SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

College of Agricultural Studies

Comparative Study Between Mishrigi-Wdkhateeb Date Fruits as Semi-wet Date Cultivar and Barakawi Date Fruits as Dry CultivarWith Respect to TheirNutritional Value

دراسة مقارنة بين فاكهة البلح مشرقي دوخطيب كصنف شبه رطب وفاكهة البلح بركاويكصنف جاف بالنسبة لقيمتهما التغذوية

A dissertation Submitted to Sudan University of Science and Technology in Partial Fulfillment for the Requirements of Master Science Degree in Food Science and Technology,Department of Food Science and Technology,

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بسم الله الرحمن الرحيم

قال تعالى

وَمِن ثَمَرَاتِ النَّخِيلِ وَالأَعْنَابِ تَتَّخِذُونَ مِنْهُ سَكَراً

...سَناً إِنَّ فِي ذَلِكَ لآيَةً لِّقَوْمٍ يَعْقِلُونَ ﴾

صدق الله العظيـــــم

سورة النحل الآية 67

I would like to dedicate this research work

To

my parents,

My brothers: Mosa'ab, Mohamed and

shehab and **sister** "Rehab"

and my extended family

With great regards & respects.

Eihab

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ABSTRACT

The main goals of this study was to compare nutritional value of Barakawi fruits as dry date cultivar with that of Mishrigi-Wdkhateeb fruits as semi-wet date cultivar. Therefore, the chemical composition, minerals content and energy value of both cultivars were studied.

The results obtained in this study showed that, the contents of dry matter , protein, fat, total carbohydrates, crude fiber, ash, total sugar and caloric value in both date cultivars ranged between 81.21 – 94.80 %, 02.17 – 05.70 %, 00.91 – 01.52 %, 89.73 – 94.37%, 05.97 – 06.76%, 02.55 – 03.06%, 69.20 – 86.27% and 376.66 – 380.22 k. cal./ 100 g, on dry weight basis.

The results showed significant variations between Barakawi and Mishrigi-Wdkhateeb date fruits cultivars. Barakawi date fruits cultivar had the higher concentrations of dry matter (94.80 %), total carbohydrates (94.37%), available carbohydrates (88.40 %), non-reducing sugars (44.51%) and energy (380.22 k. cal. /100 g). whereas, Mishrigi-Wdkhateeb date fruits cultivar had the higher concentrations of protein (05.70%), total sugars (86.27%), reducing sugars (60.44%), glucose (25.48%) and fructose (32.20%), on dry weight basis.

But, when comparing the minerals content of both date cultivars per 100g pulp, Mishrigi-Wdkhateeb date fruits had the higher concentrations of potassium (160.26 mg), sodium (17.01 mg) and magnesium (02.22 mg), while Barakawi date fruits had the higher concentrations of calcium (129.75) per 100 g dry matter. Ingeneral, both Mishrigi-Wdkhateeb and Barakawi date cultivars were found with low concentrations of iron, magnesium and zinc which ranged between 03.70 – 03.06, 02.22 – 01.16 and 02.10 – 01.27 mg/ 100g dry matter in Mishrigi-Wdkhateeb and Barakawi dates, respectively.

ملخص الدراسة

كان الهدف الأساسي لهذه الدراسة هو مقارنة القيمة التغذوية لثمار بلح البركاوي كصنف جاف مع ثمار صنف البلح مشرقي ودخطيب كصنف شبه رطب. لذلك تمت دراسة التحليل الكيميائي, متحوي المعادن ومحتوي الطاقة لكلا الصنفين.

ولقد أظهرت النتائج المتحصل عليها من هذه الدراسة, أن محتويات كل من المادة الجافة, البروتين, الدهن, الكربوهيدرايتات الكلية, الألياف, الرماد, السكريات الكلية و السعرات الحرارية لصنفي البلح تراوحت ما بين 81.12 – 94.80 %، 02.17 – 05.17 %، 00.91 – 01.52 %، 89.76 – 94.37 %، 05.97 – 06.76 %، 02.55 – 03.06 %، 69.20 – 86.27 %، 376.66 – 380.22 كيلو سعر حراري لكل 100 جرام علي أساس الوزن الجاف

أوضحت النتائج إختلافات معنوية بين صنفي البلح بركاوي ومشرقي ود خطيب, إحتوت ثمار بلح البركاوي علي أعلي نسبة من المادة الجافة (94.80%)، الكربوهيدريتات الكلية (94.37%)، الكربوهيدريتات المتاحة (88.40%)، السكريات غير المخترلة (44.51%) والطاقة (380.22 كيلو سعر حراري لكل 100 جرام). بينما إحتوت ثمار الصنف مشرقي ود خطيب علي أعلي نسب من البروتين (05.70%)، السكريات الكلية (86.27%)، السكريات المخترلة (60.44%)، سكر الجلوكوز (25.48%) وسكر الفروكتوز (32.20%) علي أساس الوزن الجاف.

إلا أنه بعد مقارنة محتوي الثمار من المعادن لصنفي البلح لكل 100 جرام من لب الثمار، وجد أن ثمار الصنف مشرقي ودخطيب إحتوت علي أعلي تركيز من عنصر البوتاسيوم (160.26 ملجم)، الصوديوم (17.01ملجم)والمغنيسيوم (06.09 ملجم)، بينما إحتوت ثمار الصنف بركاوي علي أعلي تركيز من عنصر الكالسيوم (129.75) لكل 100جرام من المادة الجافة. وعموماً وجد أن كل من الصنف مشرقي ودخطيب والصنف بركاوي يحتويان علي تركيزات منخفضة من الحديد، الغنيسيوم والخارصين والتي تراوحت ما بين 03.70 – 03.06، 02.22 – 01.19 و 02.10 – 01.27 ملجم لكل 100جرام مادة جافة من الصنف مشرقي ودخطيب والصنف بركاوي، علي التوالي.

1. INTRODUCTION

1.1 Date palm

Date palm (*Phoenix dactylifera* L.) is one of the oldest fruit crops grown in the arid regions of the Arabian Peninsula, North Africa, and the Middle East where it is considered as staple food **(Ahmed, 2008).** Dates can grow in very hot and dry climates, and are relatively tolerant of salty and alkaline soils **(Chao and Krueger, 2016).** In Sudan, about 30 Date palm cultivars (*Phoenix dactylifera* L.*)* are distributed throughout the country **(Obied, 2004)**. According to the **FAO (2013)**, the top 10 date-producing countries are Egypt, Saudi Arabia, Iran, United Arab Emirates (UAE), Pakistan, Algeria, Sudan, Oman, Libyan Arab Jamahiriya, and Tunisia. Whereas, the top five date-exporting countries are Iran, Pakistan, UAE, Saudi Arabia, and Tunisia.

Date fruits are considered with high nutritional value and as a major source of income to majority of the inhabitants in Sudan, especially at the northern states. In general, date fruits provide a wide range of essential nutrients such as sugars (44% - 88%), fibers (6.4% - 11.5%), proteins (2.3% - 5.6 %), vitamins and minerals such as thiamin (B_1), riboflavin (B_2), ascorbic acid (vit. C), potassium, sodium, magnesium, manganese, calcium, boron, cobalt, copper, fluorine, selenium, and zinc **(Chao and Krueger, 2016).** However, the chemical composition of date fruits was found to vary depending on cultivars, soil conditions, agronomic practices as well as the ripening stages **(Mohammed*, et. al.*, 2014).**

In fact, most of date fruits in Sudan are consumed fresh at their rutab and tamr stages, or as condiment in some dishes. Recently **Roach (2012)** mentioned that, several processed products have been made out of date fruits such as date juice, syrup, jam, gorrasa, madida, sharbout, date paste and date deserts**.**

1.2 Aims of the study

1.2.1 Main objective

The main goal of this study is to compare the nutritional value of Barakawi fruits as dry date cultivar with that of Mishrigi-Wdkhateeb fruits as semi-wet date cultivar.

