بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Department of Horticulture

Physical and chemical Characteristics of Three Mango Cultivars at Three Maturity Stages

الخواص الفيزيائية والكيميائية لثلاثة من أصناف المانجو في ثلاثة من مراحل النضج

By

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A thesis submitted in partial fulfillment of the requirements for the degree of M. Sc. in horticulture

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2016

الآية

بسم الله الرحمن الرحيم

قال تعالى:

ض ُ الْمَ يْ ةَ ُ أَحْ يَ يْ نَاهَ ا وَ مَأَخْ هَ َجْنَ ًّا فَمِ نْهُ يَ أْكُلُونَ (33)
ِنْ نَخِ يلٍ وَ أَعْنَ ابٍ وَ فَجَّرْ نَا فِ يهَ ا مِ نَ الْعُ يُونِ (34) يَ أْكُلُوا
ا عَ مِ لَتْهُ أَيْ دِ يهِ مْ أَفَلاَ يَ شْكُرُ ونَ (35)

صدق الله العظيم

سوره يس الآيات (33-35)

Dedication

I would like to dedicate this work

To my father

To my mother

To my sister

To my brothers

To my Husband

To my teachers and my friends

Acknowledgment

I would like to start this text by expressing my upmost, deepest, and sincere expression of gratitude firstly to my supervisor **Prof. Dr. Elsadig Hassan Elsadig** who made this journey as enlightening as it could get.

Secondly, but not underrating my dear parents, wishing that I could one day repay them the amount of ambition they fill my life with. Without both I would have never been the woman I am nor have made it this far in life, so I would be honored to dedicate this piece of research as well as my whole life to them, as a mere thank you note would never suffice.

Thirdly and undoubtedly, I would not forget all the faculty and instructors who were the torch that lit my way throughout my years and during this program.

Thank you

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Abstract

This study was conducted at the Sudan university of Science and Technology - College of Agricultural Studies Chemistry Laboratory, Department of Food Science and Technology.

The aim of this study was to compare three Sudanese mango cultivars and with respect to physical, chemical and sensory evaluation during the various stages of maturity.

The three cultivars of mango are (Kitchener, Alphons and Dr.knight) and the three stages of maturity which were the (green, moderate and yellow).

The results showed that the highest percentage of moisture content exhibited by Dr.knight cultivar (88.9%) at full maturity (yellow) and the lowest by the same cultivar at the green stage (36%). The highest percentage of fiber was exhibited by Kitchener cultivar (4.8%) at stage full maturity (yellow) and the lowest were exhibited by Alphons (0.40%) at the green stage. where the highest percentage of ash were exhibited by Kitchener cultivar (0.36%) at full maturity (yellow) ,and the lowest were exhibited by Alphons (0.14%) at the green stage.

The study also showed that the highest percentage of acidity was attained by Alphons cultivar (3.80%) at the green stage, and the lowest was attained by Kitchener cultivar at the yellow stage (0.62%).

The highest percentage of total soluble solids was attained by Kitchener cultivar and Dr. Knight (17-17%) at the yellow stage and the lowest was attained by Dr.Knight (2.5%) at the green stage.

The highest pH was attained by the Kitchener cultivar (4.35) at the yellow stage and the lowest was attained by Dr.Knight (2.81) at the green stage.

According to the sensory evaluation the most preferable color was the yellow color Alphons(2.81%), where as the least preferable color was of Dr. knight cultivar (1.31%) at the moderate stage. The most preferable taste was both (Alphons and kitchener) cultivars(3.00, 3.00%) and the least was Dr.knight(1.81%) at green stage. The most acceptable texture was obtained in both Alphons and Dr.knight cultivar(2.75, 2.75%) at yellow stage ,where as the least acceptable one was found at the moderate stage of Dr.knight cultivar (1.50%).

The most accepted overall quality was obtained at the yellow stage of Alphons cultivar(2.87%), where as the low overall quality was obtained at the moderate stage of Dr.knight (1.37%).

الخلاصة

أجريت هذه الدراسة بجامعه السودان للعلوم والتكنولوجيا – كليه الدراسات الزراعية معمل الكيمياء بقسم علوم وتكنولوجيا الأغذية.

التصميم المستخدم في هذه التجربة هو التصميم العشوائي الكامل.

والهدف من هذه الدراسة هو مقارنه ثلاثة أصناف من المانجو السودانية من حيث الخواص الفيزيائية والكيميائية عند ثلاثة مراحل من نضج الثمار.

أصناف المانجو هي (كتشنر، الفونس، د.نايت) ومراحل النضج هي (الأخضر، الوسط ، الأصفر).

أوضحت الدراسة أن أعلى نسبة رطوبة كانت في الصنف د.نايت (88.9%) في مرحلة النضج الكامل(الأصفر) وأدناها في نفس الصنف في الطور الأخضر(36%) كما أن أعلى نسبة من الألياف كانت في الصنف كتشنر (4.8%) في مرحلة النضج الكامل(الأصفر) وأدناها في الصنف الفونس (0.40%) في الطور الأخضر، وأعلى نسبة من الرماد في الصنف كتشنر (0.36%)في النضج الكامل (الأصفر)أيضا، وأدناها في الصنف الفونس(0.14%) في الطور الأخضر.

وأيضا أوضحت الدراسة أن أعلى نسبة حموضة كانت في الصنف الفونس (3.80%) في الطور الأخضر وأدناها في الصنف كتشنر في الطور الأصفر(0.62%)، وأعلى نسبة من المواد الصلبة الذائبة وجدت في الصنفين كتشنر و د. نايت (17- 17%)في الطور الأصفر وأدناها في الصنف د. نايت(2.5%) في الطور الأخضر، كما أن أعلى pH في الصنف كتشنر (4.35) في الطور الأصفر وأدناه في الصنف د.نايت في الطور الأخضر.

وفي التقييم الحسي لهذه الأصناف أوضحت الدراسة أن أكثر صنف مفضل من ناحية اللون هو الصنف الفونس في الطور الأصفر (2.81%) ، واقل صنف هو د.نايت في الطور الوسط (1.31%). ومن ناحية الطعم الأكثر تفضيلا هما الصنفان كتشنر والفونس (3 ، 3%) في الطور الأصفر، والأقل تفضيلا الصنف د. نايت في الطور الأخضر. ومن ناحية القوام الأكثر تفضيلا هما الصنفان الفونس و د. نايت (2.75 ، 2.75%) في الطور الأصفر ، والأقل تفضيلا الصنف د. نايت (1.50%) في الطور الوسط.

أما من ناحية الجودة الكلية فان أكثر الأصناف تفضيلا الفونس (2.87%) في الطور الأصفر ، والأقل تفضيلا الصنف د. نايت (1.37%) في الطور الوسط .

CHAPTER ONE

Study on Physical and Chemical Characteristics of Three Mango Cultivars on Three Ripening Stages

Introduction

Mango (*Mangiferaindica* L.) Anacardiaceae), is one of the most important crops in the tropical and subtropical regions of the world.

Mango fruit is an important crop of the tropical countries, especially in India which is the largest producer of this fruit, about two million acres(EL-Banna and Hejazi, 1987). Mango is the most popular fruit of the orient and has been called "King of the fruits"(Jagirdar, 1968) due to its high palatability, excellent taste and flavor. The pulp is rich in the essential minerals, vitamins and other nutritive factors. The mango is one of the first fruit to be cultivated by man. where has been grown in India for more than 400 years. Over the last decade (1991-2001), mango fresh fruits as well as processed consumption.

Mango can play an important role in balancing human diet by providing about 64-86 calories of energy per 100 g and when consumed regularly, can be valuable dietary source of many phytochemical compounds(Pleguezuelo*etal*,2012). In addition, among many other components, the ascorbic acid content makes the fruit an excellent source of vitamin C, its content varying from 32 to 200 mg per 100 g of edible pulp. Also it is a rich source of beta carotene which is the precursor of vitamin A. In the Sudan Mango is the most important horticultural fruit crop. it produces almost around the year in many parts of the country.

The main area of mango production in Sudan extends along the main Nile banks in Northern and River Nile States. It is also grown on small scale along the Blue Nile banks in central Sudan, and in some parts of South Kordofan and in Darfur States where the other cultivated species of mango are found (UNEP, 2005, pp 16-17). In

Sudan, area and production were 16238 ha and 651000 tons, respectively (MOAF, 2008).West Darfur State produced about 53% from the total production, South Kordofan State about 27%, Northern States 3% and Khartoum State 2% (Abdel Kareem *et al*, 1996).

Mango is leading the Sudanese horticultural exports. Many cultivars of excellent fruit qualities are currently grown such as: Abusamaka, Alphons, Dibsha, Zibda, Malguba, and Shindi. However, the majority of the mango production in Sudan is from seedling trees of which the local cultivar Kitchener.

Sudanese mango chemical composition reported as follows: 79 kcal food energy, 79.7 % moisture, 18.6% of total carbohydrates, 1.2% protein, 0.0% fat, 0.4% crude fiber,0.5% ash. Ash contains 50 mg/100g Ca, 2.6 mg/100g iron and 2 mg/100g phosphorus(El Awad ,1980).

Objectives:

- Study of the changes that occur durig the development and maturity in the three cultivares of mango.
- Study of some physical characteristics of these cultivares.
- Study of some chemical characteristics of these cultivares.
- To determination quality of fruits of these cultivares.

CHAPTER TWO

LITRETURE REVIEW

Origin and distribution:

Mango has been cultivated in India for over 4,000 years or more and then spread to all parts of the tropical world. The mango has been cultivated, praised and even revered in its homeland since Ancient times. Buddhist monks are believed to have taken the mango on voyages to Malaya and eastern Asia in the 4th and 5th Centuries B.C. The Persians are said to have carried it to East Africa about the 10th Century A.C. it is native to southern Asia, especially eastern India Burma and the Andaman Islands, and it was commonly grown in the East Indies before the earliest visits of the Portuguese who apparently introduced it to West Africa early in the 16th Century and also into Brazil. After becoming established in Brazil, the mango was carried to the West Indies, being first planted in Barbados about 1742 and later in the Dominican Republic. It reached Jamaica about 1782 and, early in the 19th Century, reached Mexico from the Philippines and the West Indies.

In time, the mango became one of the most familiar domesticated trees in dooryards or in small or large commercial plantings throughout the humid and semi-arid lowlands of the tropical world and in certain areas of the near-tropics such as the Mediterranean area (Madeira and the Canary Islands), Egypt, southern Africa, and southern Florida. Local markets throughout its range are heaped high with the fragrant fruits in season and large quantities are exported to non-producing countries.

Taxonomy:

Division: Magnoliophyta

Class: Magnoliopsida

Sub Class: Rosidae

Order: Sapindales

Family: Anacardiaceae

Genus: Mangifera

Species: indica

World production:

Mango (*Mangifera indica* L.) is a very important economical crops.it grown in 90 countries in the world . Total world production of mango about 33.8 MT.The major producers are Asia with about 74%, followed by Latin America and the Caribbean with 16%, Africa with 10% and less than 1% .India is amajor producer country in the world followimg by China, Mexico, Thailand, Pakistan, Nigeria, Brazil and Philippines.The Philippines ranks fifth with an estimated 4% of the world production.

