

**ASSESSMENT OF PRODUCTION CONSTRAINTS AND CONTRIBUTION OF AVOCADO TO FOOD SECURITY AND INCOME IN THE MOUNT KENYA REGION, KENYA**

<sup>1</sup>Grace N. Kamotho, <sup>2</sup>Lydia A. Asiko, <sup>3</sup>James K. Kibanyu, <sup>1</sup>Phares R. Kinyua, <sup>3</sup>Rebecca N. Karaya, <sup>4</sup>Patrick M. Muthee and <sup>1</sup>Zipporah M. Mwathi

Karatina University, P.O.Box 1957-10101, Karatina, Kenya, School of Agriculture and Biotechnology:

<sup>1</sup>Department of Agricultural Sciences (Crop Science),

<sup>2</sup>Department of Food Science and Nutrition,

<sup>3</sup>Department of Agricultural Sciences (Extension),

<sup>4</sup>Department of Agricultural Sciences (Agricultural Economics)

<https://doi.org/10.35410/IJAEB.2023.5859>

**ABSTRACT**

Avocado (*Persea americana* Mill.) belongs to the family Lauraceae and it is an important crop to rural communities and economies in Kenya. Currently, avocado is grown in several agro-ecological zones mainly by small-scale growers (85%) who grow it for subsistence, local markets and export. About 70% of avocado is grown in Central and Eastern region of Kenya. Central region produces 40%, Eastern 28%, Western 13%, Rift Valley 10%, Nyanza 6%, Coast 2% and Nairobi County 1%. The main production areas are Muranga, Kiambu, Thika, Embu, Meru, Taita Hills and Kitale. The aim of this study was to assess the production constraints and contribution of avocado to food security and income in Mount Kenya region. The study population comprised of smallholder avocado farmers. Purposive sampling was done in selecting highest producing sub-counties of avocado in Nyeri, Muranga and Embu counties. Simple random sampling was used to select 40 smallholder farmers from each of the selected sub-counties who participated in the survey. Data was collected using a structured questionnaire and analysed using SPSS computer package. Results indicated several constraints in the production of avocado including pests and diseases, lack of quality planting material, poor soils, lack of technical knowledge by avocado farmers and lack of well-structured marketing system. The study identified a gap in value addition of avocado in Kenya. It was also demonstrated that avocado contributes highly to household income and food security. The crop should therefore be accorded priority by policy makers and more research needs to be encouraged especially in the management of pests and diseases. Capacity building to avocado growers should be routinely carried out so as to avoid the many challenges that emanate from lack of technical knowledge. Intervention in value addition of avocado is an aspect that Kenyan county governments need to engage in by investing in cottage industries on avocado processing.

**Keywords:** Avocado, Production, Constraints, Food Security, Income.

**1. INTRODUCTION**

The avocado (*Persea americana* Mill.), also called 'Parachichi' in Kiswahili, belongs to the family of Lauraceae that also includes the laurel, the camphor and the cinnamon tree. It is native to tropical America where it is divided into three sub-species or races, that is, Mexican (sub-tropical), Guatemalan (semi-tropical) and West Indian (tropical). Several varieties (Bacon,

Booth 7, Booth 8, two strains of Fuerte from South Africa and the U.S, Hardy, Hass, Maypan, Linda, Lyon, Lula, Nabal, Puebla, Reed, Simmonds, Tonnage and Zutano) of avocado were introduced in Kenya in the 1930s by the Portuguese (Griesbach, 2005). In Kenya, it was most probably introduced by Portuguese during the 16th and 18th centuries. By 1939, such improved cultivars as Puebla, Nabal, Lyon, Lula, Linda and at least two strains of Fuerte – one from California and one from South Africa – had been introduced. They adapted very well to the highlands of Kenya, and especially Fuerte and Puebla have been promoted ever since. Commercial cultivation of avocado started in the 1960s and 23tonnes of avocado were exported to Europe in 1970 (Griesbach, 2005). Griesbach (1985), reports that the national development plan of 1974 included a programme to increase avocado hectarage from 150 to 1,450 by 1982 to meet with the local and export demand. Several avocado nurseries were established in 1980 and as a result, exports of Fuerte, Hass and Puebla increased to 1,051 tonnes (Griesbach, 1985).