1.2.2 Specific objectives

1. To determine the proximate chemical composition and minerals contents of Barakawi and Mishrigi-Wdkhateeb date cultivars.
2. To find out the energy values of both Barakawi and Mishrigi-Wdkhateeb date fruits cultivars.
3. To compare the chemical composition, minerals content and energy value of both date cultivars.

2. LITERATURE REVIEW

2.1 Date palm tree

The botanical name of the date palm tree is "*Phoenix dectylifera l.*" which is presumably derived from Phoenician name "Phoenix". While, the name "dectylifera" derived from Greek word "daktulos" which means finger or it may refers to Hebrew word "dachel" which is illustrating fruit's shape **(Zaid and Jimenez, 2003).**

Date palm tree (*Phoenix dectylifera* l.) which is known as Khajoor, Kharekh is an important fruit tree of semi-arid and arid regions of the world and it can be easily grown under poor desertic soils and saline irrigation conditions. Date palm cultivations contribute in achieving food security with high nutritive value, crop diversification, desertification control, income generation and foreign exchange earnings **(Sharma and Singh, 2013).**

2.1.1 Origin and history

Dates are supposed to have special important as sacred tree. In almost all cultures and religions of the world, Later it was important of the world's major religious groups, the Jewish, Christians and Muslims. The Jews are also believed in the date palm. For instance, in Muslims holly book "Quran" date palm have been mentioned in 17 Suras and also was said to have been the building materials of Mohammed's home and Mohammed prophet "peace be upon him" urged the Muslims to eat date fruits because it cures many heath disorders. Also, date fruits are consumed during holly month "Ramadan" by Muslims. On the other religion occasions like Christian's tradition, date palm "tree life" is believed to be mentioned in the Bible ***(Marshall and Al-Shahib, 2003).***

The tree is a member of *Arecaceae (Palmaceae)* family, which it counts for more than 3,000 varieties all around the world, since ancient

times date palm have been considered one of the most important fruit crop in the desert regions old as well as new reclaimed regions and it was cultivated as early as 4000 B. C. **(Idris, *et. al*., 2012).**

More evidence of date great antiquity is in Egyptian Nile valley where it was used as the symbol for year in Egyptian hieroglyphics and it is frond as symbol for month and also this antiquity has been confirmed by history and corroborated by the archaeological research of ancient historical remains of the Sumerians, Acadians and Babylonians **(Abdel-rahman, *et. al*., 2006).**

Date palm (*Phoenix dectylifera* L.) is one of the oldest fruit crops grown in the arid regions of the Arabian Peninsula, North Africa, and the Middle East. The most probable area of origin of the date palm was in or near what is now the country of Iraq, but date cultivation spread too many countries starting in ancient times. Dates are the major food source and income source for local populations in the Middle East and North Africa, and play significant roles in the economy, society, and environment in these areas **(Chao and Krueger, 2007).**

El-Juhany (2010) reported that, dates were introduced to northern Mexico and California by Spanish missionaries in the late of 17th century, when superior cultivars were introduced. A research station was established in Indio, California in 1904 to study date and citrus cultivation. Cultivars collected from northern Africa and the Middle East were studied by USDA scientists.

2.1.2 Geographical distribution

Daoud and Ahmed (2006) mentioned that, date palm in Sudan is cultivated in Northern, River Nile; Northern Darfur States and also in Red Sea, Kassala, Khartoum and White Nile States. Date palm is found in both the Old World (Near East and North Africa) and the New World

(American continent) where dates are grown commercially in large areas. The extreme limits of date palm distribution are between 10°N (Somalia) and 39°N (Elche/Spain or Turkmenistan). Favorable areas are located between 24° and 34°N (Morocco, Algeria, Tunisia, Libya, Israel, Egypt, Iraq, and Iran). In USA date palm is found between 33° and 35°N. Because of climatic factors, the date palm will grow, but will not fruit properly outside the above defined geographical limits. The date belt stretches from the Indus Valley in the east to the Atlantic Ocean in the west. The world total number of date palm trees is about 100 million, distributed in 30 countries and producing between 2.5 and 4 million tons of fruit per year.

If we look at the distribution region by region we find that Asia is in the first position with 60 million date palms (Saudi Arabia, Bahrain, UAE, Iran, Iraq, Kuwait, Oman, Pakistan, Turkmenistan, Yemen, etc.); while Africa is in the second position with 32.5 million date palms (Algeria, Egypt, Libya, Mali, Morocco, Mauritania, Niger, Somalia, Sudan, Chad, Tunisia, etc.). Mexico and the USA have 600,000 palms followed, by Europe (Spain) with 32,000 and Australia with 30,000 palms **(More, 2014).**

2.1.3 Date palm cultivars

Daoud and Ahmed (2006) mentioned that, date fruits divided according to their moisture content to the following cultivars:

2.1.3.1 Wet cultivars

The moisture content of these cultivars is more than 30% and consumed at khalal or rutab stage. The important cultivars in Sudan are Medina and Sukkaria whereas the international cultivars are Barhee, Halawy, Khadrawy and Medjool.

Medina date palm cultivar cultivar is earlier ripening cultivar in Sudan and it is consumed almost entirely as fresh date **(Ahmed, 2007)**.

2.1.3.2 Semi-wet cultivars

The moisture content of these cultivars ranging between 20-30%.The important cultivars in Sudan are Mishrigi Wd-laggai, Mishrigi Wd-khateeb, Dayri, Deglet Noor and Zahdi. Mishriq-Wdkhateeb is popular semi-wet date cultivar grown commercially in Sudan. It has been grows mostly in the vicinity of Abu-hamad, Mishriq-Wdkhateeb is representing 5% of palm population in Sudan **(Ahmed, 2007)**.

2.1.3.3 Dry cultivars

The moisture content of the fruits in these cultivars is less than 20%.The important varieties in Sudan are Barakawi, Gondaila, Betamouda and Thoory.

Barakawi date fruits are one of the most important dry date cultivars grown in Northern State (Sukkot, Dongola, Merowi and Wadi halfa areas. It is estimated that, Barakawi comprise about 70% of the date population in Northern State **(Dirar, 2003).**

2.1.4 Botanical description

2.1.4.1 Root system

Date palm (*Phoenix spp*.) is being a monocotyledon, which has no tap root. Its root system is fasciculate and fibrous. Secondary roots appear on the primary root which develop directly from the seed. These secondary roots are producing lateral roots (tertiary roots and so on) of the same type with approximately the same diameter throughout their length. Date palm root development and distribution depends on soil characteristics, type of culture, depth of the underground water and variety **(Zaid and Jimenez, 2003).**

All date palm roots present pneumatics, which are respiratory organs. Roots are found as far as 25 m from the palm and deeper than 6 m, but 85 percent of the roots are distributed in the zone of 2 m deep and 2 m on both lateral sides in a deep loamy soil. It is worth mentioning that, date roots can withstand in wet soil for many months, but if such conditions spread over longer periods, they become harmful to the health of the roots and to fruit production **(Zabar and Borowy, 2012).**

2.1.4.2 Trunk

The date palm trunk which is also called stem or stipe is vertical, cylindrical and columnar of the same girth all the way up. The girth does not increase once the canopy of fronds has fully developed. It is brown in colour, lignified and without any ramification. Its average circumference is about 1 to 1.10 m. The trunk is composed of tough, fibrous vascular bundles cemented together in a matrix of cellular tissue which is much lignified near the outer part of the trunk. Being a monocotyledon, date palm does not have a cambium layer **(Chao and Krueger, 2007).**

