor and Theory varieties in which about half the sugar content is sucrose or cane sugar.

Besides having a high nutritional value, the date palms also play a vital role in the upkeep of the environment in various deserts and semi-deserts. Date palms play a major role in irrigable desert lands by protecting the under-crops from the severity of the climate for example the cold weather, heat and wind. Date palms also reduce damages which are caused by wind erosion and sand storms. Moreover, with the micro climate created by date palm plantations, the farming of some annual crops and fruit palms can

be done (Elleuch, et al 2008).

2.4 Date Palm Fruit

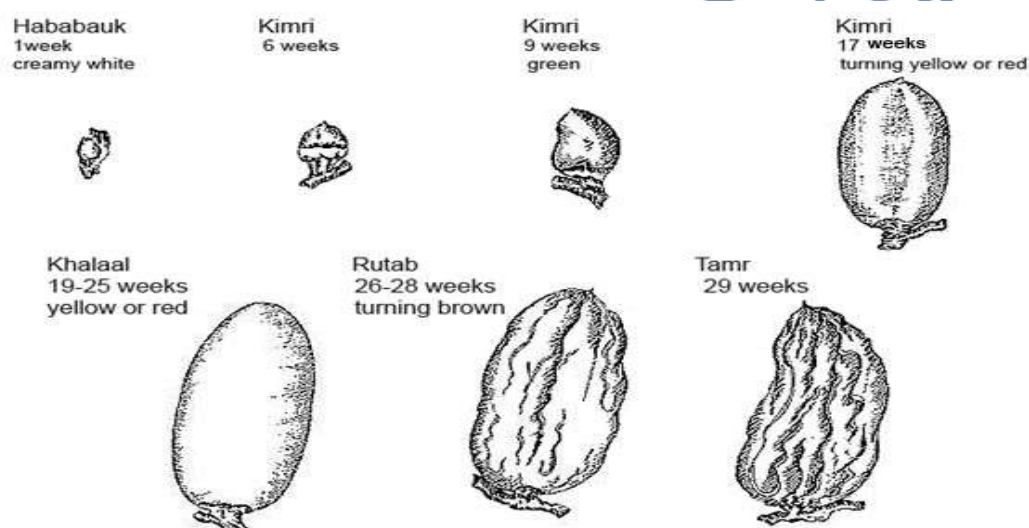
Date palm is one of the earliest species of plants that is cultivated by man. Date fruit is a healthy meal that can be kept, preserved and transported without a fuss to long distances especially in dry areas. Dates are an important source of food and income for the natives in the Middle East and North Africa countries. Thereby, it plays major role in the social, economic, and environmental issues in these places (Chao & Krueger, 2007).

Date palm fruits are rich in nutritional and functional values in comparison with other types of food (El-sohaimy & Hafez, 2010). It has carbohydrates with a total amount of sugar of 44 % to 88 %, 0.2 % to 0.4 % of fat, 2.3 % to 5.6 % of proteins, 6.4 % to 11.5 % of fibres, minerals and vitamins (Sulieman et al., 2012). The date palm fruit contains at least 15 types of minerals. The amount of minerals contained in the dried dates ranges from 0.1 to 916 mg/100g of dates based on the kind of mineral. In many kinds of dates, the potassium content can be as high as 0.9 % in the flesh and 0.5 % in some seeds. The date palm fruits also contain other minerals and salts for instance boron, calcium, cobalt, copper, fluorine, iron, magnesium, manganese, potassium, phosphorous, sodium, selenium and zinc. The date palm seeds also contains aluminum, cadmium, chloride sulphur and lead in various portions (Al-Shahib & Marshall, 2003).

2.4.1 Maturity Stages of Palm Date Fruits

There are five stages of maturity for a palm date fruits as shown in Figure 1. Where by the full progress will take around seven months. When the fruit reach maturity, it might have a yellow to reddish brown hue.

FIGURE 1: Formation and Ripening of the Dates (Barreveld, 1993).