Avocado is an important crop to rural communities and economies in Kenya (Gyau et al., 2016; Mwambi et al. 2016). Between 2003 and 2013, avocado production in Kenya almost tripled, from 70,948 tons in 2003 to 191,505 tons in 2013 and the area under avocado production doubled during the same period, from 5,099 ha in 2003 to 11,000 ha in 2013 (Wasilwa et al., 2017). Total avocado exports from Kenya were valued at \$29.3 million in 2013 (FAOSTAT, 2013). About 85 percent of the avocado production in Kenya is by small-scale farmers who grow the crop for subsistence, local markets and export (Oduol et al., 2017). Further, the avocado's contribution to food security in Kenya is also reported to be significant and its consumption is increasing as more people discover the nutritional values of this fruit.

A programme to evaluate avocado for adaptability in Kenya started in 1965 (Griesbach, 2005). Findings from these studies showed that the West Indian race (cultivars Hardy and Simmonds) was adapted from sea level to 1000 m; the Guetemalan race (Hass and Reed) was best adapted to areas between 1,000-2,000 m and the Mexican race (Puebla and Teague) from 1,500-2,500 m. Fruits from the Guetemalan race mature late; those from the Mexican race mature early to mid-season whereas those from the West Indian race mature early.

In Kenya, avocado cultivation is concentrated in the highlands between 1200 and 1800 m. Avocado is grown in several agro-ecological zones mainly by small-scale growers (85%) who grow it for subsistence, local markets and export (Mulubrhan, 2019). About 70% of avocado is grown in Central and Eastern Provinces. Central Province produces 40%, Eastern 28%, Western 13%, Rift Valley 10%, Nyanza 6, Coast 2% and Nairobi County 1% (Horticulture Validated Report, 2020). The main production areas are Muranga, Kiambu, and Thika in Central region of the country, Embu and Meru in Eastern region, Taita Hills in Coast region and Kitale in Rift Valley region. Although Kenya has 7,500 ha under avocado production yielding about 81,000 tonnes, not every fruit harvested is converted into income or food due to several challenges (Horticulture Validated Report, 2020). Extent to which constraints and opportunities faced by different categories of small holder farmers and also the interventions, are likely to be different for each group of smallholders. Yet, there is paucity of information on the type of interventions that work best in the avocado value chains. This study sought to assess the production constraints and contribution of avocado to food security and income in Mount Kenya region.

**1.1 Objectives Of The Research**

The study sought to address food security which remains a contemporary global challenge for an ever growing population with a focus on avocado production. The overall objective of this study is to identify specific constraints limiting production of avocado and document them for future reference by other researchers. The study also elucidated on how avocado contributes to income and food security in areas where it is grown.

The following were the specific objectives of the study.

- i. Assess the challenges faced by avocado growers in Nyeri, Embu and Murang'a.
- ii. Assess the factors that influence marketing of avocado.
- iii. To determine opportunities for value addition of avocado

**2. METHODOLOGY**

The study employed a value chain approach while triangulating on data collection methods. A combination of data collecting techniques were used including discussion with community opinion leaders, group discussions, administering questionnaires inform of interview schedules to a sample of 120 avocado growers in the selected sub-counties. Disproportionate stratified random sampling was used as illustrated by Chung et al., 2016. This is a sampling method in which the size of the sample drawn from a particular stratum is not proportional to the relative size of that stratum (Chung et al., 2016). Thus, regardless of the population size in each county, data was taken from 120 respondents. The strata were counties and sub-counties. Data was taken from Tetu Sub- county (Nyeri County), Kigumo Sub-County (Murang'a County) and Runyenjes Sub-County (Embu County).

**3. RESULTS****3.1 Section One: Farmers Background Information**

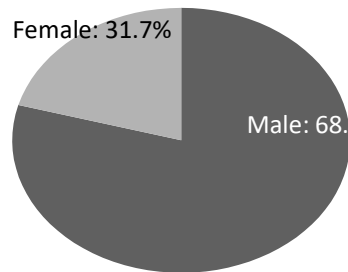
Number of respondents was 120 drawn from three counties, that is, Nyeri, Embu and Murang'a as shown in Table 3.1.