The trunk is covered for several years with the bases of the old dry fronds, making it rough, but with age these bases weather and the trunk becomes smoother with visible cicatrices of these bases. Vertical growth of date palm is ensured by its terminal bud. However, the terminal bud could experience an abnormal growth caused by a nutritional deficiency, which leads to shrinkage of the trunk, and its height could reach 20 meters **(More, 2014).**

2.1.4.3 Leaves

Leaf structure is variety depending on age of a palm and environment. The adult date palm has approximately 100 to 125 green

leaves with an annual formation of 10 to 26 new leaves. Leaves of a date palm are 3 to 6 m long, and have a normal life of 3 to 7 years **(Chao and Krueger, 2016).**

2.1.4.4 Fiber, spines and leaflets

Spines, also called thorns, vary from a few cm to 24 cm in length and from a few mm to 1 cm in thickness. They are differentially arranged on the two outer edges of the fronds while their number varies from 10 to about 60. Spines can be single, in groups of two, or in groups of three **(Zaid and Jimenez, 2003).**

More (2014) mentioned that, the base of the frond is a sheath encircling the palm. This sheath consists of white connective tissue ramified by vascular bundles. As the frond grows upwards, the connective tissue largely disappears leaving the dried, and now brown, vascular bundles as a band of tough, rough fiber attached to the lateral edges of the lower part of the midribs of the fronds and unsheathing the trunk. Varieties differ in the height to which the fiber grows up the central column of unopened fronds, and in the texture of the fiber and also somewhat in colour. Leaflets or pinnae are 120 to 240 per frond, entirely lanceolate, folded longitudinally and obliquely attached to the petiole. Their length ranges from 15 to over 100 cm and in width from 1 to 6.3 cm. Their arrangement depends on variety and could be in groups of 1, 2, 3, 4, or 5 pinnate**.**

2.1.4.5 Inflorescences

Date palm is a dioecious species with male and female flowers being produced in clusters on separate palms. These flowering clusters are produced with axis of leaves of the previous year's growth. In rare cases both pistillate (female) and staminate (male) flowers are produced on the same spike while the presence of hermaphrodite flowers in the

inflorescence. Palms which carry both unisexual and hermaphrodite flowers are known as polygamous. The unisexual flowers are pistillate and staminate in character; they are borne in a big cluster (inflorescence) called spadix or spike, which consists of a central stem called rachis and several strands or spikelet's**.** Only one ovule per flower is fertilized, leading to the development of one carpel which in turn gives a fruit called a date; the other ovules aborted. The aborted carpels persist as two brown spots in the calyx of ripe fruits **(Zaid and Jimenez, 2003).**

The female flower has a diameter of about 3 to 4 mm and has rudimentary stamens and three carpels closely pressed together and the ovary is superior. The three sepals and three petals are united together so that only tips diverge. On opening the female flowers show more yellow colour while the male ones show white colour dust, produced on shaking. The pollen sacs usually open within an hour or two after the bursting of the spathe **(Chao and Krueger, 2016).**

2.1.4.6 Fruits

The fruit is known as a date. The fruit's English name (through Old French), as well as the Latin species name "dactylifera" both of them came from the Greek word for "finger", dáktulos, because of the fruit's elongated shape. Depending on the variety, environmental conditions and the technical care given (fertilization, pollination, thinning…etc.), fruit characteristics vary tremendously. The date fruit is a single, oblong, terete, one-seeded berry, with a terminal stigma, a fleshy peri-carp and a membranous endocarp **(Zaid and Jimenez, 2003).**

Dates are oval-cylindrical, 3–7 cm long, and 2–3 cm (0.79–1.18 in) diameter, and when ripe, range from bright red to bright yellow in colour, depending on variety ***(Marshall and Al-Shahib, 2003).***

2.1.4.7 Seeds

As with the fruit, seed characteristics vary according to cultivar, environmental and growing conditions. The seed is usually oblong, ventrally grooved, with a small embryo, and with a hard endosperm made of a cellulose deposit on the inside of the cell walls. A seed's weight could range from less than 0.5 g to about 4 g, length from about 12 to 36 mm and in breadth from 6 to 13 mm **(Zaid and Jimenez, 2003).**

2.1.5 Date palm maturity stages

Date palm fruits ripened in five stages which can be described as follows:

2.1.5.1 Hababouk stage

Habbabok or Hababouk stage, it is characterized by the loss of two unfertilized carpels and a very slow growth rate, it is usually takes four to five weeks to complete and continues until the beginning of the subsequent stage. Fruit at this stage is immature and is completely covered by the calyx and only the sharp end of the ovary is visible. Its average weight is one gram and the size is about that of peas (**Daoud and Ahmed, 2006).**

2.1.5.2 Kimri stage

Khimri or Jimri, also called green stage. It is the longest stage of growth and development of dates and lasts a total of nine to fourteen weeks, during this period in the first 4 to 5 weeks, there is an average of relative weekly growth of 90 %, and while during the second period of kimri stage there is only about 22 % growth. At this stage the fruit is quite hard and apple green colour and it is not suitable for eating. The first phase is characterized by a rapid increase in weight and volume, rapid accumulation of reducing sugars, highest active acidity, high moisture content though slightly less than that of the second phase **(Zain eldein, *et. al.*, 2007).**

2.1.5.3 Khalal stage

Khalal stage is also called colour stage. The fruits in this stage are physiologically mature, hard ripe and the colour changes completely from green to greenish yellow, yellow, pink, red or scarlet depending on the variety. It lasts three to five weeks depending on varieties, with a low average relative weekly increase in fruit weight (3 to 4 %). At the end of this stage, date fruit reaches its maximum weight and size, but sugar concentration (sucrose), total sugar and active acidity have a rapid increase associated with a decrease in water content (around 50-85 % moisture content). At this stage colour of the seed changes at the end from white to brown. Some varieties are consumed in this stage, such as Barhee, Hallawi, Hayani and Zaghloul, as they are very sweet, juicy and fibrous but not sour. The Khalal season will last for a couple of weeks. Cultivars harvested and marketed at Khalal stage present the following advantages: minimum infestation, possibility of cutting the whole bunch, easy handling and packing, high yield and consequently high income. However, Khalal dates must be eaten immediately after harvesting as they will keep for only a few days without cold storage (7°C for one week or 0-1 °C for longer periods) due to their high sugar and water content which cause fermentation during hot weather. If supply and demand are in equilibrium **(Daoud and Ahmed, 2006).**

2.1.5.4 Rutab stage

Routab or rutab meaning a wet, also called soft ripe stage. At this stage the tip at the apex starts ripening, changes in colour to brown or black and becomes soft; however, some cultivars such as Khadraoui (Iraq) and Bousekri (Morocco) turn to green at this stage. It begins to lose its astringency and starts acquiring a darker and less attractive colour from the previous stage. This in total lasts for 2 to 4 weeks, there is a

continuous decrease in fresh fruit weight mainly due to loss of moisture 10 % weekly. An increase in reducing sugar, a rapidly increasing rate of conversion of sucrose, a gain of total sugars and total solids also characterize this stage. It has already been observed in respect of the reducing sugar type date, i.e. Barhee that all the sucrose accumulated during the previous, Khalal stage, inverts and there is a continuous decrease in active acidity and decrease also in moisture content (average 30 - 45 %). With softening, the last of the tannin under the skin is precipitated in an insoluble form, so that the fruit loses any astringency that may have remained in the previous stages. It is a very good stage for consumption as a hard ripe date; fruit at this stage is very sweet. It is, however, very important to harvest and market the fruit at this stage. Unless they are cold stored, the fruits quickly turn sour and become of no commercial value. For dessert purposes, most people prefer dates after they have passed the Rutab stage **(Zain-eldein, *et. al.*, 2007).**