The production of mango in the regions of Sudan

State	Area(feddan)	Production(tons)	Production(%)
South kordofan	23500	211500	50.08
Sinnar	7000	42000	9.94
Blue nile	4125	36900	8.74
Northern	4921	30000	7.10
Gadarif	3000	16000	3.79
Gezira	2700	24300	5.75
South Darfur	2000	21000	4.97
West Darfur	1500	20000	4.74

Kassala	1000	200	0.05
River nile	900	9300	2.13
Khartoum	880	7830	1.85
White nile	400	3600	-
Total	51926	422630	99.97

Ministry of Agriculture and Forests. Dep. Of Horticulture (2011). Khartoum sudan.

Botanical description:

Tree:

Mango tree is an erect, branched, evergreen plant, reaching about forty meters in height and may live up to hundred years (Gibbon and Pain, 1985),with a broad, rounded canopy which may, with age, 30-38 m in width, or more. It has upright, oval, relatively slender crown, depending on propagation type. Mango tree, grown from seed, known as "seedling", has a long straight pole. Tree is sympodially branched (Scarron's model). Grafted trees are dwarf with spreading branches. Bark is usually dark grey-brown to black, rather smooth, superficially cracked or inconspicuously fissured, peeling off in irregular, rather thick pieces. The bark contains 78% resin and 15% gum in addition to tannic acid.

Root

In mango trees the taproot descends to a 6m depth, the profuse, wide-spreading, feeder root system also sends down many anchor roots which penetrate for several feet(Morton, 1987). Sometimes feeder roots can develop above the water table and fibrous roots may extend away from the drip line.

Leaf

The leaves are evergreen, alternate simple (15-35 cm) long and (6-16 cm) broad, the petiole varies in length from 1 to 12 cm, always swollen at the base. . Full-grown leaves may be (10-32 cm) long and (2-5.4 cm) wide. The phyllotaxy is usually 3/8 but as the leaves are arranged very closely at the tips they appear to be whorled. Leaves are variable in shapes like oval-lanceolate, lancelets, oblong, linear-oblong, ovate, obovate-lanceolate or roundish-oblong (Singh, 1960).

Inflorescence

The mango inflorescence is primarily terminal on a panicle (Bally, 2006). Inflorescence color ranges from yellow to light green. The inflorescence is a narrowly to broadly conical panicle up to a 45 cm long. The number of panicles per plant ranges from 600-6000, and the panicle bears 500-600 flowers of which 1-70% are bisexual, remainder are male depending on the cultivar and temperature during its development.

Flower

Mangos are monoecious and self-fertile, both male and hermaphrodite flowers are borne on the same tree. The size of both male and hermaphrodite flowers varies from 6- 8 mm in diameter. Hundreds and even as many as 3,000 to 4,000 small, yellowish or reddish flowers, 25% to 98% male, the rest hermaphroditic, are borne in profuse, showy, erect, pyramidal, branched clusters 2 1/2 to 15 1/2 in (6-40 cm) high (Morton, 1987).The androecium consists of stamens and staminodes, altogether five in number, of which usually one, or rarely two, are fertile and the rest are sterile**.** The fertile stamens are longer than the staminodes and are nearly equal to the length of the pistil.

Fruit

The fruit of mango is fleshy drupe. It varies considerably in size, shape, colour, presence of fiber, flavor, taste and several other characters, they may be nearly round, oval, ovoid-oblong, or somewhat kidney-shaped. The length varies from 2.5-30 cm, and weigh from approximately 200 g to over 2 kg. The leathery skin is waxy and smooth. The flesh ranges from pale-yellow to deep-orange, with a taste of light acidic to extremely sweet. Generally the quality of the fruit is based on the scarcity of fiber and the taste.

Pollen and pollination:

The pollen grains are variable in shape and size. Pollen viability is more prominent immediately after anther opening (Singh,1968) mango trees have limited fruit production, since only 35% of all flowers are pollinated and only 0.01% is transformed into fruits. Mango is highly cross pollinated crop, flower opens in the morning and anthesis is generally completed by noon.Pollination is by flies, wasps, and bees.

Environmental requirements:

Mango is very well adapted to tropical and subtropical climate.

Temperature:

Mango does best at an average annual temperature between 15 and 30 ^{o}C. Growth slows with decreasing temperature.

Rainfall:

Annual rainfall of 850-1000 mm is sufficient for successful cultivation. A distinct dry or cold season stimulates flowering. Rain during flowering seriously reduces fruit set. After a mango tree is well established, it is drought tolerant, especially when the taproots have reached the water table.

Soil:

Mango trees are well adapted to many types of soils, but prefer deep (at least 3 m) soils. Although it grows very well in high to medium fertility soils, its cultivation can be made successful even in low fertility soils by appropriate management especially during early stages of growth. Very poor and stony soils on hill slopes should, however, be avoided. The loamy, alluvial, well drained, aerated and deep soils rich in organic matter with a pH range of 5.5 to 7.5 are most favorable for mango cultivation.

Nutritional value of mango:

- Mango fruit is rich in pre-biotic dietary fiber, vitamins, minerals, and poly-phenolic favonoid antioxidant compounds.
- Mango fruit is an excellent of vitamine-A and flavonoids like beta-carotene, alpha-carotene, and beta-cryptoxanthin.
- Fresh mango is agood source of potassium. 100g fruit provide 1.56g of potassium while just 2g of sodium.
- It also a very good source of vitamin-B6 (pyridoxine), vitamin-C and vitamin-E.
- Further, it composes moderate amount of copper. Copper is co-factor for many vital enzymes, including cytochrom c-oxidase and superoxide dismutase (other minerals function as co-factor for these enzymes are manganese and zinc)
- Additionally mango peel is also rich in phytonutrients such as the pigment antioxidants like carotenoids and polyphenols.

Chemical composition:

The different chemical constituents of the plant, especially the polyphenolics, flavonoids, triterpenoids, mangiferin a xanthone glycoside major bio-active constituent, isomangiferin, tannins & gallic acid derivatives. The bark is reported to contain protocatechic acid, catechin, mangiferin, alanine, glycine, γ-aminobutyric acid, kinic acid, shikimic acid and the tetracyclic triterpenoids cycloart-24-en-3β,26diol, 3-ketodammar-24 (*E*)-en-20S,26-diol, C-24 epimers of cycloart-25 en 3β,24,27-triol and cycloartan-3β,24,27-triol.(Scartezzini ,2000)**.**

Ripe fruits are generally have sweet taste due to total reducing sugars and total soluble solids, but unripe fruits are acidis in taste. The acidity of the fruit expressed in terms of citric or malic acid, since they are the main accumulated free organic acids contributing to the acidity of the fruit besides tartaric, oxalic and glycolic

(Nagy, 1980).Texture of the flesh varies across cultivars, some have a soft, pulpy while others are firmer and some may have a fibrous texture. Mango flavor is constituted by several volatile organic chemicals mainly belonging to terpne, furanone, lactone, and ester classes.Ethylene, a ripening-related hormone well known to be involved in mango fruit, causes changes in the flavor composition of mango fruits upon exogenous application, as well (Lalel *etal*,2003 and Chidley *etal*,2013).Mango peel pigments under study include carotenoids, such as the provitamin A compound, beta-caroten, lutein and alpha-carotene(Berardini *etal*,2005 and Gouado *etal*,2007) and polyphenols, such as quercetin, kaempferol, gallic acid, caffetic acid, catechins and tannins.Up to 25 different carotenoids have been isolated from mango pulp, the densest of which was beta-carotene, which accounts for the yellow-orange pigmentation of most mango cultivars (Chen *etal*, 2004).

Nutritional value per 100g fresh pulp

Constituent	Per 100g fresh pulp	Constituent	per 100g fresh pulp
Water	81.79 g	Tocopherols,alpha	1.12 mg
Energy	65 Kcal (272 KJ)	**Lipids**	
Protin	0.51 g	Total saturated fatty acids	0.07 g
Fats	0.27 g	Total monounsaturated fatty acid	0.10 g
Carbohydrates	17.00 g	Total polyunsaturated fatty acids	0.05 g
Total dietary fiber	1.80 g	Cholesterol	0.00 g
Ash	0.50 g		
Minerals		**Aminoacids**	
Calcium	10.00 mg	Tryptophan	0.008 g
Iron	0.13 mg	Threonine	0.019 g
Magnesium	9.00 mg	Isoleucine	0.018 g
Phosphorus	11.00 mg	Leucine	0.031 g
Potassium	156.00 mg	Lycine	0.041 g
Sodium	2.00 mg	Methionine	0.005 g
Zinc	0.04 mg	Phenylalanine	0.017 g
Copper	0.11 mg	Tyrosine	0.010 g
Manganese	0.027 mg	Valine	0.026 g
Selenium	0.60 mg	Arginine	0.019 g
Vitamin		Histidine	0.012 g
Vitamin C	27.20 mg	Alanine	0.051 g
Thiamine	0.056 mg	Aspartic acid	0.042 g
Riboflavin	0.57 mg	Glutamic Acid	0.060 g
Niacin	0.58 mg	Glycine	0.021 g
Pantothenic acid	0.16 mg	Proline	0.018 g
Vitamin B6	0.16 mg	Serine	0.022 g
Total folate	14.00 mg_RE		
Vitamin A IU	3894.00 IU		
Vitamin A RE	389.00 mg_RE		
Vitamin E	1.12 mg_ATE		

Source: USDA nutrient standard reference (release 14 July 2001)

Meg-RE = micrograms of retinol equivalent, IU = amount of a substance based on measured biological activity or effect, ATE = alpha tocopherol equivalent, Vitamin E activity(adapted from Bally, 2006).

Propagation:

Generally there are two basic methods of propagation of mango trees:

1- Sexual propagation (by seed)

2- Asexual propagation (by grafting)

Mango seeds are either mono-embryonic (single embryo) or poly-empryonic (multiple embryos) depending on the cultivar. In these type generally, one of the embryos in the seed is a hybrid, the others (up to 4) are vegetative growths which faithfully reproduce the characteristics of the parent. Most cultivars of mango do not produce seedlings true-to-type. Therefore grafting is often necessary to overcome this problem. Grafting also means that trees produce uniform yield, fruit size and quality. (Morton, 1987).

Propagation by seed:

The flesh should be completely removed, Then the husk is opened by carefully paring around the convex edge with a sharp knife and taking care not to cut the kernel, which will readily slide out. Husk removal speeds germination and avoids cramping of roots, and also permits discovery and removal of the larva of the seed weevil in areas where this pest is prevalent. Finally, the husked kernels are treated with fungicide and planted without delay(Morton, 1987). Mango seeds lose viability very rapidly. It is essential to clean the seed as soon as possible after its removal from the fruit. It then needs to dry in the shade for a day or two. The seeds are kidney-shaped. Plant the seed on its edge with the concave edge facing downwards. Leave part of the top of the seed uncovered. Germination takes between 10 and 14 days.

Propagation by grafting:

Grafting is the process by which part of the parent tree to be reported (scion) is joined with a rooted plant(rootstock).Grafting is best performed when weather conditions are milder(autumn or spring).The best scion material is obtained from the tips of mature shoots with prominent buds .