**Table 3.1: Number of respondents from different counties**

<b>County</b>	<b>No of respondents</b>	<b>Percentage</b>
Nyeri	39	32.5
Embu	40	33.3
Murang'a	41	34.2
<b>Total</b>	<b>120</b>	<b>100%</b>

**Gender of the respondents**

As shown in Figure 1, majority of the respondents were men 68.3% and women were 31.7%.



**Figure 3.1:** Gender of respondents

**Age category of respondents**

Majority (37.7%) of the respondents were between 41 to 60 years old, followed by the age category of 61 to 70 years at 30.8%. The youth, 20 to 40 years old, were at 8.3%, as shown in Table 3.2.

**Table 3.2** Age category of respondents

Age in years	No of respondents	Percentage
20 - 40	11	9.2
41-60	49	40.8
61- 70	37	30.8
Above 70	23	19.2
<b>Total</b>	<b>120</b>	<b>100%</b>

**Size of land**

Land size per member was recorded where majority of the respondents (77.7%) were small scale farmers with less than two acres of land. This was followed by farmers with 2.1 to 6 acres at 24.1%. Only 4.2% of the respondents had more than 6 acres of land, Table 3.3.

**Table 3.3 Size of land**

Size of land in acres	Frequency	Percentage
>1	23	19.2
0.1 - 2	63	52.5
2.1 - 4	22	18.3
4.1 – 6	7	5.8
6.1 – 8	2	1.7
8.1 - 10	2	1.7
10.1<	1	0.8
<b>Total</b>	<b>120</b>	<b>100%</b>

### 3.2 Section 2: Avocado Enterprise

#### 3.2.1 Adoption of Avocado Enterprise

Farmers gave various reasons that informed their decision to adopt growing avocado (Table 3.4). Majority (39.2%) were attracted to the enterprise by the high income obtained. Diversification for food security (20.8%), sensitization by various agents on the enterprise (20.8%) and influence by neighbors (15.8%) were other reasons why farmers adopted the enterprise.

**Table 3.4 Adoption of Avocado Enterprise**

Reason	Number of respondents	Percent
Exposure from other counties	4	3.3
Sensitization by various agents including MoA, HcD, KALRO, Plant nursery operators and County government	25	20.8
A profitable enterprise	47	39.2
Diversification for food security	25	20.8
Influence from neighbours	19	15.8
Total	120	100.0

**3.2.2 Age of Avocado Trees in Farmer’s Fields**

It was noted that majority (47.5%) of farmers had started the avocado enterprise in the last five years. It was also observed that in general, the avocado enterprise in the study area was a young enterprise where 86.7% of the farmers had avocado trees of 15 years old and younger (Table 3.5).

**Table 3.5 Age of avocado trees in farmer’s fields**

Age of trees (years)	Number of respondents	Percent
0-5	57	47.5
6-10	36	30.0
11-15	11	9.2
16-20	6	5.0
21-25	3	2.5
over 25	7	5.8
Total	120	100.0

**3.2.2 Source of Avocado Seedlings**

Only 30% of respondents obtained avocado seedlings from reputable sources, that is, from nurseries registered by Horticultural Crop Development (HCD) and Kenya Plant Health Inspectorate Services (KEPHIS). The two organizations provide guidelines on how to produce high quality seedlings devoid of transmissible pests and diseases. Other growers who formed the majority (70%) of respondents obtained avocado seedlings from various places which are questionable in provision of quality seedlings (Table 3.6).

**Table 3.6 Source of Avocado seedlings**

Source of seedlings	Number of respondents	Percentage
HCD/KEPHIS registered nursery	36	30.0
Own raised seedlings	27	22.5
Roadside sellers	15	12.5
Any plant nursery	19	15.8
Gift by friends /neighbours	11	9.2
Grafted an indigenous tree	6	5.0
Through the group	5	4.2
Kakuzi	1	.8
Total	120	100.0

### 3.2.2 Source of Seed for Raising Own Seedlings

Farmers who raised seedlings to plant in their farms obtained seeds from various sources. Majority of them (48.15%) sourced seeds from the local markets while 29.63% obtained seeds from their neighbours' trees. Some respondents (22.22%) relied on volunteer avocado plants that grew in their farms (Figure 3.2). All these sources of seeds are of disreputable quality.