2.1.5.5 Tamar stage

Date palm can take 4 to 8 years after planting and before they will bear fruits, and produce viable yields for commercial harvest between 7 to 10 years. Mature date palms can produce 68 to 176 kilograms of dates per harvest season, although they do not all ripen at the same time so several harvests are required. In order to get fruit of marketable quality, the bunches of dates must be thinned and bagged or covered before ripening so that the remaining fruits grow larger and are protected from weather and pests such as birds ***(Marshall and Al-Shahib, 2003).***

Dates in all the above stages except the Tamer are perishable, due to their high water content. Whole dates are harvested and marketed at three stages of their development (Khalal, Rutab and Tamer) depending

on variety; climatic conditions and market demand **(Zain-eldein, *et. al.*, 2007).**

Tamer or Tamr, also called full ripe stage or final stage in the date ripening, and they completely change the colour from yellow to dull brown or almost black. The texture of the flesh is soft. The skin in most varieties adheres to the flesh, and wrinkles as the flesh shrinks. The colour of the skin and of the underlying flesh darkens with time. At this stage, the date contains the maximum total solids and has lost most of its water to such an extent (below 25 % down to 10 % and less) that it makes the sugar water proportion sufficiently high to prevent fermentation. This is the best condition for storage. The average relative decrease in fruit weight during this stage is 35 %. The loss in fruit weight continues if fruits are left on the palm. At the Tamr stage, the fruits on a bunch do not all ripen simultaneously, but over almost a month. Hence, three to four harvest times are necessary **(Zabar and Borowy, 2012).**

2.1.6 Date nutritional value

2.1.6.1 Chemical composition

The main component in date fruits is carbohydrate which provide readily available source of energy to human body. The total sugars, reducing sugars and sucrose contents of dry date cultivars ranged between 73.00 - 82.00 %, 17.0 – 76.0 % and 1.0 – 36.0 %, respectively. Whereas, the total sugars, reducing sugars and sucrose contents of semi-wet date cultivars were found to range between 71.00- 82.00 %, 42.0 – 60.0 % and 0.0.- 17.0 %, respectively. The glucose and fructose contents ranged between 29.04 - 34.53 % and 20.72 - 23.65 %, respectively **(Zaid and Jimenez, 2003).**

Daoud and Ahmed (2006) analyzed the chemical composition of some Sudanese date fruit cultivars. The moisture, protein, fiber, ash, total

sugars and reducing sugars contents of semi-wet date cultivars were found to range between 12.30 - 12.70 %, 02.52 - 02.63 %, 01.74 - 02.14 %, 01.18 – 01.36 %, 67.69 – 70.13 % and 63.90 – 68.00 %, respectively. While, the moisture, protein, fiber, ash, total sugars and reducing sugars contents of dry date cultivars ranged between 12.12 - 12.64%, 02.42 – 03.18 %, 02.26 – 02.70 %, 01.73 – 01.89 %, 71.30 – 73.50 %, and 65.35 – 68.33 %, respectively as indicated in Table (1).

Dates protein plays a vital role in their non-oxidative browning and precipitation of their tannins during ripening. Dates protein ranged between 1.0 – 4.0 % and contains many essential amino acids which are favorable to human needs **(Elleuch*, et. al.*, 2008)**.

The chemical composition of dates was found to vary depending on cultivars, soil conditions, agronomic practices as well as the ripening stages. The moisture content of semi-wet date cultivars were about 18.77 %, whereas, the moisture content of dry date varieties were about 7.2 %. Also, the dates dietary fiber was found to range between 6.4 % - 11.5 % depending upon their cultivars and ripening stage. The main dietary fiber fractions were found to be cellulose, hemicelluloses, pectin and lignin. However, the average date lipids content was ranged between 0.14 % - 0.38 % in dry cultivar (Barakawi), whereas that of semi-wet cultivar (Mishrigi) was found to be ranged between 1.87 - 2.06 % (**Mohammed, *et. al.*, 2014)**.

Assirey (2015) reported that, date fruits contained high concentrations of aspartic acid, proline, alanine, glycine, valine, leucine and low concentrations of threonine, serine, isoleucine, tyrosine, arginine, phenylalanine, lysine methionine and histidine.

Table (1): Chemical composition of some Sudanese date fruit cultivars

Chemical composition	Moisture	Protein	Fiber	Ash	Total sugars	Reducing sugars
Cultivars	**(%)**					
Wd-khateib	12.7	2.52	2.14	1.36	70.13	68.00
Betamouda	12.64	2.42	2.26	1.73	73.50	66.58
Barakawi	12.61	2.63	2.45	1.79	71.30	65.35
Wdlaggai	12.30	2.62	1.74	1.18	67.69	63.90
Gondela	12.12	3.18	2.70	1.89	71.90	68.33

Source: Daoud and Ahmed (2006).

2.1.6.2 Vitamins and minerals content

The minerals contents of some Sudanese date cultivars were studied by **Daoud and Ahmed (2006).** The concentration of nitrogen, phosphorus, potassium, calcium, magnesium and sodium, iron, manganese and copper as (g / 100g) in semi-wet date cultivars was found to range between 0.77 – 1.21, 0.14 – 0.16, 0.90 – 1.01, 0.26 – 0.27, 0.10 – 0.18 and 0.09 – 0.11, respectively. Whereas that, the iron, manganese and copper was found to range between 67 – 76, 67 – 76 and 24 – 28 mg/kg, respectively. On the other hand, the concentration of nitrogen, phosphorus, potassium, calcium, magnesium and sodium as (mg/ 100g) in dry date cultivars ranged between 0.67 – 0.87, 0.11 – 0.14, 0.82 – 0.96, 0.22 – 0.24, 0.10 – 0.11 and 0.10 – 0.11, respectively. While that of, iron, manganese and copper ranged between 4 – 64, 40 – 64 and 16 – 18 mg/ kg, respectively as indicated in Table (2).

Table (2): Minerals content of some Sudanese date fruits cultivars

Mineral	N	P	K	Ca	Mg	Na	Fe	Mn	Cu
Variety	**(g/100g)**						**(mg/kg)**		
Wdlaggai	1.21	0.16	1.01	0.26	0.18	0.11	67	67	28
Wdkhateib	0.77	0.14	0.90	0.27	0.10	0.09	76	76	24
Gondela	0.87	0.14	0.96	0.24	0.11	0.10	40	40	18
Barakawi	0.67	0.11	0.82	0.22	0.10	0.11	64	64	16

Source: Daoud and Ahmed (2006).

As published by **Elleuch*, et. al.* (2008),** dates contain high levels of selenium, copper, potassium, magnesium and moderate concentrations of manganese, iron, phosphorus, calcium and small quantities of boron. The high potassium and low sodium contents in dates were found to be desirable for people suffering from hypertension. Boron is useful in the treatment of cancer of the brain. Boron and vitamins are also used in the treatment of rheumatism as well as a practical supplement for iron deficiency without any side effects such as nausea, headache and anorexia.

Assirey (2015) found that, date fruits contained significant amounts of minerals. The highest minerals concentration was recorded for potassium (289.6 – 512 mg/100 g, followed in descending order by calcium (123 –187 mg/100 g), magnesium (56–150 mg/100 g), phosphorus (12 – 27 mg/100 g) and sodium (4.9 – 8.9 mg/100 g). Also, dates were considered as reasonable source of vitamins such as thiamin, riboflavin, niacin, ascorbic acid, pyridoxine, and vitamin-A.