Scion can be stored for up to 7days wrapped in a moist newspaper in a zip lock plastic bag in a cool, dark place. A Scion that is the same width or slightly narrower than the width of the rootstock is selected. Cut the end of the scion were cut into a wedge. The top of the rootstock is cut off and then 2cm slit is cut down the middle, Then the scion wedge is pushed into the silt on top of the rootstock.

About two weeks after grafting the terminal bud will start swelling.The grafting tap can be removed after 8-10 weeks (Morton, 1987).

Pruning:

Fruit is borne on new season growth and usually on the tips of the outer Therefore, it is only necessary to lightly thin trees by removing weak, overcrowded or broken branches, keeping the centre of the tree open. The branches which are too near the ground and cut off. Developing trees should be trained to eliminate low branches less than 2 feet from the ground, leaving three to four main branches on the trunk at different heights. Pruning of well-formed older trees is usually confined to removal of dead branches. Pruning is preferably done after fruiting before a growth flush occurs. Pruning can also be done to restrict tree size for small yards or when more than 35 trees per acre are planted. Some delay in flowering can be expected from new growth produced in response to pruning. Post harvest pruning is a common practice. The tree must receive full sun for optimum growth and fruiting. Mangos may be pruned to control size in early and late winter. Dead wood must be removed.

Irrigation:

The objectives of irrigation is to apply the required quantity of water as per tree requirement at the right time. The frequency and amount of irrigation need depends on the type of soil, its properties, previling climatic conditions, rainfall and distribution, age and size of tree.

Young mango tree should not lack water. If rainfall is limited, irrigation water should be applied about once every two weeks during the first year, every three weeks during the second year, and once a month thereafter.properly irrigated trees have fruit of better size and juicie than those trees with soil moisture deficit.

Mature trees are more productive if irrigation water is withheld for at least two months befor flowering. Although hot, dry weather is favorable to fruit development, supplementary irrigation between flowering and harvest is advisable for good yields. It is advisable to stop irrigation at least 10-15days befor harvest.

Fertilization:

During mango tree establishment phosphorus(P) is important for root development.Young trees: should receive 0.1-0.2 pounds of N (e.g , 1-2 pound of 10 20 20 fertilizer) per year during the first year and 0.15-0.3 pound of N (e.g , 10 20 20) during year two and three , Nitrogen(N) and potassuim(K) are needed by bearing trees for good yields. Half of the fertilizer should be applied just before flowering and the rest applied after the crop is harvested.Tip burn of leaves is due to potassium deficency, moisture deficency(water stress), salt accumilation can cause the damge.

Diseases and pests:

Diseases:

1- Mango malformation:

Among all the known diseases, mango malformation is undoubtedly the most serious.(Majumder and Sinha,1972) have correlated seasonal variation with the prevailing temperatures at the time of flowering. The disease generally occure on young rather than an old trees(Puttarudriah and Channa Basavanna, 1961).

Depending on the plant part affected, two categories of malformation are recognized. This includes vegetative malformation and floral malformation.

2-Anthracnose:

c.o. Colletotrichum gloesosporioides penz

anthracnose is an important disease cause of loss in mango all over the world . the disease is prevalent in moist regions .the symptoms appear on all parts including young leaves, stem, flower, clusters and fruits. The disease appears in the form of small brown or black spots. In advanced stage, shot hole symptoms are also produced ,sometimes as much as 20-25spots are visible on a single leaf (suharban *et al*, 1986). On young stem , characteristic gray brown spots are noticed. These enlarge and cause girding and drying of the affected area, often resulting in dieback symptoms. On flower they appear as small dark spots on the main and secondary rachis of panicle.

3- **Diplodia stem-end rot:**

C.o. *Diplodia natalenis* pole evans

Lasiodiplodia theorbramae pal (Botryodiplodia theobromae pal)

Stem end rot is considered as the most important post harvest disease of the ripe mango fruits.Symptoms initiate as black irrigular areas around the pedical.Soon the affected area enlarges to form circular black patches and gradually extends downwords. The whole fruit gets completely black and rotten within 5-7 days. The pulp of the diseased fruit becomes brown and soft. The phathogen incites a soft rot with the aid of pectinolytic and cellolytic enzymes (Pathak and Srivastava, 1967 and Pathak and Prasad, 1969).

4-Black mould rot:

c.o. *Aspergllus niger*

van teighsymptoms appear as greyish or pale brown spots anywhere on

the fruit surface, which becomes soft and sunken with a whitish growth and later gets covered with a sooty mass of black spores.

5-Soft rot:

c.o. *Rhizopus oryzae*

R . arrhizus Fischer

infection is favoured by injuries . the growth of the fungus is rapid. The rind turns black and in advanced stage the pulp beneath the skin gets collapsed. Profuse leakage is also noticed.

6-Powdery mildew:

Oidium mangiferae

One of the most serious diseases, The fungus affects the flowers and causes young fruits to dehydrate and fall, and 20% of the crop may be lost.

Pests:

1- fruit flies
2- mango seed weevils
3- mango-leaf webber or "tent caterpillar" *Orthaga euadrusalis*.
4- The citrus thrips *Scirtothrips aurantii*

Alternate bearing:

The termalternate,biennial or irregular bearing generally signifies the tendency of mango trees to bear a heavy crop in one year(on year) and very little or no crop in succeeding year(off year). The problem has been attributed to the casuses like genetic, physiological, environmental and nutritional factors.

For overcoming biennial bearing, deblossoming is recommended to reduce the crop load in the (on year) such that it is balanced in the (off year).

Harvesting:

Mangoes are generally harvested at physiological mature stage and ripened for optimum quality. Mangos normally reach maturity in 4-5 months from flowering (Morton, 1987).When the mango is full-grown and ready for picking, the stem will snap easily with a slight pull. If a strong pull is necessary, the fruit is still somewhat immature and should not be harvested. When flowering occurs in several flushes, all the fruits will not be ready for harvest at one time. in such a situation, selective harvesting of mature fruits should be carried out. You will see The fruit will begin to fill and expand in size. A ripened mango will be somewhat soft to the touch.

Allow the mangos to ripen on the tree for the most full-flavour fruit. The fruit will show that it is ready for harvest when the first fruit show a full colur. The full colour of mango is determined by the selected variety of mango tree. Studies about the processes involved in the ripening process of mango fruit would be useful

(Gomez-Lim, 1997).Climbing thin branches becomes risky, as the wood is brittle. Therefore use of a traditional harvesting stick is advisable. The harvesting stick is prepared by tying two irons or bamboo hooks 5-6cm long at the tip of a straight, long bamboo. A net made of jute or coir rope, attached to an iron ring of 30-40cm diameter, is tied to the bamboo, around the hook. Or it can be shaking the tree to remove the fruit. Shaking the tree is a much better option to remove the fruit from tree. After harvesting the fruit is placed on storage bin or try to complete the ripening process. It is best to place the mango stem side down at room temperature and cover the fruit with a mesh cloth.

Uses of mango:

Mangos are extremely nutritious and contain carbohydrates, proteins, fats, minerals, vitamins: vitamin A (beta carotene), B1, B2, and vitamin C (ascorbic acid) (Bally, 2006). The importance of mango that ripened fruits are eaten fresh everywhere, and used to make juice or marmalade, dried and made into candy.

Seed kernels:

After soaking and drying to 10% moisture content, the kernels are fed to poultry and cattle. Without the removal of tannins, the feeding value is low. The kernel is also used for medicinal purposes in moderation of anti-bacterial and anti-fungal activities (Jekayinfa and Durowoju, 2005).

Wood:

It is gray or greenish-brown, coarse-textured, medium-strong, hard, durable in water but not in the ground, easy to work and finishes well. In India, after preservative treatment, it is used for rafters and joists, window frames, agricultural implements, boats, plywood, shoe heels and boxes, including crates for shipping tins of cashew kernels. It makes excellent charcoal((Morton, 1987).

Bark:

The bark possesses 16% to 20% tannin and has been employed for tanning hides.

Gum:

A somewhat resinous, red-brown gum from the trunk is used for mending crockery in tropical Africa. In India, it is sold as a substitute for gum Arabic.

In addition to mangoes food value, it has also been used for medicinal values, in Samoa, a Brake infusion has been a traditional remedy for mouth infection in children, and also mango stone are useful as a substitute for maize in finishing broiler diets. The kernel is also used for medicinal purposes in moderation of anti-bacterial and anti-fungal activities (Jekayinfa and Durowoju, 2005).

Varieties of mango:

In India, there are more than 1000 varieties with varied characteristics like fruit yield, size, taste and flavor of pulp (Krishna Murthy *et al*., 1984).

In the Sudan, mangoes are divided into two main groups (Baladi) or fibrous group and (introduced) Indian group. The "Baladi" group is seed propagated, supposedly more adopted to the local condition, and stand adverse soil conditions better than the introduced group. The fruit is small, fibrous, brightly colored, and sweet and has good flavor. The most popular variety of this group is locally known as Kitchener, which is an early-mid season variety, whereas the introduced "Indian "group is vegetatively propagated, probably less adapted to local conditions and requires fertile soil compared to the Baladi group, and the main cultivars in this group are locally known as Abu-Samaka (Totapari) and Alphons (Abu sin and Hamed, 1971).

Country	Cultivares
Egypt	'Alphonso', 'Bullock's Heart', 'Hindi Be Sennara', 'Langra', 'Mabrouka', 'Pairie', 'Taimour', 'Zebda'.
India	'Alphonso', 'Banganapalli', 'Bombay', 'Bombay Green', 'Chausa', 'Dashehari', 'Fazli', 'Fernandian', 'Himsagar', 'Kesar', 'Kishen Bhog', 'Langra', 'Mallika', 'Mankurad, 'Mulgoa', 'Neelum', 'Pairi', 'Samar Behisht Chausa', 'Suvarnarekha', 'Totapuri', 'Vanraj', 'Zardalu', 'Amrapali', 'Bangalora', 'Gulabkhas'.
Pakistan	'Anwar Ratol', 'Baganapalli', 'Chausa', 'Dashehari', 'Gulab Khas', 'Langra', 'Siroli', 'Sindhri', 'Suvarnarekha', 'Zafran'
Philippines	'Carabao', 'Manila Super', 'Pico', 'Binoboy', 'Carabao', 'Dudul', 'Pahutan', 'Senora'.
Thailand	'Nam Doc Mai', 'Ngar Charn', 'Okrong', 'Rad', 'Choke Anand', 'Kao Keaw', 'Keow Savoey', 'Pimsenmum'.
USA	'Keitt', 'Kent', 'Tommy Atkins'.
Brazil	'Bourbon', 'Carlota', 'Coracao', 'Espada', 'Itamaraca', 'Maco', 'Magoada', 'Rosa', 'Tommy Atkins'
Kenya	'Boubo', 'Ngowe', 'Batawi'
Mexico	'Haden', 'Irwin', 'Kent', 'Manila', 'Palmer', 'Sensation', 'Tommy Atkins', 'Van Dyke'.
South Africa	'Haden', 'Irwin', 'Kent', 'Manila', 'Palmer', 'Sensation', 'Tommy Atkins', 'Van Dyke'

CHAPTER THREE

MATERIALS ANDMETHODS

Plant Material

Three mango cultivars, namely, Baladi, known also as Kitchener, Alphons and Dr.knight which are commonly cultivated and consumed in Sudan, were chosen in this study. Nine samples from each variety were obtained from the orchard of Horticulture Sector, Ministry of Agriculture and Irrigation, Mogran, Khartoum, Sudan. Three stages of mango fruit ripening were selected (green, moderate, yellow).These fruits were cleaned and kept refrigerated prior to further treatment and analysis. The percentage of peel, stone and mango pulp were calculated(Saeed and Khattab, 1974).