The sweetness of dates is closely linked to the maturity and ripening stage of the fruit. Multiple internal and external changes that happen while the fruit is growing and maturing can be noticed through the color and chemical content of the fruit. The dates are classified into five stages called Hababouk, Kimri, Khlalal, Rutab and Tamar; kimri (unripe), Khalal (full-size, crunchy), Rutab (ripe and soft) and Tamr (fully ripe) according to when they are harvested. Normally dates are harvested at fully ripen stage. Most dates are eaten at the Rutab and Tamr stages. The amount of packaged dates have been increasingly and rising steadily recently due to the backing and assistance given to the date palm production industry by the relevant authorities (Al-Hooti et al., 1997).

I. The Hababouk Stage

This is the first stage of growth that goes on for approximately four to five weeks. The unripe fruits are fully layered with calyx leaving only one sharp edge of the ovary noticeable

II. Khimri Stage

The Khimri stage also known as the green stage and the growth goes on for nine to fourteen weeks; the longest stage. The green fruit is quite tough, with a dry weight combination of 80% moisture and 50 % sugar (glucose and fructose). It is normally bitter and not edible. The shape can be from a tiny berry to an oblong.

III. Khalal Stage

At this level, the maturity is based on the variety; the color will change from green to greenish yellow, yellow, pink, scarlet or red. This level lasts for six weeks and the fruit is fully matured, hard and ripe. A quick rise in the concentration of sugar decreases the concentration of water in the fruit around 50 % to 85 %.

VI. Rutab Stage

This stage also known as the soft ripe stage and it lasts for two to four weeks. The apex starts ripening; the fruit turns soft and it starts to turn brown or black.

V. Tamer Stage

This is the fully ripe stage or the final level in ripening of the fruit which goes on until the date palm fruit looks dried. The semi-dehydrated and dehydrated dates have 50 % sucrose and decline in sugar content. The flesh becomes soft and wrinkles appear in most varieties of date palm fruits as the inner flesh shrivels (Baliga et al., 1983).

2.4.2 Vitamins, Minerals and Phytochemical Components

Dates contain calcium, copper, magnesium, iron, phosphorus, potassium, zinc, manganese, selenium, vitamins A, A1, B, B1, B2, B3, B5, B6, and C as well as an array of amino acids. Proper muscle contractions including that of cardiac muscles are promoted by potassium; an essential mineral in the body. A healthy nervous system and efficient metabolism can also be promoted by engaging a diet rich in potassium (Ali & Khamis, 2004) In addition, dates contain niacin, riboflavin, thiamine and pantothenic acid. These vitamins and minerals are essential to help the body to produce haemoglobin, a protein in red blood cells which binds to oxygen and carries oxygen from the lungs to tissues.

Besides being an excellent source of dietary fiber, dates are also sodium free, fat free and cholesterol free. These factors therefore reduce the risk of heart disease and cancer. Fiber in dates can be of soluble and insoluble nature. Low density lipoprotein (LDL) cholesterol can be lowered and high blood sugar levels can be reduced. The body's ability and rate at which food is processed through its entirety can be accelerated by the presence of insoluble fibers (Al-Farsi et al., 2005).

2.5 Importance of Date Palm

Date palm is a common agricultural crop in the Near East and North Africa. It survives in many of the hot and barren parts of the world, becoming closely adopted as an integral part of the culture and tradition of these parts of the world (Sawaya, 2000). It is also considered as a main fruit commodity in many Arab countries. Due to the different environmental conditions that each country experiences, intention paid and social conventions, the number of date palms, the production cycle and consumption also varies between countries (Kader and Hussein, 2009).

Besides serving as an energy food, date palms also create a more conducive habitat for the local community by providing much needed shade and protection from the desert winds. Apart from that, agricultural production and domestic utensils are also influenced by date palm yields. Date palms with the advent of modern technology can provide raw materials for industrial purposes. Every part of the date palm tree has its own purpose and benefits best suited to them except for the roots. The fruit of the date is a drupe and has monogamous seeds, which vary in size, shape, colour and quality of flesh. It has been historically, a source of food for the people of Arab nations. It proves to be the best resource in times of food shortages and crises. This crop has proven capable of sustaining large population groups by aiding them to settle in rural areas versus migration to urban centres. It shelters and parties against wind and also prevents soil degradation and desertification, thus protecting the environment. It is an eloquent example of integrated sustainable use of renewable material source. The fruits, bark and leaves are the most procured parts of the date palm as they possess great commercial and medicinal value. Dates are rich in protein, vitamins and mineral salts, which is a

primary produce of the date palm. As such, it is an essential element of diet for the cultivator himself and his animals (EI-Mously, 1998).