2.1.7 Date utilization

2.1.7.1 As food

Date palm fruits are considered as staple food of the Bedouin in the deserts and are usually eaten with cardamom-flavored coffee. To a desert traveler, the sight of a date palm not only mean food, but also provide valuable shelter, shade and water, as date trees grow where there is water in the desert. It is rich in vitamins, minerals, fibers and its fruit is considered as a complete nutritious meal. Also, the fruits are usually used as chopped dates in cereal products and ice cream **(Abdel Rahman, *et. al.*, 2006).**

As indicated by **Al-Yahyai and Manickavasagan (2012)**, date fruits are especially delicious as a fresh fruit, but when used in baking they provide superb taste to the final product. Dates are also used as an ingredient in food preparations like sweets, snacks, confectionery, baking products, institutional feeding and health foods. Moreover, young date leaves are mentioned to be cooked and eaten as a vegetable. The finely ground seeds are mixed with flour to make bread in times of scarcity. The flowers of the date palm are also edible. Traditionally, the female flowers are the most available for sale and weigh 300–400 grams. The flower buds are used in salad or ground with dried fish to make a condiment for bread. Date seeds are also ground and used in the manner of coffee beans, or as an additive to coffee, roasting date seeds used to make different flavored coffee. Desert travelers used this as the cheap alternative to their favorite beverage. Add cardamom and you will get a mild version of Arabic coffee.

2.1.7.2 As medicine

In Kingdom of Saudi Arabia, young unripe green dates (and the dried version) are considered as fertility foods, which yield estrogenic principle that will stimulate the function of the female ovaries. Also, the

Bedouin boiled the young unripe green dates or the dried version, and drink the water to help women for pregnancy. Fertility-boosting ingredients are usually proteins that come from plant sources. It must also be rich in antioxidants, folate, iron and calcium. These are all present in dates and may be even more potent in the unripe date. Also, date flowers were found more effective than unripe dates **(Chao and Krueger, 2007).**

As reported by **Diab and Aboul-Ela (2012),** the Bedouins, who live in the desert, are usually used date fruits as medicine due to their high nutritional values. The experimental studies revealed that feeding mice with the aqueous extract of date pits exhibit anti-genotoxic and reduce DNA damage. In addition to that, taking date fruits on a daily basis during and after pregnancy was mentioned to strengthen the uterine muscles, assist in the delivery and avert the post-delivery bleeding. Moreover, date fruits were found to activate prolactin (milk hormone), promote the flow of milk and helps woman who breastfed. The Bedouins and others from the Middle Eastern and Northern African countries also use date palms as natural sources of medicine. Date fruits were found to provide relieve from different diseases such as sore throat, colds, fever, throat and chest infections by mixing equal amount of dates, fig, hibiscus and raisin and boiled in water. Also, date fruits are mixed with fenugreek and used as astringent for bronchial asthma, intestinal problem, diarrhea and toothache treatment.

2.1.7.3 Others

Date palm leaves are used for Palm Sunday in the Christian religion. In North Africa, they are commonly used for making huts. Mature leaves are also made into mats, screens, baskets, rafters, shutters, stairs of houses and fans. Processed leaves can be used for insulating board. Dried leaf petioles are a source of cellulose pulp, used for walking

sticks, brooms, fishing floats and fuel. Leaf sheaths are prized for their scent, and fiber from them is also used for rope, coarse cloth, and large hats, Stripped fruit clusters are used as brooms. Recently the floral stalks have been found to be of ornamental value in households **(Zaid and Jimenez, 2003).** In Pakistan, viscous, thick syrup made from the ripe fruits is used as a coating for leather bags and pipes to prevent leaking **(Roach, 2012).**

Date Palm stump showing the wood structure, date palm wood is used for posts and rafters for huts; it is lighter than coconut and not very durable. It is also used for construction such as bridges and aqueducts, and parts of dhows. Leftover wood is burnt for fuel **(Sharma and Singh, 2013).**

2.1.8 Date processing

Dates are often processed into paste, syrup, jam, jelly, date cubes, date sugar powder, date vinegar and even date alcohol. Date fiber also used in cooking bread, cakes and other desserts. Dates now are used to cover chocolate products which sometimes are sprinkled with chopped pistachios, walnuts and raisins. In some African countries, dates and peppers are added to their native beer to make it less potent and intoxicating **(Abdel Rahman, *et. al*., 2006).**

Sharma and Singh (2013) The main date products are classified into the following groups:

(1) Home-made delicatessen such as pastry, bakery, confectionery products, beverages, Sandwich spreads, Party, snacks, salads and appetizers

(2) Semi-finished date products such as whole pitted dates, Macerated chips, date paste and date paste mixtures, extruded date pieces and diced

dates, dehydrated dates, date flour (dietetic baby foods) and breakfast foods (dates with other dried fruits, cereals, almonds and nuts).

(3) Ready for use date products such as sweets and snacks (date nut roll), Chocolate-coated and stuffed dates (with nuts), date jams, date butter or cream, date preserves and condiments, caramel products and date desserts (with juice, ice-cream, whipped cream, etc.).

(4) Derived date fruit products such as date juice and syrup, liquid sugar Saccharin as a low calorie sweetener for soft drinks, protein yeast and vinegar and fermented products such as wine, alcohol, organic acids, etc.

3. MATERIALS AND METHODS

3.1 Materials

Samples of ripe date fruits (*Phoenix dectylifera* L.) namely Barakawi and Mishrigi-wdkhateeb cultivars were obtained from Northern State (Dongola, Algaba) at the harvesting season (2015 / 2016). The samples were tightly kept in polyethylene bags and stored at -18 °C until needed for the different investigations.

3.2 Methods

3.2.1 Chemical methods

3.2.1.1 Moisture content

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists **(AOAC, 2003).**

Principle: The moisture content in a weighed sample is removed by heating the sample in an oven (105°C). Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure: A sample of 2 ± 0.001 g was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (No.03-822, FN 400, Turkey) at 105°C until a constant weight was obtained. After drying, the covered sample was transferred to desiccators and cooled to room temperature before reweighing. Triplicate results were obtained for

each sample and the mean value was reported to two decimal points according to the following formula:

Calculation:

$$\text{Moisture content (\%)} = \frac{(W_s - W_d) \times 100\%}{\text{Sample weight (g)}}$$

Where:

[eq.1]

W_s = weight of sample before drying

W_d = weight of sample after drying.

3.2.1.2 Crude protein content

The protein content was determined in the different samples by micro-Kjeldahl method using a copper sulphate-sodium sulphate catalyst according to the official method of the **AOAC (2003).**

Principle: The method consists of sample oxidation and conversion of its nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. After that, the solution is made alkaline and the ammonia is distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex which is titrated against a standard solution of HC1 (0.1N). The protein content is calculated by multiplying the total N % by 6.25 as a conversion factor for protein.

Procedure: A sample of two grams(2 ± 0.001 g) was accurately weighed and transferred together with, 4± 0.001g $NaSo_4$ of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and 25m1 of concentrated sulphuric acid (No.0548111, HDWIC, India) was added into a Kjeldahl digestion flask. After that, the flask was placed into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) for about 2 hours until a colourless digest was obtained and the flask was left to cool to room

temperature. The distillation of ammonia was carried out into 25m1 boric acid (2%) by using 20ml sodium hydroxide solution (45%). Finally, the distillate was titrated with standard solution of HC1 (0.1N) in the presence of 2-3 drops of bromocreasol green and methyl red as an indicator until a brown reddish colour was observed.

Calculation:

$$\text{Crude Protein (\%)} = \frac{(\text{ml HCl sample} - \text{ml HCl blank}) \times N \times 14.00 \times F}{\text{Sample weight (gm)} \times 1000} \times 100\%$$

Where:

[eq.2]

N: normality of HCl (0.1N).