#### Sources of seed for own raised nurseries

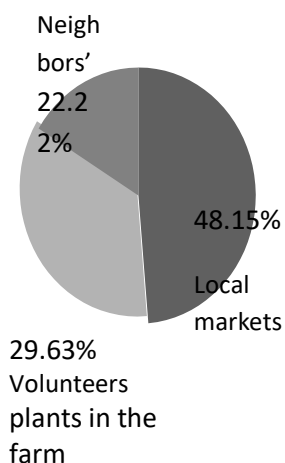


Figure 3.2 Sources of seed for own raised nurseries

### 3.2.3 Identification of Horticultural Crops Development (HCD)/Kenya Plant Health Inspectorate Services (KEPHIS) Registered Nurseries by Avocado Farmers

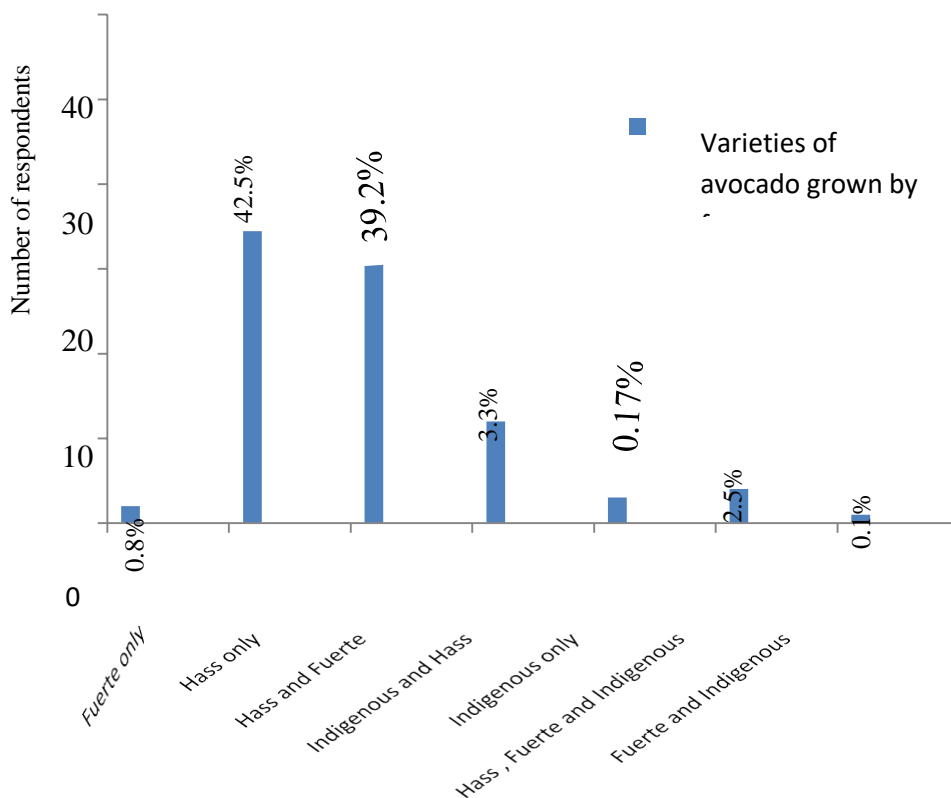
It was observed that, out of 120 respondents, 36 of them (30%) acquired seedlings from registered nurseries. The respondents identified the nurseries through several means where majority of them acquired the information through the Ministry of Agriculture (27.85%) and from friends (25%).

**Table 3.7 Identification of HCD/KEPHIS registered Nurseries by avocado farmers**

Agents	Frequency	Percent
Ministry of Agriculture/Extension Officers	10	27.8
From friends	9	25.0
Nursery operator	4	11.1
Sensitized by group officials	5	13.9
Internet	2	5.6
Other farmers	5	13.9
KEPHIS	1	2.8
Total	36	100.0

**3.2.5 Varieties of Avocado Grown by Farmers**

Majority of farmers (81.87%) grow the most marketable avocado varieties, that is, Hass and Fuerte. Farmers who are growing indigenous avocado variety are a minority at 2.5% while those who are growing a mixture of Hass, Fuerte and indigenous varieties are at 4.2% (Figure 3.3).