Dates have increased in popularity not only as a food source; being a staple food in many countries, but also as a component in food preparations like sweets, confectionery, baking products, institutional feeding and health foods (Barreveld, 1993).

2.6 Atomic Absorption Spectroscopy (AAS)

Atomic absorption spectroscopy (AAS) is a routine analysis beside other applications requiring a high degree of precision and accuracy, such as food, drug safety, clinical diagnostics and environmental monitoring. Atomic Absorption Spectrometers can be utilised with flame, graphite furnace or vapor hydride generation atomizers. These atomizers aspirate the sample into the light path, where it is illuminated by a hollow-cathode lamp (HCL), which subsequently emits light at the wavelength characteristic of the desired elements. A detector device which measures the light and the ratio of the absorbance are used to determine the analyte concentration (Garcia & Baez, 2011). Atomic absorption method has two vital requirements:-

- a. Source of radiation that can be taken in by the atoms from the subject to be studied.
- b. A medium for changing the subject into a gaseous matter which will take in radiation from a basic source of the matter to be recognized.

The first requirement is met by using Hollow cathode lamp as a source of radiation, the lamp gives out the emission spectrum of precise element when agitated by an electric

signal. The agitated atom emits a beam which is passed across the path of an elongated burner. The next requirement is a burner atomizer. Here the subject studied is aspirated to create a fine mist which is burned in the oxidizer fuel system which is relevant to the test being done. The oxidizer fuel system in use are oxyacetylene, air acetylene, nitrous oxide acetylene, air hydrogen and air coal gas. The most basic and commonly utilized is the air acetylene system. The burning of the subject creates a population of atoms required to take in the radiation from the beam of the hollow cathode lamp (Robinson, 1960).

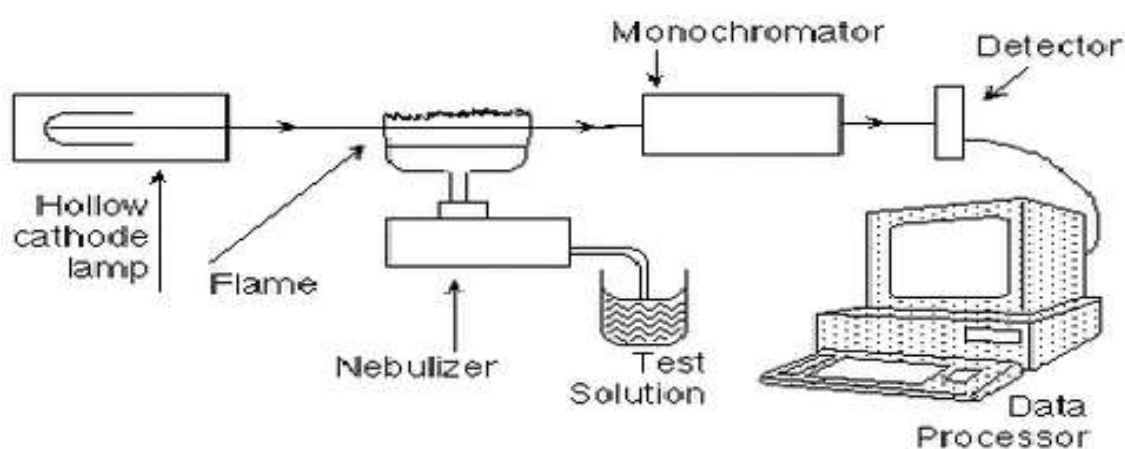
2.6.1 Flame Atomic Absorption Spectroscopy (FAAS)

Using flame atomic absorption spectrometry (FAAS) is a commonly used to identify elements as it is easy to install, robust, fairly easy to maintain and possesses good discernment (Nascentes et al., 2004).