Preparation of the Mango fruits

Mango fruits were first weighed, sorted, and then thoroughly washed under running water. Cleaned fruits were peeled, sliced by a sharp clean stainless steel knife. The slices were blended using an electric blender; and the weight of the peel, stone and pulp was recorded.

Physicochemical analysis:

Total soluble solids (T.S.S):

Total soluble solids (T.S.S) of mango pulp were measured with a hand Refractometer type(0-50% Brix) at 20 C°, it was expressed as (%) or degree Brix (A.O.A.C., 1990).

pH Value:

The pH of the pulp was measured with glass electrode pH meter(Model: HANNA instruments 8521) at ambient temperature. This has been calibrated with two standard buffers, 6.8 and 4.0.

Total titratable acidity:

The total titratable acidity was calculated according to Board Method(1988).ten grams of mango pulp were weighted into a 250 ml Beaker, diluted with 100 ml of distilled water and titrated against 0.1 N NaOH (SDFCL Mubai – India) using phenolphthalein as an indicator and it was calculated as follows :-

Calculation:

Total acidity (mg/100g) expressed as citric acid =

$$\frac{Titer\ (ml)\ x\ N\ (NaOH)\ x\ dilution\ x\ equivalent\ weight\ x\ 100}{\text{Weight of the sample taken}}$$

Moisture content:

The moisture content was determined according the standard method of the Association of Official Analytical Chemists(AOAC, 1990).

Principle:

The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressre) at 105 ± 1 ºC. then, the difference in weghit before and after drying is calculated as a percentage from the initial weight.

Procedure:

A sample of 5 g was taken from whole mango fruit weighed into a pre-dried alminioum dish. Then the sample was placed into an oven and left to dry at105 ± 1 C° until a constant weight was obtained. After drying, the coverd sample was

transferred to a desicator 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:

$$\textbf{Moisture content [\%]} = \frac{\mathbf{W2-W3]}}{\mathbf{[W2-W1]}}$$

Where;

W1: weight of dish + cover

w2: weight of dish + cover + sample before drying

W3: weight of dish + cover +sample after drying

The dry matter (DM) as percent was calculated by subtracting the percentage of moisture content from 100%.

Fiber content:

About 5g of defatted sample was placed into a conical flask containing 200ml of H2SO4 (0.26N). The flask was fitted to a condenser and allowed to boil for minutes. At the end of the digestion period, the flask was removed and the digest was filtered through a proclaim filter crucible (No.3), after that, the precipitate was repeatedly rinsed with distilled boiled water followed by boiling in 200 ml NaOH(0.23) solution for 30 minutes under reflux condenser alcohol(96%) and 20 ml diethyl ether. Finally, the crucible was dried at 105C° until a constant weight was obtained and the difference in weight was considered fiber.

Calculation:

Crude fiber % =

$$\frac{[(Dry\ residue\ +\ crucible\ (g) - (ignited\ residue\ + crucible\ (g)]x100}{\text{Sample weight}}$$

Ash content:

The standard analysis method of the Member Companies of Corn Refiners Association Inc.(1995) was used for determination of ash content in the sample.

Principle:

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

Procedure:

A ground sample of 5 g±1 was weighed into a pre-heated, cooled weighed and tarred porcelain crucible. Before ashing, the sample was pre-washed on an electrical pre-asher and placed into a muffle furnace (Carbolated, Sheffield, England) at 525 - 600C° until a constant weight was obtained. The weight of the residue after ashing was defined as ash content and expressed as percentage based on the dry matter content in the ground sample.

Calculation:

Ash content(DM%)=

$$\frac{Residue\ weight\ (g)\ x\ 100\ x100}{\text{Samplewt (g) x } [100 - \text{sample moisture (\%)}]}$$

Organoleptic Evaluation

Organoleptic evaluation was done for mango fruits, using the Hedonic Scoring Test method (Ranganna SPD, 2001). sixteen panelists from the students of the College of Agricultural Studies, Sudan University of Science and technology, were provided with code samples of mango slices in plastic dishes and were asked to

evaluate: color(Green=1. Greenish yellow =2, yellow=3),taste(very acid =1, acid = 2, sweet = 3,very sweet = 4)texture(hard = 1, semi hard = 2, soft = 3) and overall quality (1 = acceptable, 2 = half acceptable, 3 = not acceptable).

Statistical analysis technique:

Technique:

Data generated were subjected to SAS computer program. Two-factor CRD (ANOVA) was assessed where factor A=maturity stages (green, moderate, yellow) and factor B=mango cultivars (kitchener, Alphons and Dr. Knight). Means were separated using DMRT as described (Snedecor and Cochran, 1987).

2-Abbreviation:

SAS ≡ Statistical Analysis System.

CRD ≡ Complete Randomized Design.

ANOVA ≡ Analysis of Variation.

DMRT ≡ Duncan Multiple Range Test.

Lsd ≡ Least significant difference.

±SD ≡ Standard Deviation.

SE± ≡ Experimental Standard Error.

n.s ≡ not significant ($p \geq 0.05$).

* ≡ Significant ($p \leq 0.05$).

** ≡ Highly significant ($p \leq 0.01$).

CHAPTER FOUR

RESULTS AND DISCUSSION

Table 1 Shows that Kitchener cultivar fruit dimensions (length, width and weight) at the three different maturity stages (green, moderate and yellow). There are no significant differences($p \geq 0.05$) in length but there are significant differences($p \leq 0.05$) in width and weight.

Also there are significant differences($p \leq 0.05$)in the fruit dimensions (length, width and weight) at the three different stages(green, moderate and yellow) for both Alphons and Dr.Knigh cultivars.

There are also significant differences($p \leq 0.05$) in length and width but there is a highly significant difference in weight among the three cultivars at the three maturity stages (green, moderate and yellow).

These significant differences in length, width and weight of the three cultivars at the three maturity stages (green, moderate and yellow) may be due to variations among cultivars in genotype and due to differences the response to cultural and environment.

TABLE 1: DIMENSIONS AND WEIGHT OF FRUITS OF THREE SUDANESE MANGO CULTIVARS AT THE THREE MATURITY STAGES

cultivar	Length (cm)			Width (cm)			Weight (g)		
	Maturity stage								
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
Kitchener	9.17^{ab}	9.40^{ab}	9.43^{ab}	6.20^{c}	7.17^{a}	6.97^{ab}	147.40^{e}	191.80^{bc}	174.10^{cd}
Alphons	9.13^{ab}	8.43^{bc}	9.70^{a}	6.23^{c}	6.17^{c}	6.47^{bc}	222.30^{a}	143.90^{e}	210.40^{ab}
Dr. Knight	7.30^{d}	8.10^{cd}	8.17^{cd}	6.27^{c}	6.10^{c}	6.60^{bc}	154.10^{de}	183.70^{c}	174.90^{cd}
$Lsd_{0.05}$	0.90*			0.52*			22.41**		
SE	0.30			0.17			7.54		

Mean (s) sharing same superscript(s) are not significantly (>0.05) different according to DMRT.