F: protein conversion factor = 6.25

3.2.1.3 Fat content

Fat content was determined according to the official method of the **AOAC (2003).**

Principle: The method determines the substances which are soluble in petroleum ether (65-70°C) and extractable under the specific conditions of Soxhlet extraction method. Then, the dried ether extract (fat content) is weighed and reported as a percentage based on the initial weight of the sample.

Procedure: A sample of 5 ± 0.00l g was weighed into an extraction thimble and covered with cotton that previously extracted with hexane (No.9-16-24/25-29-51, LOBA Cheme, India). Then, the sample and a pre-dried and weighed extraction flask containing about 100 ml hexanes were attached to the extraction unit(Electro-thermal, England) and the extraction process was conducted for 6 hrs. At the end of the extraction

period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude ether extract was put in an oven at 105°C for 3 hrs , cooled to room temperature in a desiccators, reweighed and the dried extract was registered as fat content according to the following formula;

Calculation:

$$\text{Fat content (\%)} = \frac{(W_2 - W_1) \times 100\%}{W_3}$$

[eq.3]

Where;

W_1 =Weight of the empty flask

W_2 =Weight of the flask and ether extract

W_3=initial weight of the sample

3.2.1.4 Total carbohydrates

Total carbohydrates were calculated by difference according to the following equation:

Total carbohydrates (%) = 100% - (Moisture% + Protein% + Fat% + Ash %).

[eq.4]

3.2.1.5 Crude fiber content

The crude fiber was determined according to the official method of the **AOAC (2003).**

Principle: The crude fiber is determined gravimetrically after the sample is being chemically digested in chemical solutions. The weight of the residue after ignition is then corrected for ash content and is considered as a crude fiber.

Procedure: About 2 ± 0.001 g of a defatted sample was placed into a conical flask containing 200 m1 of H2SO4 (0.26 N). The flask was then, fitted to a condenser and allowed to boil for 30 minutes. At the end of the digestion period, the flask was removed and the digest was filtered (under vacuum) through a porcelain filter crucible (No.3). After that, the precipitate was repeatedly rinsed with distilled boiled water followed by boiling in 200 ml NaOH (0.23 N) solution for 30 minutes under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, 20m1 ethyl alcohol (96%) and 20 ml diethyl ether. Finally, the crucible was dried at 105°C (overnight) to a constant weight, cooled, weighed, ashed in a Muffle furnace (No.20. 301870, Carbolite, England) at 600°C until a constant weight was obtained and the difference in weight was considered as crude fiber.

Calculation:

$$\text{Crude fiber (\%)} = \frac{(W_1 - W_2) \times 100\ \%}{\text{Sample weight (gm)}}$$

[eq.5]

Where:

W_1 = weight of sample before ignition (gm).

W_2 = weight of sample after ignition (gm).

3.2.1.6 Available carbohydrates

Available carbohydrates were calculated by difference according to the following equation:

Available carbohydrates (%) = Total carbohydrates% – Crude fiber%.

[eq.6]

3.2.1.7Total sugars, reducing and non-reducing sugars

The total sugars as well as reducing and non-reducing sugars were determined according to Lane and Eynon titrometric method as described by the Association of Official Analytical Chemists (**AOAC, 2003)**.

Principle: Reducing sugars in pure solution in plant materials after suitable pre-treatment (to remove interference substances) may be estimated by using copper sulphate as oxidizing agent in a standard Fehling's solution.

Sample preparation

(A) Reducing sugars: A sample of 10 ±0.001 g was weighed and transferred to 250 ml volumetric flask. 100 ml of distilled water was carefully added and then neutralized with 1.0 N NaOH to a pH 7.5 – 8.0. Then, about 2 ml of standard lead acetate (NO. 23500, BDH, England) was added and the flask was shaked and left to stand for 10 min. After that, 2 ml of sodium oxalate were added to remove the excess amount of lead acetate and the solution was made up to volume (250 ml) with distilled water and filtered.

(B)Total sugars: From the previous clear sample solution, 50ml were taken into a 250 ml conical flask and 5± 0.001 g citric acid and 50 ml distilled water were added slowly. Then, the mixture was gently boiled for 10 min to complete the inversion of sucrose and left to cool at room temperature. After that, the solution was transferred to 250 ml volumetric flask, neutralized with 20% NaOH solution in the presence of few drops of phenolphthalein (No. 6606 J. T Baker, Holland) until the colour of the mixture disappeared and the sample was made up to volume before titration.

Procedure: A volume of 10ml from the mixture of Fehling's (A) and (B) solutions was pipetted into 250 ml conical flask. Then, sufficient amount of the clarified sugars solution was added from burette to reduce Fehling's solution in the conical flask. After that, the solution was boiled until a faint blue colour is obtained. Then, few drops of methylene blue indicator (S-d-FINE-CHEM LIMITED) were added to Fehling's solution and titrated under boiling with sugars solution until brick-red colour of precipitate cuprous oxide was observed. Finally, the titer volume was recorded and the amount of inverted sugars was obtained from Lane and Eynon Table. The total sugars, reducing and non-reducing sugars were calculated by using the following formulas:

$$\text{Total sugars (\%)} = \frac{\{\text{invert sugar (mg)} \times \text{dilution factor}\}}{\text{Titre} \times \text{sample weight (g)} \times 1000} \times 100\% \quad \text{[eq.7]}$$

$$\text{Reducing sugars (\%)} = \frac{\{\text{invert sugar (mg)} \times \text{dilution factor}\}}{\text{Titre} \times \text{sample weight (g)} \times 1000} \times 100\ \% \quad \text{[eq.8]}$$

$$\text{Non-reducing sugars (\%)} = \{\text{Total sugars (\%)} - \text{reducing sugars (\%)}\} \quad \text{[eq.9]}$$

Where:

Titre = (Sample – blank).

3.2.1.8 Ash content

The ash content was determined according to the method described by the **AOAC (2003).**

Principle: The inorganic materials which are varying in concentration and composition are customary determined as a residue after being ignited at a specified heat degree.

Procedure:

A sample of 5 ± 0.001 g was weighed into a pre-heated, cooled, weighed and tarred porcelain crucible and placed into a Muffle furnace (No.20. 301870, Carbolite, England) at 600 $^{\circ}$C until a white gray ash was obtained. The crucible was transferred to a desiccator, allowed to cool to room temperature and weighed. After that, the ash content was calculated as a percentage based on the initial weight of the sample.

Calculation:

$$\text{Ash (\%)} = \frac{[(\text{Wt of crucible} + \text{Ash}) - (\text{Wt of empty crucible})] \times 100\%}{\text{Sample weight (g)}}$$

[eq.10]

3.2.1. 9 Minerals content

Ten milliliters (10 ml) of HCL (2N) were added to the remaining ash sample and placed in a hot sand path for about 10-15 min. Then, the sample was diluted to 100 ml in a volumetric flask and filtered. The trace elements ferrous (Fe^{++}), zinc (Zn) and manganese (Mn^{++}) were determined according to **Perkin Elmer (1994)** by using Atomic Absorbance Spectroscopy (JENWAY 3110, UK). Sodium (Na) and potassium (K) were determined by using Flame Photometer (Model PEP7 JENWAY). While, calcium (Ca), and magnesium (Mg) were determined as described by **Chapman and Parratt (1961).**

3.2.1.10 Food energy value

The energy value of date fruits was calculated based on Atwater factors as indicated by **Leung (1968).**

Protein = 3.87 K. cal/g

Fat = 8.37 K. cal/g

Carbohydrate = 4.12 K. cal/g

K. cal = 4.184 kJ

3.2.2 Statistical analysis method

The results obtained in this study were subjected to Statistical Analysis System (SAS) by using One-Factor Analysis of Variance (ANOVA). The Mean values were also tested and separated by using Duncan's Multiple Range Test (DMRT) as described by **Steel, *et. a1*. (1997).**

4. RESULTS AND DISCUSSION

4.1 Nutritional value of Barakawi as dry date cultivar and Mishrigi-Wd khateeb date as semi-wet cultivar

4.1.1 Chemical composition of Barakawi date cultivar

Table (3) shows the chemical composition of Barakawi date fruits cultivar on wet and dry basis. The dry matter, protein, fat, total carbohydrates, crude fiber, ash and total sugars were found to be 94.80 %, 02.17 %, 00.91 %, 94.37 %, 05.97 %, 02.55 % and 69.20 %, respectively on dry basis. Among the total sugars, the reducing sugars and non-reducing sugars constitute about 24.68 % and 44.51 %, respectively. The main reducing sugars were found to be glucose (14.66 %) and fructose (09.39 %). The results obtained in this study in well agreement with those reported by **Zaid and Jimenez (2003); Elleuch, *et. al.* (2008) and Mohammed, *et. al,* (2014),** but they in disagree with those reported by **Daoud and Ahmed (2006),** especially for moisture, fiber, ash and reducing sugars contents in Barakawi date cultivar.