It requires that a liquid sample be aspirated, aerosolized, and mixed with combustible gases, such as acetylene and air or acetylene and nitrous oxide. A flame whose temperature ranges from 2100 to 2800 °C is used to ignite the mixture. Atoms of the element of interest in the sample will be reduced to free, unexcited ground state atoms during a combustion process. These atoms are able to absorb light at characteristic wavelengths. The characteristic wavelengths are element specific and accurate. A light beam from a lamp whose cathode is made of the element being determined is passed through the flame in order to provide element specific wavelengths. Flame atomic absorption hardware is divided into six fundamental groups as shown in Figure 2 that serve two major purposes: generating atomic signals and signal processing. Signal processing is an additional feature integrated or externally fitted to the instrument.

A stable light source which is provided by a cathode lamp is required to produce sharp characteristic spectrums of the element to be analysed. Each element is identified by different cathode lamp, although there are some lamps that are able to detect three of four different elements if the cathode contains all of them. During each change of lamp, proper alignment must be carried out to get the maximum penetration of light through the flame, whereby the analyte is atomized and delivered into the monochromator. The atom cell is the part with two major functions: nebulization of sample solution into a fine aerosol solution, and the separation of the analyte elements into free gaseous ground state form. As the sample penetrates the flame the beam of light passes through the flame into the monochromator. The monochromator filter specific spectrum line emitted by the light source through spectral dispersion, and focuses it upon a photomultiplier detector, whose function is to change the light signal into an electrical signal. The processing of electrical signal is fulfilled by a signal amplifier. The signal could be observed for readout or further relayed into a data station for printout by the requested format.

FIGURE 2: Flame Atomic Absorption Spectroscopy (FAAS) (NMSU, 2013).



Flame atomic absorption spectrometry has been used to determine minerals ion composition of six different cultivars of Bahraini dates palm (*Phoenix dactylifera*) seeds like pottasium (K), ferum (Fe), manganese (Mn), cadmium (Cd), lead (Pb) and Zinc (Zn) whereas the essential metal ions in the six cultivars was found K. Consequently the decreasing order of essential trace metal ion concentrations Fe, Mn and Zn and Lead ion content was found to be higher than cadmium ion as metal ion pollutant (Ali-Mohamed & Khami, 2004).

FAAS is also commonly utilized for the recognition the trace elements in apricot samples like Fe, Cu, Mn, Zn and Ni ions. Fe was found to be the dominant elemental ion followed by Zn and Mn ions (Saracoglu et al., 2009).

2.7 Multivariate Data Analysis

Multivariate data analysis is techniques are those able to detect pattern and relationship between several variable simultaneously (CAMO, 2011). Simply, it is a set of techniques dedicated to the analysis of data with more than one variable (Abdi, 2003).

In analysing data, the concentration between individual variable is critical where it is performed simultaneously with other variables and it indicates the relative importance of the characteristics investigated and produces more impactful information (CAMO, 2011). In data analysis , where it consist of more than two variate the relationship among sets variables is known as Multivariate analysis (Johnson & Wichern., 2007).

2.7.1 Principal Component Analysis (PCA)

Principal Components Analysis (PCA) is most popular multivariate statistical technique and it is widely used by almost all scientific disciplines (Abdi and Williams, 2010). Also it is commonly utilized method for analyzing data and processing large amount of data (Tipping & Bioshop, 1999). PCA involves a calculation of a covariance matrix of a dataset to reduce the redundancy and maximize the variance (Abdi and Williams, 2010). PCA is defined as a method of data reduction to elucidate the relationship between two or more characterize and to divide the total variance of the original characters into a limited number of uncorrelated new variables (Tipping & Bioshop, 1999).

Abdi (2003) has stated that the goal of PCA is to decompose the data table with correlated measurement into new set of uncorrelated variables, those variables are called Principal components, factors, singular vectors, eigenvectors or loading. Each unit is also assigned a set of scores which correspond to its projection on the components. The result of the analysis is often presented with graphs blotting the projection of the unit onto the components and the loading of the variables. The importance of each component is expressed by the variance (i.e., eigenvalue) of its projection or by the proportion of the variance.