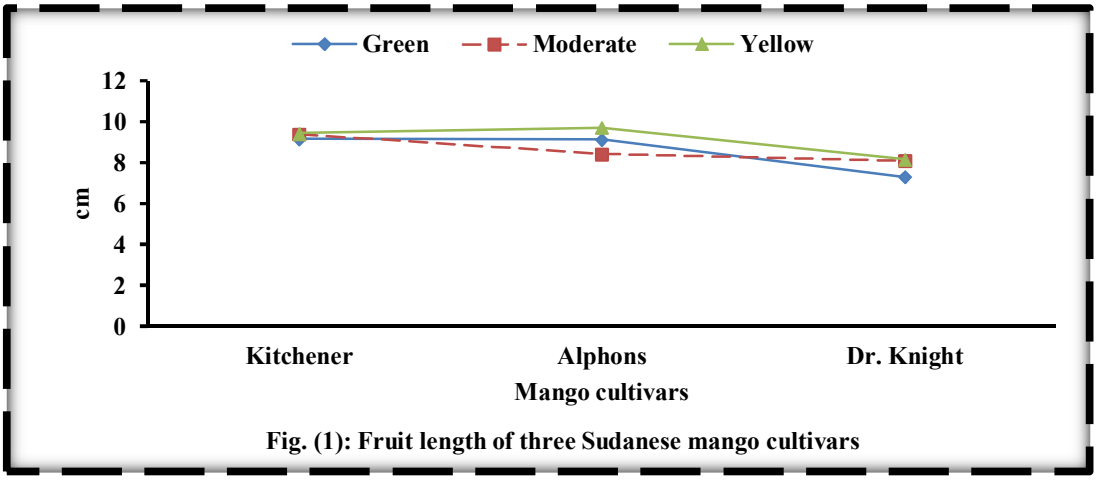

Fig. (1): Fruit length of three Sudanese mango cultivars

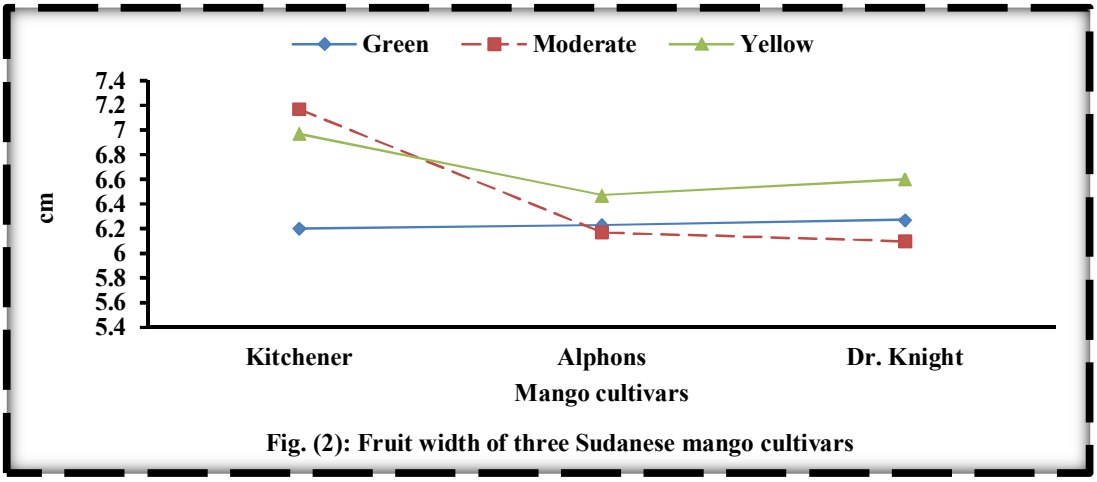

Fig. (2): Fruit width of three Sudanese mango cultivars

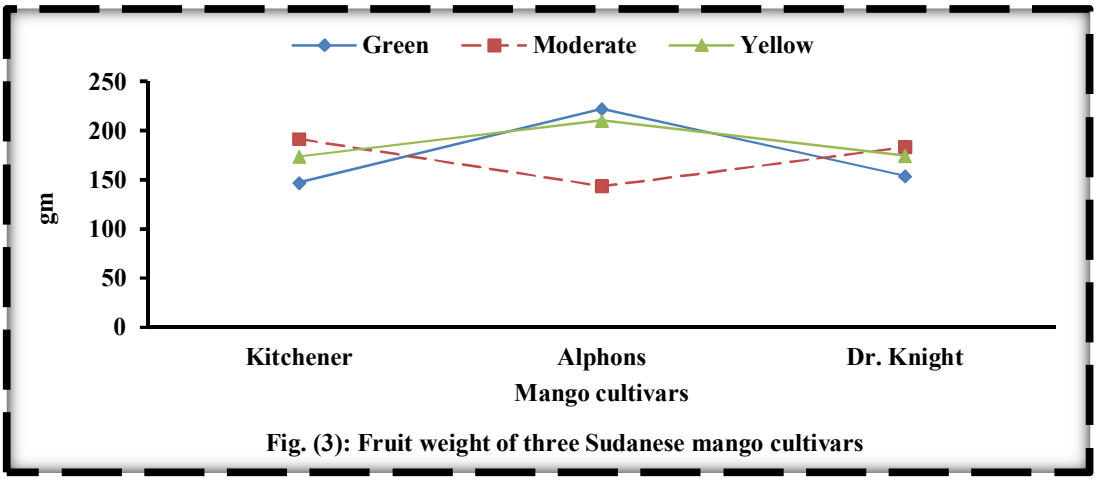

Fig. (3): Fruit weight of three Sudanese mango cultivars

Table2 Shows that dimensions and weight of the seed of the three mango cultivars. There are significant differences($p \leq 0.05$) in length and width, but there is a highly significant difference ($p \leq 0.01$) in weight(3.832) of the three cultivars at the three maturity stages (green, moderate and yellow).

TABLE 2: DIMENSIONS AND WEIGHT OF THE SEED OF THE THREE SUDANESE MANGO CULTIVARS AT THREE MATURITY STAGES

Cultivar	Length (cm)			Width (cm)			Weight (g)		
	Maturity stage								
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
Kitchener	6.63^{ab}	7.03^{a}	6.83^{a}	3.53^{bc}	3.97^{ab}	4.23^{a}	16.41^{de}	26.28^{a}	25.26^{ab}
Alphons	6.83^{b}	6.53^{ab}	6.87^{a}	3.47^{bc}	3.43^{bc}	3.80^{abc}	18.25^{cde}	14.73^{e}	19.61^{cd}
Dr. Knight	5.47^{c}	6.43^{abc}	5.70^{bc}	3.50^{bc}	3.70^{abc}	3.37^{ac}	19.68^{cd}	22.35^{abc}	21.95^{bc}
$Lsd_{0.05}$	0.9285^{*}			0.506^{*}			3.832^{**}		
SE	0.3125			0.1703			1.29		

Mean (s) sharing same superscript(s) are not significantly (>0.05) different according to DMRT.

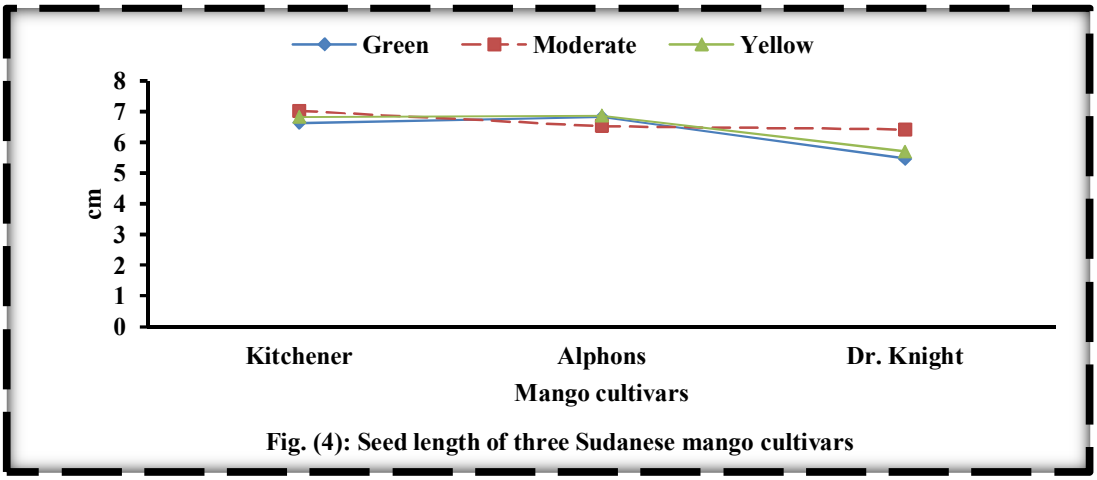

Fig. (4): Seed length of three Sudanese mango cultivars

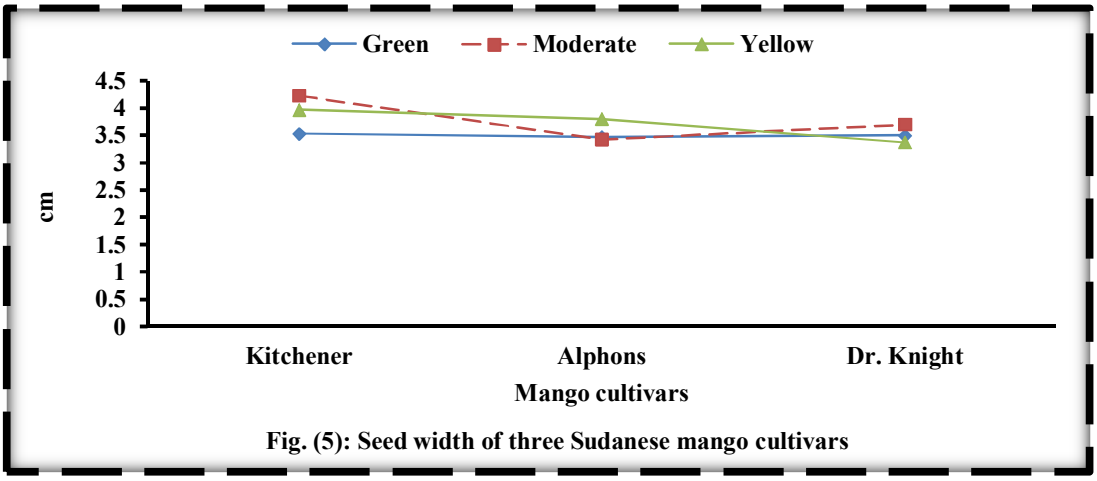

Fig. (5): Seed width of three Sudanese mango cultivars

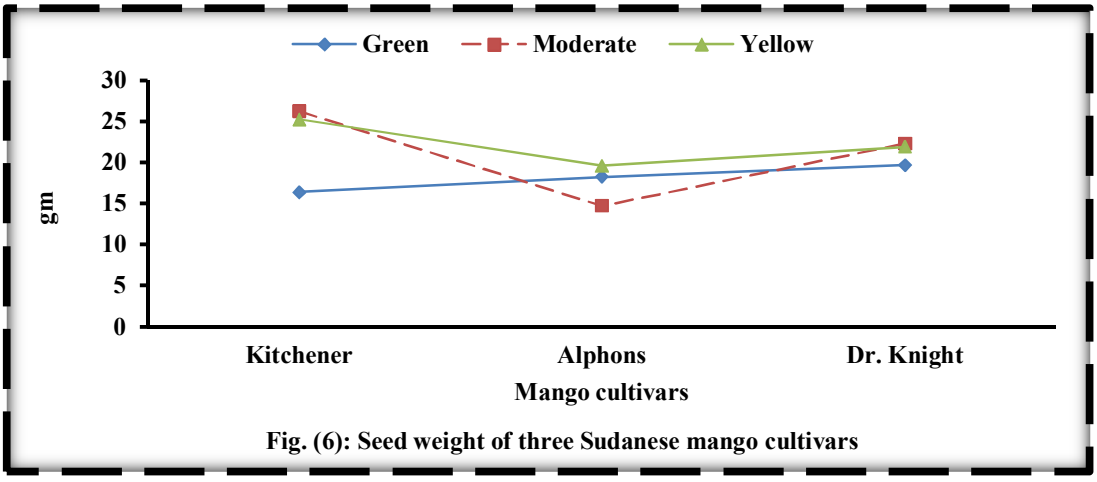

Fig. (6): Seed weight of three Sudanese mango cultivars

Table 3 Shows that there are significant differences($p \leq 0.05$) in length and width of the pulp and highly significant differences ($p \leq 0.01$) in the weight of pulp and weight of peel of the three cultivars at the three maturity stages. This May be due to genotype of the cultivars.

TABLE 3: DIMENSIONS AND WEIGHT OF PULP AND WEIGHT OF PEEL OF THREE SUDANESE MANGO CULTIVARS

cultivar	Length (cm)			Width (cm)			Weight (g)			Peel weight (g)		
	Maturity stage											
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
Kitchener	2.34^{a}	2.37^{a}	2.50^{a}	2.40^{ab}	2.40^{ab}	2.67^{a}	107.60^{ef}	140.00^{bc}	127.10^{cd}	20.70^{d}	29.33^{bcd}	22.18^{cd}
Alphons	2.03^{ab}	1.73^{b}	2.33^{a}	2.43^{ab}	2.40^{ab}	2.60^{ab}	162.30^{a}	105.00^{ef}	153.60^{ab}	48.25^{a}	24.12^{cd}	37.23^{ab}
Dr. Knight	1.73^{b}	1.70^{b}	1.77^{b}	2.30^{ab}	2.03^{b}	2.50^{ab}	100.10^{f}	114.8^{def}	119.40^{de}	34.30^{bc}	39.47^{ab}	42.23^{ab}
Lsd$_{0.05}$	0.49*			0.54*			14.88**			11.96**		
SE	0.16			0.18			5.00			4.02		

.Mean (s) sharing same superscript(s) are not significantly (>0.05) different according to DMRT