4.1.2 Chemical composition of Mishrigi-Wdkhateeb date cultivar

Table (4) shows the chemical composition of the Mishrigi-Wdkhateeb date fruits cultivar on wet and dry basis. The dry matter, protein, fat, total carbohydrates, crude fiber, ash and total sugars were found to be 81.12%, 05.70%, 01.52%, 89.73%, 06.76%, 03.06% and 86.27%, respectively on dry basis. Among the total sugars, the reducing sugars and non-reducing sugars constitute about 60.44% and 25.82 %, respectively. The main reducing sugars were found to be fructose (32.20%) and glucose (25.48%). The results obtained in this study are also in agreement with those reported by **Zaid and Jimenez (2003); Elleuch, *et. al.* (2008) and Mohammed, *et. al.* (2014).** Except for the total sugars, the other results disagree with those published by **Daoud and Ahmed (2006).**

Table (3): Chemical composition of Barakawi date fruits as dry cultivar

Date cultivar	Barakawi	
Chemical composition and energy value	**On wet basis**	**On dry basis**
	[%, n = 3 ± SD]	
Moisture or Dry matter	05.20 ± 0.14	94.80 ± 0.14
Protein	02.06 ± 0.02	02.17 ± 0.01
Fat	00.86 ± 0.02	00.91 ± 0.03
Total carbohydrates	89.46 ± 0.11	94.37 ± 0.02
Fibers	05.66 ± 0.03	05.97 ± 0.04
Available carbohydrates	83.80 ± 0.13	88.40 ± 0.02
Total sugars	65.60 ± 0.00	69.20 ± 1.78
Reducing sugars	23.40 ± 0.00	24.68 ± 0.54
Non-reducing sugars	42.20 ± 0.00	44.51 ± 2.24
Glucose	13.90 ± 0.03	14.66 ± 0.13
Fructose	08.90 ± 0.05	09.39 ± 0.14
Ash	02.42 ± 0.05	02.55 ± 0.05
Caloric value/ 100 g	360.43± 0.04 K. cal 1508.02 ± 0.06 K. J	380.22 ± 0.17 K. cal 1590.85 ± 0.70 K. J

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

Table (4): Chemical composition of Mishrigi-Wdkhateeb date fruits as semi-wet cultivar

Date cultivar	Mishrigi-Wdkhateeb	
Chemical composition and energy value	**On wet basis**	**On dry basis**
	[%, n = 3 ± SD]	
Moisture or Dry matter	18.88 ± 0.02	81.12 ± 0.03
Protein	04.62 ± 0.24	05.70 ± 0.30
Fat	01.23 ± 0.23	01.52± 0.22
Total carbohydrates	72.79 ± 0.11	89.73 ± 0.28
Fibers	05.48 ± 0.15	06.76 ± 0.18
Available carbohydrates	67.31 ± 0.13	82.98 ± 0.40
Total sugars	69.98 ± 0.32	86.27 ± 0.47
Reducing sugars	49.03 ± 0.59	60.44 ± 0.88
Non-reducing sugars	20.95 ± 1.55	25.82 ± 0.27
Glucose	20.67 ± 1.02	25.48 ± 1.26
Fructose	26.12 ± 0.42	32.20 ± 0.52
Ash	02.48 ± 0.32	03.06 ± 0.39
Caloric value/ 100 g	305.49 K. cal 1278.68 K. J	376.66 ± 2.90 K. cal 1575.95 ± 12.15 K. J

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

4.1.3 Minerals content of Barakawi date fruits cultivar

Table (5) presents the minerals content of Barakawi date fruits cultivar, on wet and dry basis as (mg/100g). From the results, the concentration of calcium found to be the highest concentration among the different minerals (129.75), followed in descending order by potassium (84.39), sodium (12.97), magnesium (3.21), iron (3.06), zinc (1.27) and manganese (1.16), on dry weight basis. In general, the results of this study are in a good agreement with those stated by **Daoud and Ahmed (2006); Elleuch, *et. al.* (2008)** and **Assirey (2015).**

4.1.4 Minerals content of Mishrigi-Wdkhateeb date fruits cultivar

Table (6) illustrates the minerals content of Mishrigi-Wdkhateeb date cultivar, on wet and dry basis as (mg/100g). From the results, the concentration of potassium was found to be the highest concentration among the different minerals (160.26), followed in descending order by calcium (72.73), sodium (17.01), magnesium (6.09), iron (3.70), manganese (2.22) and zinc (2.10), on dry weight basis. In general, the results of this study are also well agreed with those reported by **Daoud and Ahmed (2006); Elleuch, *et. al.* (2008)** and **Assirey (2015).**

4.2 Comparison between Barakawi fruits as dry date cultivar and Mishrigi-Wdkhateeb fruits as semi-wet date cultivar with respect to their nutritional values

4.2.1 Comparison between Barakawi and Mishrigi-Wdkhateeb date fruits with respect to their chemical composition and energy values

Table (7) indicates the chemical composition and energy value of both Barakawi and Mishrigi-Wdkhateeb date fruits, on dry basis. When comparing the results of both cultivars, Barakawi date cultivar had the higher concentration of dry matter (94.80%), total

carbohydrates (94.37%), available carbohydrates (88.40%) and non-reducing sugars (44.51%), whereas,

Table (5): Minerals content of Barakawi date as dry cultivar

Minerals		**On wet basis**	**On dry basis**
		[mg/ 100 g, n = 2 ± SD]	
Sodium	[Na]	012.30 ± 0.09	012.97± 0.10
Potassium	[K]	80.00 ± 0.11	84.39 ± 0.12
Calcium	[Ca]	123.00 ± 0.11	129.75± 0.10
Magnesium	[Mg]	003.04 ± 0.00	003.21 ± 0.00
Iron	[Fe]	002.90 ± 0.05	003.06 ± 0.04
Manganese	[Mn]	001.10 ± 0.02	001.16± 0.02
Zinc	[Zn]	001.20 ± 0.01	001.27± 0.00

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

Table (6): Minerals content of Mishrigi-Wdkhateeb date as semi-wet cultivar

Minerals		On wet basis	On dry basis
		[mg/ 100 g, n = 2 ± SD]	
Sodium	[Na]	013.80 ± 0.22	017.01 ± 0.03
Potassium	[K]	130.00 ± 0.09	160.26 ± 0.11
Calcium	[Ca]	059.00 ± 0.15	072.73 ± 0.17
Magnesium	[Mg]	004.94 ± 0.50	006.09 ± 0.54
Iron	[Fe]	003.00 ± 0.02	003.70 ± 0.01
Manganese	[Mn]	001.80 ± 0.02	002.22 ± 0.04
Zinc	[Zn]	001.70 ± 0.01	002.10 ± 0.00