PCA is also a way to sum up the original data with a large amount of variable into simpler data with only few variables (Wise et al, 2006). Similar to clustering, PCA often used to find patterns in data to see if some sample differ from others score plots. PCA find the directions with the largest variance, meaning the largest spread of the

points, and fits the line of the direction in such a way that the minimum squared distance from the line to each point is minimized (Beebe et al., 1998).

The first step in PCA is to calculate eigenvalues, which define the amount of total Variation that is displayed on the PC axes. The first PC summarizes most of the variability present in the original data relative to all remaining PCs. The second PCs explain most of the variability summed up by the first PC and uncorrelated with the first because PCs are orthogonal and independent of each other. Each PC unveils different properties of the original data and may be interpreted independently. The proportion of variation accounted by each pc is expressed as eigenvalue divided by the sum of the eigenvalue. The eigenvalue defines the relation of the PC axes to the original data axes (Jolliffe, 1986).

PCA model that consist of few principal components is created to approximate and simplify the data. The PCs are fitted so that the Principal component is aligned with the direction with the most variance. The second PC is the fitted so that it goes to that direction orthogonal PC1 that has the next largest variance in the points. The third PC and all the rest of the PCs are always orthogonal to all of the preceding PCs similarly go to the direction of the largest remaining variance. The PCs are in order of significance : PC1describe the most variance and is therefore most important because there is random noise distributed to the whole row space and the amount of variance explained by the first PC is largest the signal to noise to ratio to PCs decreasing for each following PC. Eventually, the later PC have signal to noise so they mostly describe just noise and are therefore useless (Abdi and Williams, 2010: Jolliffe ,2002: Beebe et al, 1998).

Mathematically PCA is an orthogonal linear transformation and uses the assumption that all basic vectors are an orthonormal matrix. PCA deals with discovering the variances and coefficients of a set of data by seeking mensions) is their tendency to be together as the eigenvalues and eigenvectors. The PCA is calculated by defining the eigenvalues and eigenvalues of the covariance matrix. The covariance matrix is utilized to calculate how much the dimensions differ from the mean. The covariance of two random situations (di-mansions) is as below: -

$$Cov(x: y) = E[E[X] - X].E[E[Y] - [Y]$$

Where $E[X]$ and $E[Y]$ denote the expected value of X and Y respectively for a sampled dataset, this can be explicitly written out is as below:-

$$cov(X, Y) = \sum_{i=1}^N \frac{(x_i - \bar{x})(y_i - \bar{y})}{N}$$

With $\bar{x}$ = average(x) and $\bar{y}$ = mean (y), where N is the size of the dataset. The Covariance matrix is a matrix A with elements $A_{i: j} = cov(i, j)$. It centers the data by subtracting the mean of individual sample vector (Jeong et al., 2009).

PCA is commonly utilized in every type of studies from neuroscience to computer graphics because it is a basic, non-parametric technique of extracting useful data from complicated datasets. With a little effort, PCA gives a road map on how to decrease a complicated data set to a smaller dimension to unveil the a simple paradigm beneath it.

PCA was used to examine the variation structure in dates of the two varieties stored

under different storage conditions, based on measured variables. Calculations of eigenvectors were made using correlation matrices with Kaiser's Varimax rotation of axes, and cumulative percentage variance was used for determining the appropriate number of components (Ismail, 2006).

The most interesting information gained from PCA is the scores and loadings. The distance of the samples (points) from a particular PC is called the scores on respective PC. The scores hold information on the samples, sample with similar scores are closed to each other in the row space and are therefore somehow similar the loading on other hand hold information on the variables and measure alignment of the particular PC with the variable axes PC the high value of loadings will describe the significant of the variable (Wise et al, 2006).

2.7.1.1 Eigenvalue

PCA is a powerful technique for pattern recognition that explain the variance of large set of inter correlated value and transforming them into a smaller set of independent (uncorrelated) variables (Svetlana et al., 2012) and the size of each principal component (PC) can be measured and called an eigenvalue. The earlier (more significance) the components are the larger their size and the higher the degree of correlation among the variables in data.