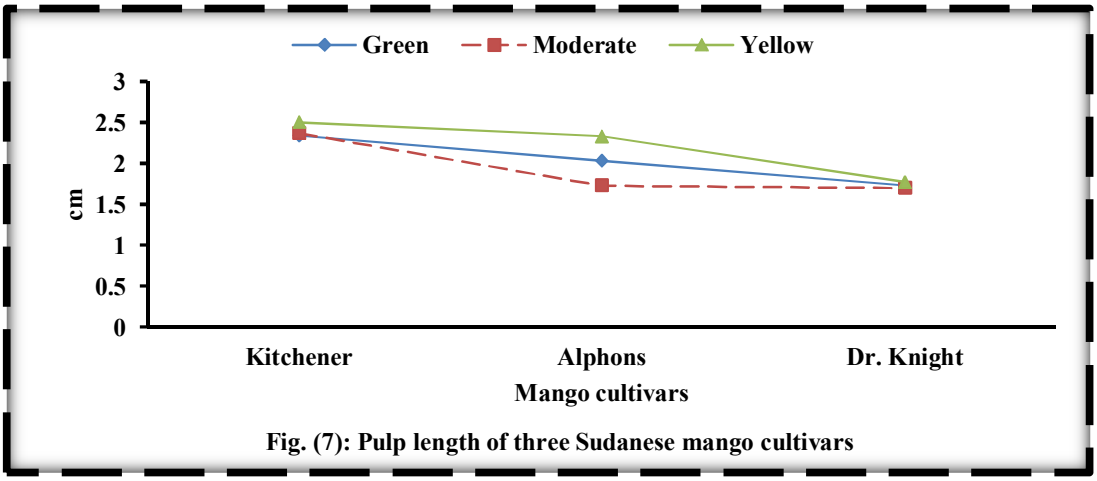

Fig. (7): Pulp length of three Sudanese mango cultivars

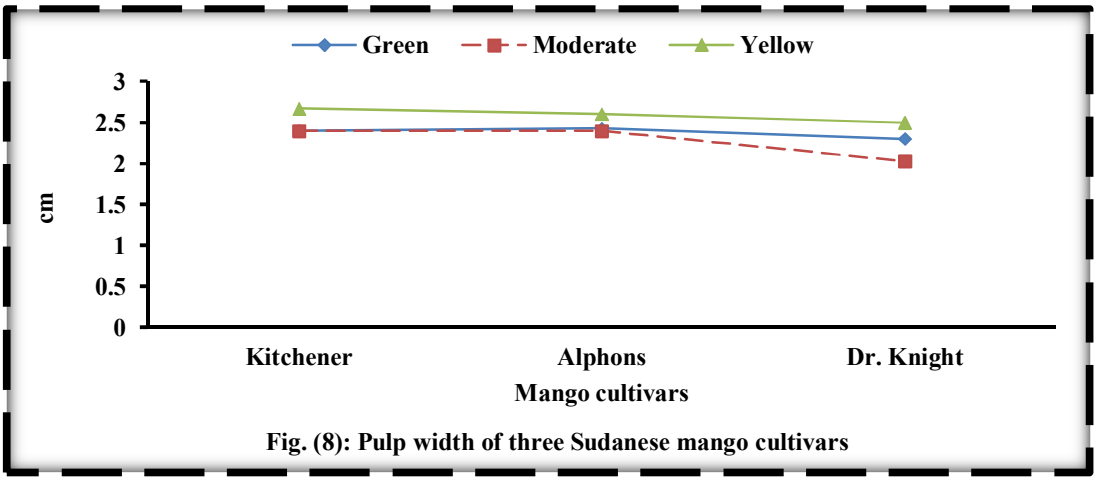

Fig. (8): Pulp width of three Sudanese mango cultivars

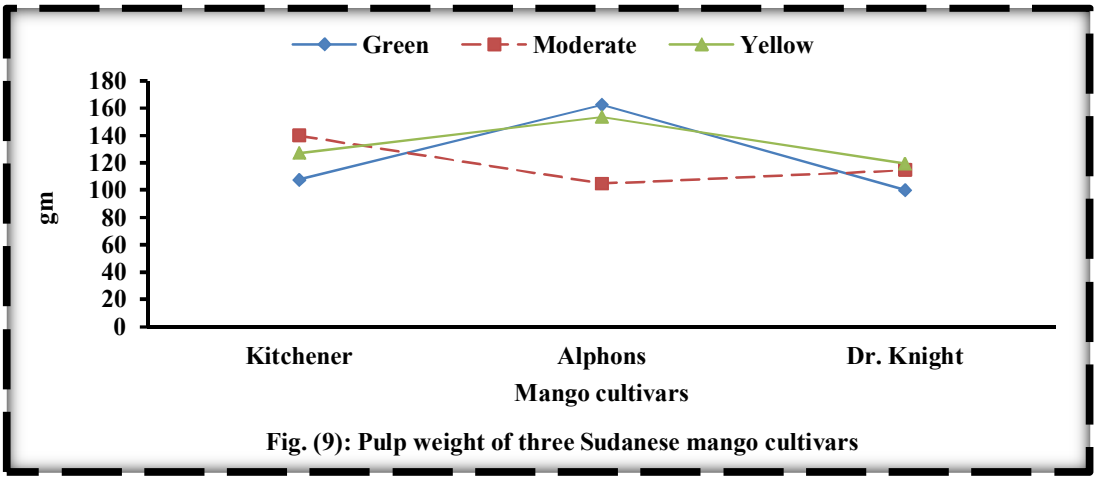

Fig. (9): Pulp weight of three Sudanese mango cultivars

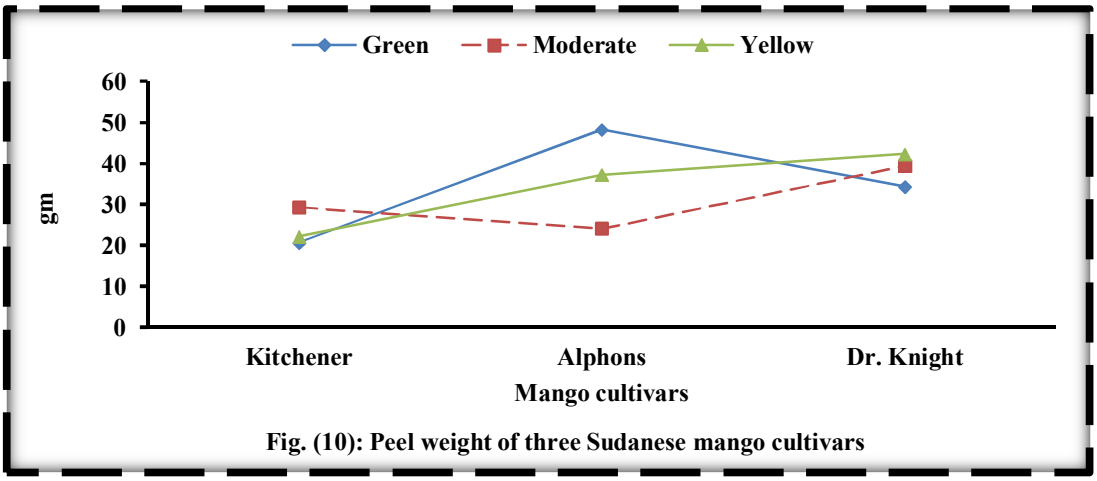

Fig. (10): Peel weight of three Sudanese mango cultivars

Table 4a shows that there is highly significant difference($p \leq 0.01$) in the percentage of moisture content (1.15) among the three mango cultivars(kitchener, Alphons and Dr.knight) at the three maturity stages. The increase in moisture content during maturity from green to yellow may be due to break down of chemical transformations which occur in the fruits.

Also there is a highly significant difference ($p \leq 0.05$) in the percentage of crude fiber (0.17) which increased during maturity.

Like wize change in percentage of ash during maturity of the three cultivars.

TABLE4$_A$: PHYSICOCHEMICAL PROPERTIES OF THREE SUDANESE MANGO CULTIVARS AT THREE MATURITY STAGES

cultivar	Moisture content (%)			Crude fiber (%)			Ash content (%)		
	Maturity stage								
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
Kitchener	82.00^{d}	85.00^{b}	86.00^{b}	1.60^{d}	3.20^{b}	4.80^{a}	0.31^{c}	0.33^{b}	0.36^{a}
Alphons	83.20^{c}	85.80^{b}	87.90^{a}	0.40^{h}	0.80^{g}	1.20^{e}	0.14^{i}	0.16^{g}	0.17^{e}
Dr. Knight	36.00^{e}	80.90^{d}	88.90^{a}	0.70^{g}	1.00^{f}	2.30^{c}	0.20^{f}	0.23^{e}	0.27^{d}
Lsd$_{0.05}$	1.15**			0.17**			0.0005425*		
SE	0.38			0.057			0.0001826		

Mean(s) sharingsame superscript(s) are not significantly (>0.05) different according to DMRT