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

Table (7): Comparison between chemical composition of Barakawi and Mishrigi-Wdkhateeb date fruits on dry weight basis

Chemical composition and energy value	Date cultivar		P-value	SE±
	Barakawi	Mishrigi-Wdkhateeeb		
	[%, n = 3 ± SD]			
Dry matter	$94.80^{a} \pm 0.14$	$81.12^{b} \pm 0.03$	0.002^{**}	0.06
Protein	$02.17^{b} \pm 0.01$	$05.70^{a} \pm 0.30$	0.0003^{**}	0.12
Fat	$00.91^{b} \pm 0.03$	$01.52^{a} \pm 0.22$	0.0138^{*}	0.09
Total carbohydrates	$94.37^{a} \pm 0.02$	$89.73^{b} \pm 0.28$	0.0004^{**}	0.11
Fibers	$05.97^{b} \pm 0.04$	$06.76^{a} \pm 0.18$	0.002^{**}	0.08
Available carbohydrates	$88.40^{a} \pm 0.02$	$82.98^{b} \pm 0.40$	0.0001^{**}	0.16
Total sugars	$69.20^{b} \pm 1.78$	$86.27^{a} \pm 0.47$	0.0001^{**}	0.75
Reducing sugars	$24.68^{b} \pm 0.54$	$60.44^{a} \pm 0.88$	0.0002^{**}	0.42
Non-reducing sugars	$44.51^{a} \pm 2.24$	$25.82^{b} \pm 0.27$	0.0001^{**}	0.92
Glucose	$14.66^{b} \pm 0.13$	$25.48^{a} \pm 1.26$	0.0001^{**}	0.52
Fructose	$09.39^{b} \pm 0.14$	$32.20^{a} \pm 0.52$	0.0002^{**}	0.22
Ash	$02.55^{a} \pm 0.05$	$03.06^{a} \pm 0.39$	$0.0944^{n.S}$	0.16
Caloric value	$380.22^{a} \pm 0.17$ K. cal $1590.85^{a} \pm 0.70$ K. J	$376.66^{b} \pm 2.90$ K.cal $1575.95^{b} \pm 12.1$K.J	0.0435^{*} 0.0435^{*}	1.19 4.97

SD ≡ Standard deviation.

SE± ≡ overall experimental error.

n ≡ Number of independent determinations.

Mean ± S.D value(s) having different superscript letter(s) within rows are significantly different ($P \leq 0.05$).

* ≡ Significant at ($P \leq 0.05$). ** ≡ highly significant at ($P \leq 0.01$). n.s ≡ not significant.

Mishrigi-Wdkhateeb had the higher concentration of protein (05.70%), total sugars (86.27%), reducing sugars (60.44%), glucose (25.48%) and fructose sugar (32.20%).

In despite of these variations, the differences found between the two cultivars were not highly significant with respect to their caloric values. Barakawi date cultivar had caloric value of 380.22 k. cal. /100g, whereas that, of Mishrigi-Wdkhateeb was 376.66 k. cal. /100g pulp.

However, **Mohammed, *et. al.* (2014)** mentioned that, the chemical composition of date cultivars vary according to cultivars, soil conditions, agronomic practices as well as ripening stages. Also, **Diab and Aboul-Ela (2012)** reported that, date fruits are usually used as medicine due to their high nutritional value, especially during or after pregnancy period. Date fruits were found to assist delivery, avert the post-delivery bleeding, activate prolactin hormone and promote milk flow during the lactation period.

4.2.2 Comparison between Barakawi and Mishrigi-Wdkhateeb date fruits with respect to their minerals contents

Table (8) shows the minerals content of Barakawi date fruits as dry cultivar and Mishrigi-Wdkhateeb fruits as semi-wet date cultivar as (mg/ 100g), on dry basis. In general, the two date cultivars had high concentration of potassium, calcium, sodium and low concentration of magnesium, iron, zinc, and manganese. But, when comparing the minerals content of both cultivars per 100 g pulp, Mishrigi-Wdkhateeb fruits date had the higher concentration of potassium (160.26 mg), sodium (17.01 mg), magnesium (6.09 mg), iron (3.70 mg), manganese (2.22 mg) and zinc (2.10 mg). Also,

Assirey (2015) reported that, date fruits had high concentration of potassium (289.60 -512.00 mg), calcium (123.00 – 187.00 mg), manganese (56.00 – 150.00 mg) and low concentration of sodium (4.90 – 8.90 mg) per 100g pulp.

Table (8): Comparison between minerals content of Barakawi and Mishrigi-Wdkhateeb date fruits on dry weight basis

Minerals		Barakawi	Mishrigi-Wdkhateeb	P-value	SE±
		[mg/ 100g, n= 2± SD]			
Sodium	[Na]	$12.97^{b} \pm 0.10$	$17.01^{a} \pm 0.03$	0.0006**	0.11
Potassium	[K]	$84.39^{b} \pm 0.12$	$160.26^{a} \pm 0.11$	0.0001**	0.07
Calcium	[Ca]	$129.75^{a} \pm 0.10$	$72.73^{b} \pm 0.17$	0.0002**	0.08
Magnesium	[Mg]	$003.21^{b} \pm 0.00$	$006.09^{a} \pm 0.54$	0.0001**	0.22
Iron	[Fe]	$003.96^{a} \pm 0.04$	$003.70^{b} \pm 0.01$	0.0412*	0.02
Manganese	[Mn]	$001.16^{b} \pm 0.02$	$002.22^{a} \pm 0.04$	0.2826**	0.02
Zinc	[Zn]	$001.27^{b} \pm 0.00$	$002.10^{a} \pm 0.00$	0.0003**	0.00

SD ≡ Standard deviation.

SE± ≡ overall experimental error.

n ≡ Number of independent determinations.

Mean ± S.D value(s) having different superscript letter(s) within rows are significantly different ($P \leq 0.05$).

* ≡ Significant at (P≤0.05). ** ≡ highly significant at (P≤0.01). n.s ≡ not significant.

However, **Elleuch, *et. al.* (2008)** stated that, the high potassium and low sodium contents in date fruits were found to be useful for people suffering from hypertension.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in this study it can be concluded that, both Barakawi and Mishrigi-Wdkhateeb date fruits have high nutritional value with respect to their chemical composition, energy value and minerals content. But, Mishrigi-Wdkhateeb date cultivar has the higher concentration of total sugars, reducing sugars, potassium, sodium, magnesium, iron, manganese and zinc, when compared with those of Barakawi date cultivar. Whereas Barakawi date cultivar has the higher concentration of dry matter, total carbohydrates, non-reducing sugars, energy content and calcium.

5.2 Recommendations

1. Date fruits containing high concentration of total sugars (soluble sugars), potassium and low concentration of sodium render the fruits to be valuable in production of special juices and drinks for people who suffering from hypertension, energy malnutrition (EM) and also, could be used for sportsmen.
2. Mishrigi-Wdkhateeb as Semi-wet cultivar could be suitable for utilization in Jame, Juice, drinks and syrups production due to its high concentration of total sugars (reducing and non-reducing sugars).
3. Efforts should be directed in Sudan towards industrial utilization of date fruits in production of different food products such as juice, jams, syrup, candy….etc.
4. Industrial utilization of date fruits in Sudan not only will add

economical value to the raw materials, but also, will provide job opportunities in dates production areas.

5. Comprehensive survey should be conducted in Sudan to estimate the actual total production and productivity of date fruits as well as to study the chemical, physical and physicochemical characteristics of different date cultivars in Sudan.

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Plate (1): Mishrigi-Wdkhateeb Date Fruits Cultivar

Plate (2): Barakawi Date Fruits Cultivar