Eigenvalue of a PC is defined as the sum of squares of the scores and the eigenvalue is presented in percentage successive eigenvalue correspond to smaller percentage. The closer value to 100 %, the more faithful is the PC model (Breteton, 2003).

2.7.1.2 Scores and Loadings

PCA results in transformation of the original data matrix into scores and loadings. The scores have as many rows as the original data matrix and the loadings have as many columns as the original data matrix. Each scores matrix consists of a series of column vectors and each loadings matrix consists of a series of row vectors. The scores matrices and loadings matrices are composed of several each vectors, one for each principal component (Jolliff, 2002).

2.7.2 K-means Cluster

Cluster analysis was first developed by Tryon (1939) which includes a number of different algorithms and processes for categorizing objects into respective groups (Jain, 2010). *K*-means cluster is one of the most important area of multivariate analysis in clustering where it can facilitate analysis in various fields of applications (Jajuga, 2005). Clustering serves to reduce the amount of data by grouping similar data items to provide automated tools to help in constructing categories (Pennington & Fisher, 2009).

Data is segregated into groups as a part of the cluster analysis exercise. Objects that are put into groups, known as clusters, are categorized by using variables. Cluster analysis can be further separated by several variants, each possessing a unique set of procedures. Data that are logically similar are physically stored together during data clustering. By minimizing the number of disk accesses, efficiency in the database systems can be increased. During the process, objects of similar properties are grouped into one class of objects and the entirety of the class is accessible and available via a single point (Sridhar & Sowndarya, 2010).

K-means cluster is an algorithm which is used to classify or group objects based on attributes or features into *k* number of group. *K* is a positive integer number. The grouping is done by minimizing the sum of squares of distances between the data and the corresponding cluster centroid. Thus, the purpose of *k*-mean clustering is to group the data (Teknomo, 2006). The numerous names of clusters; Q analysis, typology construction classification analysis and numerical taxonomy are a result of the usage of clustering methods in diverse disciplines as psychology, biology, sociology economics , engineering and business. They all share a common dimension even though the names differ. Thus the classification of data serves as the primary value of cluster analysis. Cluster analysis is differ from PCA where PCA primarily aimed in grouping variables (Hair et al., 1998).

Clustering procedures are made up of two main sub divisions. The number of clusters are predefined in the first procedure, in which is known as the *k*-means of clustering method. Hierarchical cluster analysis (HCA) is used when the number of clusters was not predefined. Metrics used between different objects influence the great variety of clustering procedures. The most frequently used metrics are the Euclidean metric, Manhattan metric and others. Some rules are also applied for creating the clusters. Members of some groups allow members to share different clusters while others only allow members with exclusive membership (Scott et al., 1974).

2.7.3 Review of Research Works on Principle Component Analysis (PCA) and Clustering.

Multivariate data analysis has been used extensively by several authors to decompose mixed data structure into its components to reduce this relatively large number of variables into a simpler number.

Multivariate analysis was applied on 17 seeded strains of date palm “Phoenix dactylifera L.” grown in Basrah region to investigate variations in protein pattern of leaflets and fruits among these strains. Cluster and principle component analysis were used to identify the degree of similarity and differences between date palm strains. The leaflet and fruit protein pattern on SDS-PAGE showed differences in band number, location, thickness and density leading to variations in protein quantity and quality among the studied strains. Cluster analysis data showed a high degree of similarity between leaflet and fruit samples. The principle component analysis showed that protein banding characters for leaflets and fruits could be used for identification of date palm seeded strain (Attaha et al.,2013).

Another study carried out on 239 apricot cultivars (*Prunus armeniaca L.*) The closest pair of apricot cultivars was identified by using both cluster analysis (CA) and principle component analysis (PCA). All apricot cultivars were clustered according to common biochemical properties (their amino acid and polyphenol content and antioxidant activities) into three clusters by using three-dimensional presentation for evaluation of

similarity of individual apricot cultivars. Three separated clusters of apricot cultivars were observed (Sochor et al., 2011).