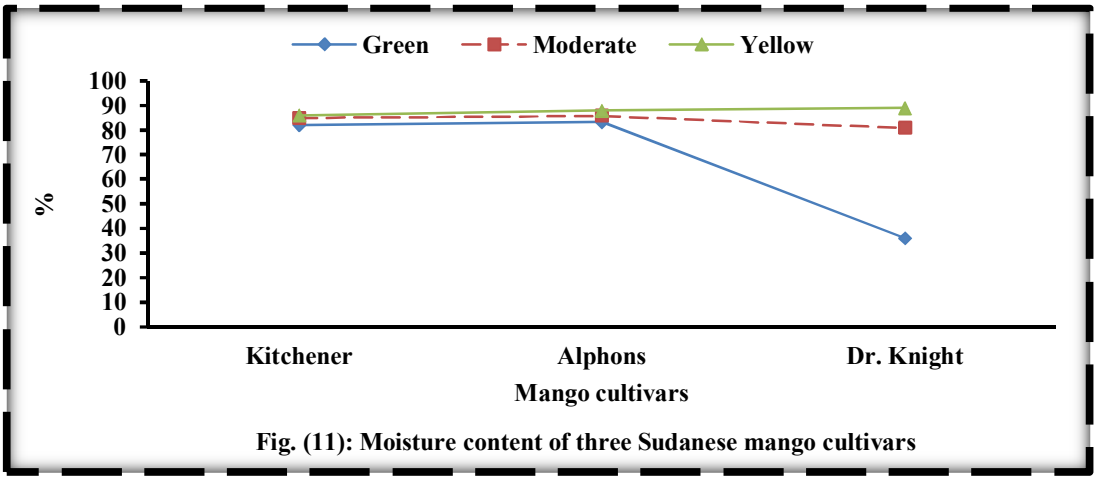

Fig. (11): Moisture content of three Sudanese mango cultivars

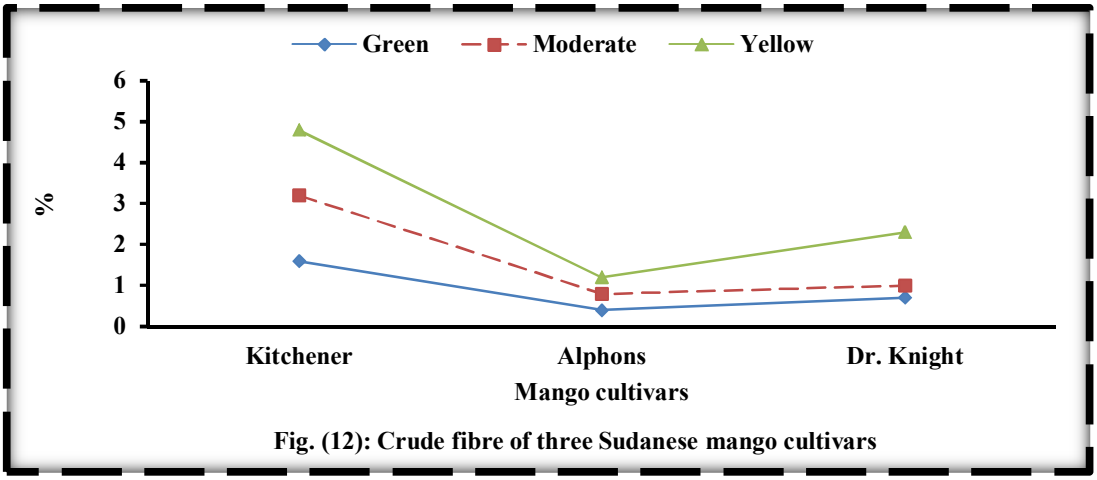

Fig. (12): Crude fibre of three Sudanese mango cultivars

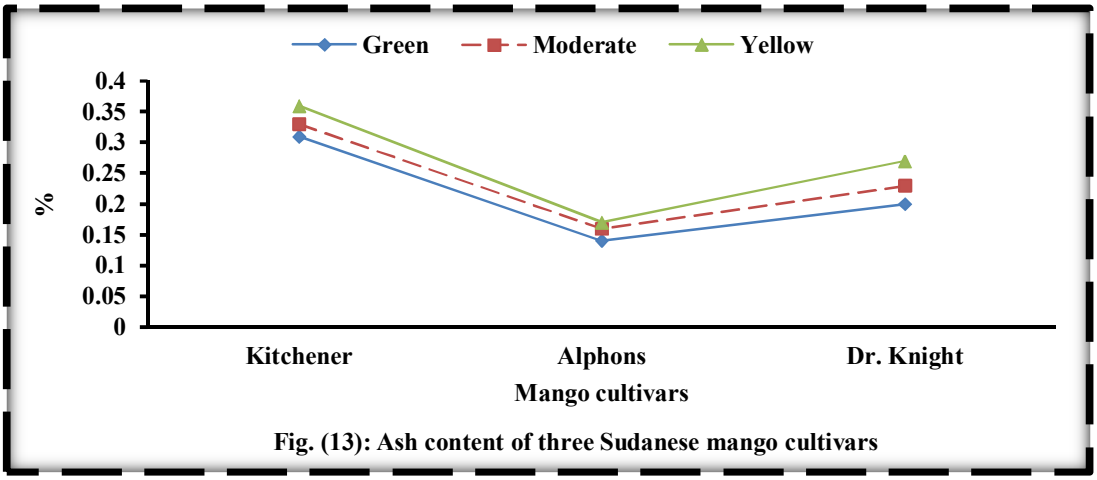

Fig. (13): Ash content of three Sudanese mango cultivars

Table 4bshowshighly significant differences($p \leq 0.01$) in percentage of titratable acidity (0.58), total soluble solids(1.15) and PH-value (0.0005425) at the three cultivars(kitchener, Alphons and Dr.knight). The decrease in titratable acidity (expressed as citric acid) during maturity may be due to the change of acids to sugars.

Increase in TSS may be due to hydrolysis of insoluble solid to soluble solid compounds.

The increase of the pH values from green to yellow stage may be due to the decrease in acid content and increase in sugars.

TABLE 54B: CONTD.

Mango cultivar	Titratable acidity (%)			Total soluble solids (%)			pH-value		
	Maturity stage								
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
Kitchener	1.51^{cd}	0.85^{ef}	0.62^{f}	8.50^{d}	13.00^{bc}	17.00^{a}	4.12^{c}	4.29^{b}	4.35^{a}
Alphons	3.80^{a}	3.30^{ab}	1.40^{cde}	12.50^{bc}	13.50^{b}	16.30^{a}	2.97^{g}	3.43^{i}	3.96^{e}
Dr. Knight	3.00^{b}	1.96^{c}	1.10^{def}	2.50^{e}	12.00^{c}	17.00^{a}	2.81^{e}	3.19^{f}	4.05^{d}
$Lsd_{0.05}$	0.58^{**}			1.15^{**}			0.0005425^{**}		
SE	0.19			0.38			0.0001826		

Mean (s) sharing same superscript(s) are not significantly (>0.05) different according to DMRT.

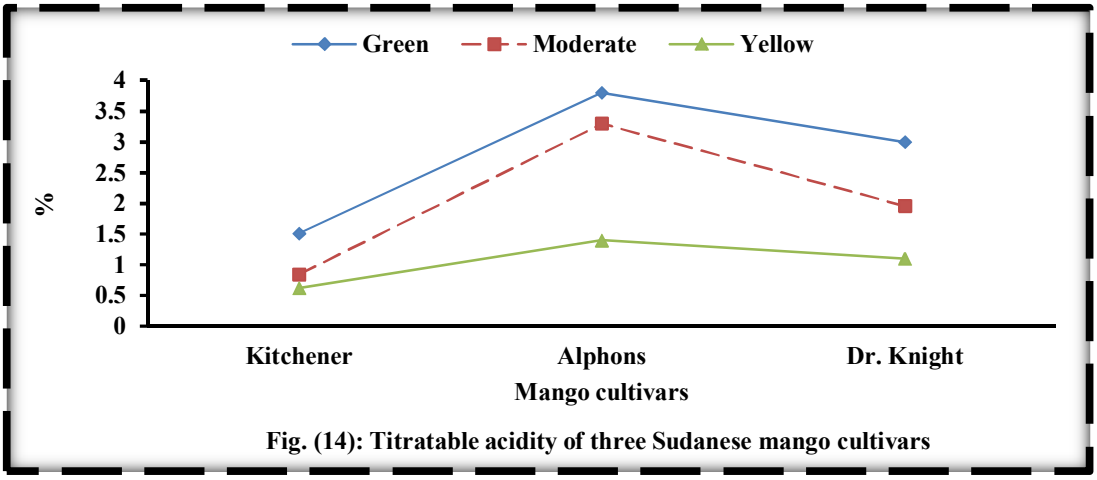

Fig. (14): Titratable acidity of three Sudanese mango cultivars

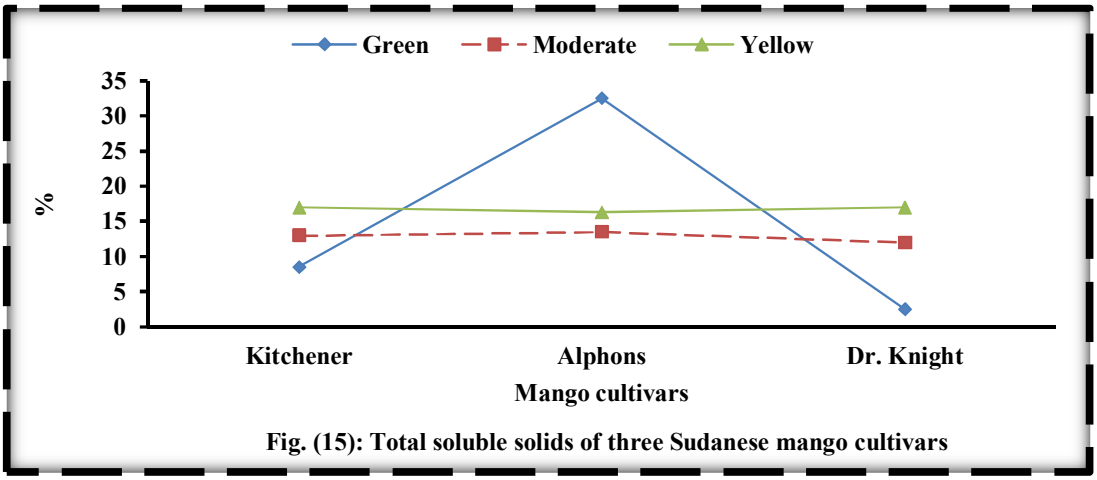

Fig. (15): Total soluble solids of three Sudanese mango cultivars

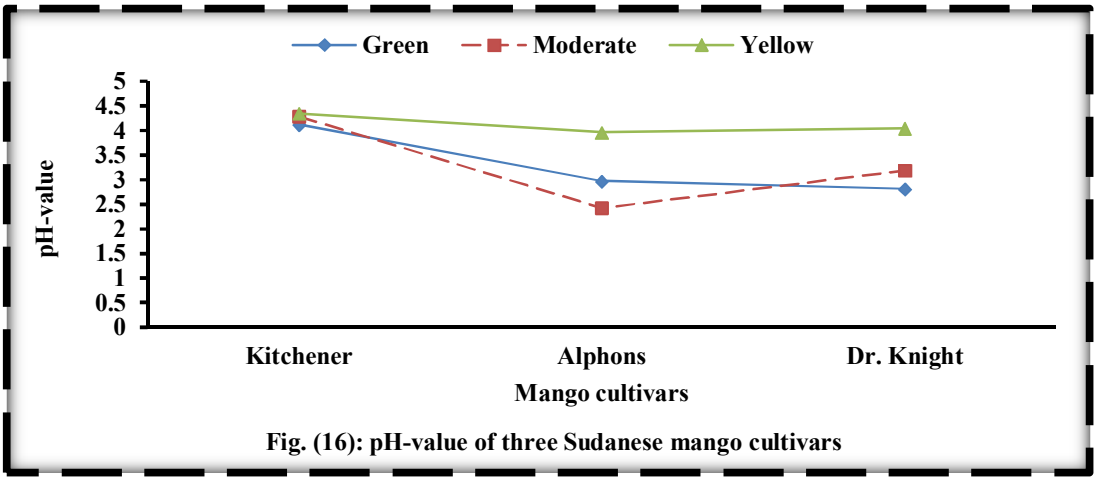

Fig. (16): pH-value of three Sudanese mango cultivars

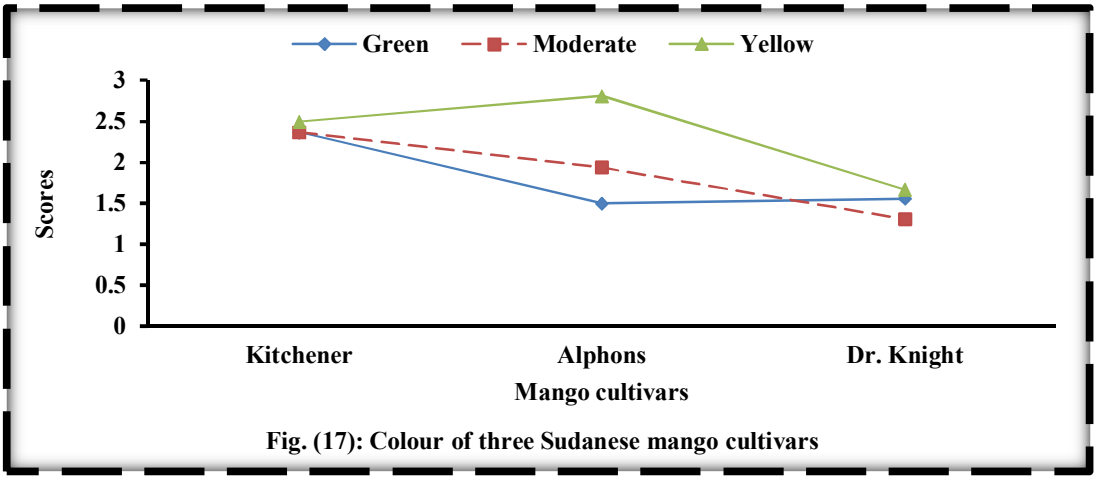

Fig. (17): Colour of three Sudanese mango cultivars

Table5 Shows the sensory evaluation of the fruit at the different stages of maturity of the three mango cultivars (kitchener, Alphons and Dr.knight). There is a highly significant difference ($p \leq 0.01$) in the color due to changes in the pigments (chlorophyll to beta carotene).

There are changes in the taste of the fruits from very acid to very sweet and change in texture from hard to soft due to degradation of pectic substances and also change in overall quality.

TABLE 65: SENSORY EVALUATION OF THREE SUDANESE MANGO CULTIVARS AT THREE MATURITY STAGES

cultivar	Color			Taste			Texture			Overall quality		
	Maturity stage											
	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow	Green	Moderate	Yellow
	Scores											
Kitchener	2.37^{ab}	2.37^{ab}	2.50^{a}	2.69^{ab}	2.75^{ab}	3.00^{a}	2.56^{ab}	2.50^{ab}	2.31^{abc}	2.50^{a}	2.50^{a}	2.62^{a}
Alphons	1.50^{cd}	1.94^{bc}	2.81^{a}	2.12^{c}	2.25^{bc}	3.00^{a}	1.87^{cde}	2.06^{bcd}	2.75^{a}	1.94^{b}	1.94^{b}	2.87^{a}
Dr. Knight	1.56^{cd}	1.31^{d}	1.67^{cd}	1.81^{c}	2.00^{c}	2.75^{ab}	1.62^{de}	1.50^{e}	2.75^{a}	1.62^{bc}	1.37^{c}	2.50^{a}
$Lsd_{0.05}$	0.4411^{**}			0.4984^{*}			0.4885^{**}			0.4119^{**}		
SE	0.1577			0.1782			0.1746			0.1473		

Mean (s) sharing same superscript(s) are not significantly (>0.05) different according to DMRT.

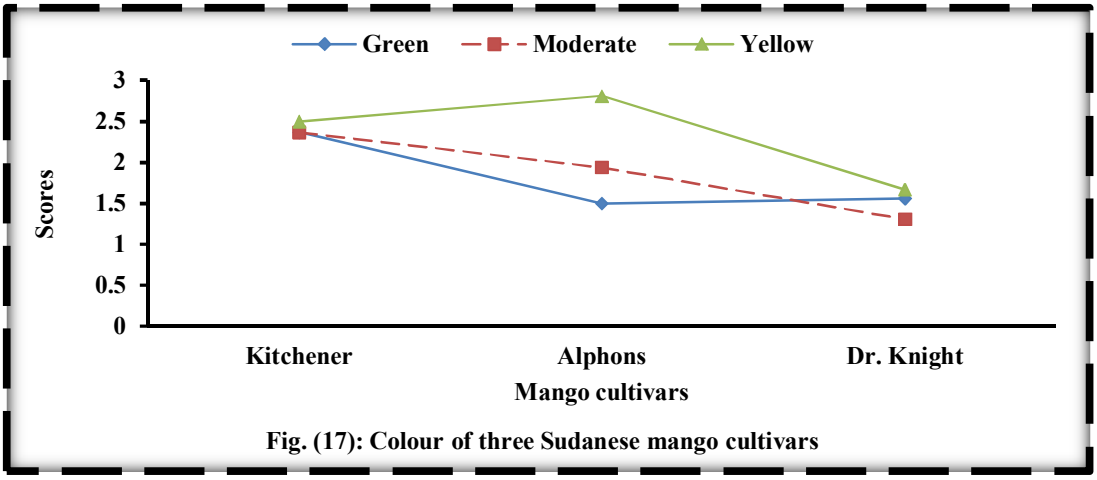

Fig. (17): Colour of three Sudanese mango cultivars

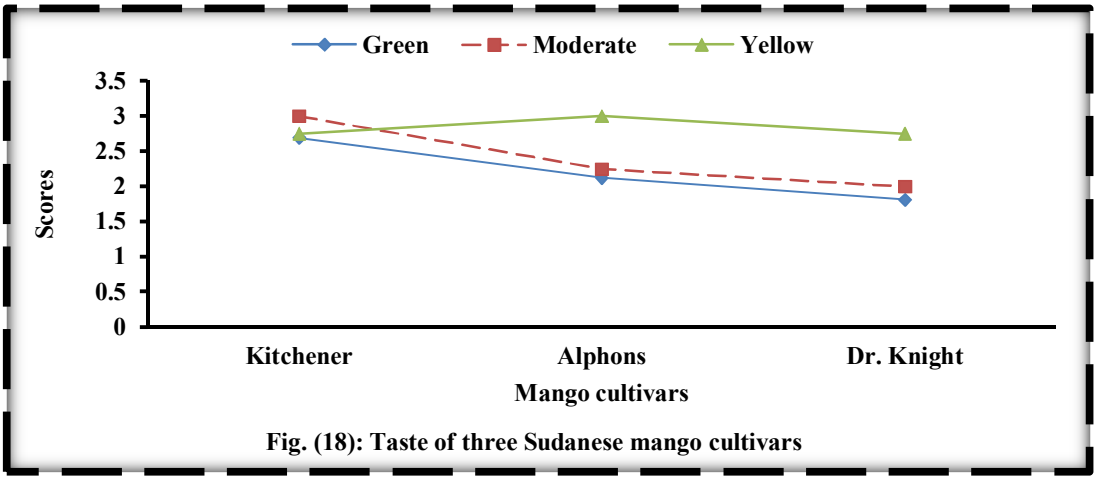

Fig. (18): Taste of three Sudanese mango cultivars

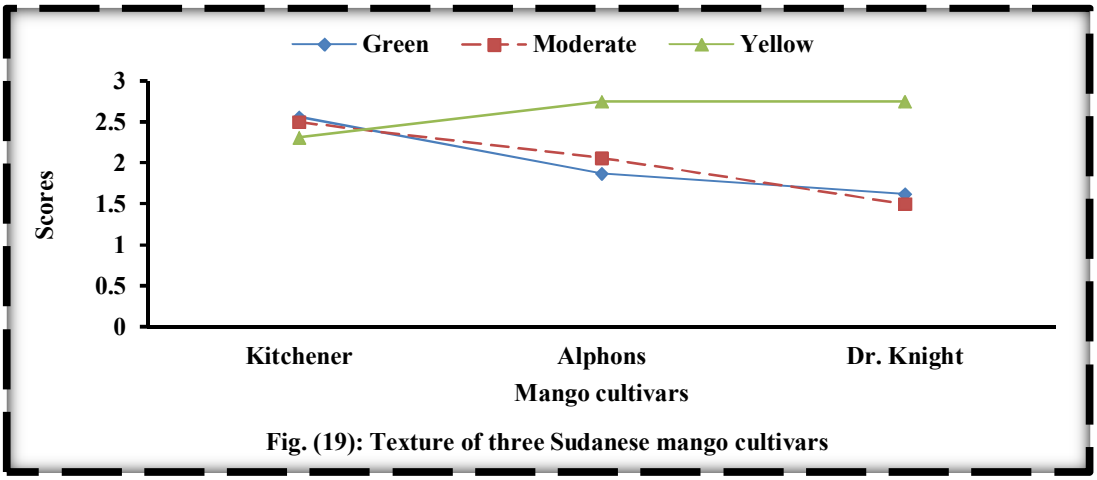

Fig. (19): Texture of three Sudanese mango cultivars

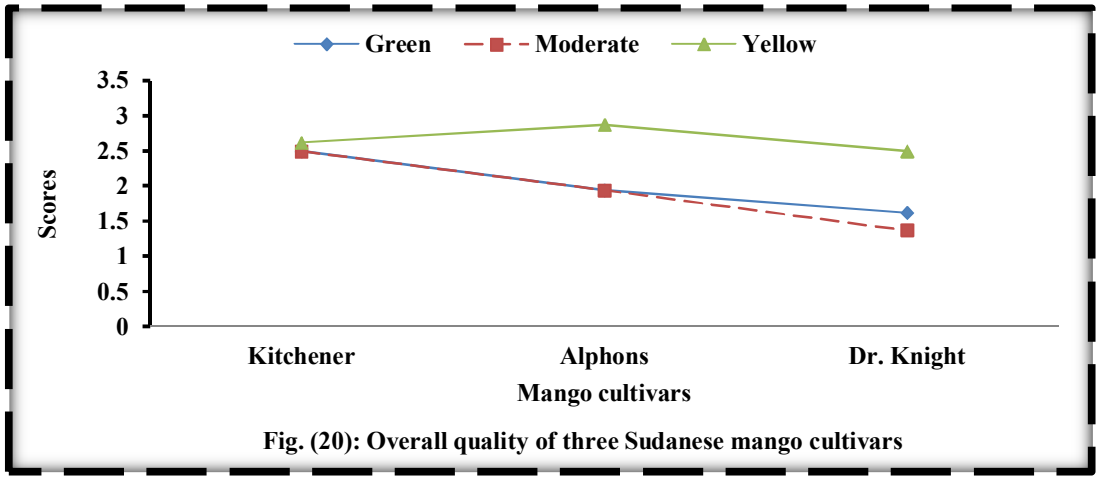

Fig. (20): Overall quality of three Sudanese mango cultivars

CHAPTER FIVE

Conclusion and Recommendations

Conclusion:

From the interpretation of the results obtained in this study the following points can be concluded:-

- The longest fruits exhibited by Alphons cultivar at the yellow stage, while the shortest fruit exhibited by Dr.knight cultivar at green stage. The maximum width of fruit exhibited by kitchener cultivar at moderate stage, while the minimum width exhibited by Dr.knight at moderate stage. The maximum weight of fruit exhibited by Alphons cultivar at green stage, while the minimum weight exhibited by the same cultivar at moderate stage.
- The highest moisture content exhibited by Dr.knight cultivar at yellow stage, while the lowest moisture content exhibited by the same cultivar in green stage.
- The highest acidity exhibited by Alphons cultivar at green stage , while the lowest acidity exhibited by kitchener cultivar at yellow stage.
- The highest total soluble solids exhibited by cultivars (Kitchener and Dr.knight), while the lowest T.S.S in Dr.knight cultivar at green stage.
- The highest PH exhibited by kitchener cultivar at yellow stage, while the lowest PH exhibited by Dr.knight at green stage.
- The highest crude fiber exhibited by kitchener cultivar at yellow stage, while the lowest crude fiber exhibited by Alphons cultivar at green stage.
- The highest ash content exhibited by kitchener cultivar at yellow stage, while the lowest ash content exhibited by Alphons cultivar at green stage.

- The sensory evaluation of three cultivars showed the following results : the most preferable color was for Alphons cultivars at yellow stage , where the least preferable color was for Dr. knight at moderate stage.
    - The most preferable taste was found in both (Alphons and kitchener) cultivars, where e least preferable was found in Dr.knight.
    - The most acceptable Texture was obtained in both Alphons and Dr.knight cultivar at yellow stage ,where the unacceptable one was found at the moderate stage of Dr.knight cultivar.
    - The most accepted overall quality was obtained at the yellow stage of Alphons cultivar, where the low overall quality was obtained at the moderate stage of Dr.knight.

Recommendations:

1. Alphons is considered a fiber less cultivar which is suitable for export.
2. Kitchener cultivar is fibrous cultivar while it is suitable for local consumption.
3. In Dr. knight cultivar, the color is not an indicator for maturity because the peel of the fruit at the ripening stage, is green or greenish yellow.
4. The Total soluble solids (TSS%) among the three cultivars of Mango at yellow stage of ripening indicate a full maturity and harvesting stage of the fruits.

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