**Figure 3.3** Varieties of avocado grown by farmers



**3.2.6 Avocado Cropping System**

Most avocado farmers (68.3%) intercropped avocado with crops such as beans, maize, cabbage, coffee, macadamia, watermelon, potato, kales, mango and banana. Only 25.8% of farmers grow their avocado on pure stand, while 3.3% practiced both pure stand and intercropping. A minority of farmers grow the avocado along the farm boundaries.

**3.2.7 Comparing Avocado with other Farm Enterprises**

Majority of respondents (76.7%) observed that compared to other farm enterprises, avocado is a more profitable enterprise and a source of food. Only 3.3% of respondents who indicated that avocado give less income compared to other farm enterprises (Table 3.8).

**Table 3.8 Comparing Avocado with other Farm Enterprises**

Observation	Number of respondents	Percent
Has high potential and less farm input demand	6	5.0
More profitable enterprise and provides food	92	76.7
Requires less input and labour and has many uses eg., shade and water conservation	18	15
Avocado gives less income compared to other crops	4	3.3
Total	120	100

**3.2.8 Challenges in Avocado Production**

A myriad of challenges in avocado production were identified. Majority of respondents (33.3%) identified the challenge of diseases and pests. The challenge of expensive farm inputs was also experienced by many farmers (23.3%) (Table 3.9).

**Table 3.9 Challenges in avocado production**

Challenge	Number of respondents	Percentage	Challenge	Number of respondents	Percentage
Poor market prices	6	5	Drought	12	10
Expensive farm inputs	22	18.3	Lack of water for Irrigation	12	10
Pests	18	15	Price fluctuations	15	12.5
Diseases	18	15	Costly labour	8	6.7
Small land sizes	5	4.2	Poor soils	4	3.3
<b>Total</b>				<b>120</b>	<b>100</b>

**3.2.9 Coping Strategies by avocado farmers**

Farmers attempted many coping strategies to navigate through the challenges. However, majority (32.7%) did not know of any coping strategies while 18.3% sprayed chemicals to their crops to control pests and diseases (Table 3.10).

**Table 3.10 Coping strategies**

<b>Activity</b>	<b>Number of respondents</b>	<b>Percentage</b>
None	52	43.33
Spray to control pests and diseases	22	18.3
Bargain for better prices in the market	3	2.5
Reduce scale of operations	2	1.7
Traps to control insect pests	3	2.5
Reporting incidences to Ministry of agric.personnel	2	1.7
Sell in local markets	1	.8
Sell at prevailing prices	1	.8
Sought extension services	2	1.7
Diversification of crops	2	1.7
Joining farmer groups	2	1.7
Irrigating avocados only	3	2.4
Loans from banks, SACCO, friends etc	4	3.3
Farmer to farmer extension	2	1.7
Field sanitation	1	.8
Use of farmyard manure	4	3.3
Water harvesting by use of storage tanks	2	1.7
Use of organic chemicals	1	.8
Smoking using tithonia leaves and other botanicals to control pests	1	.8
Utilise family labour	2	1.7
Sell through brokers	2	1.7
Sell to many buyers	1	.8
Keep livestock to diversify source of income	1	.8
Total	120	100.0

**3.2.10 Harvesting of Avocado - Maturity Indices**

Various observations were given by respondents on how they determine that avocado fruits are ready for harvesting (Table 3.11). Many of the respondents use size of fruit and colour change as maturity indices. However, in as much as the two indicators are important, some fruits will remain small even at maturity due to various contributing factors such as heat or cold stress and plant nutrition. Some varieties do not exhibit conspicuous colour change at maturity for example the Fuerte avocado variety. However, for such a variety, change of texture would be an important maturity indicator.

**Table 3.11 Harvesting of Avocado - Maturity Indices**

<b>How to identify mature avocado for harvesting</b>	<b>Number of respondents</b>	<b>Percent</b>
Size, colour change and seasons	25	20.83
Colour change and seasons	3	2.50
Change of colour	49	40.83
Buyers information	16	13.33
Information from members of the farmers' cooperative groups	2	1.67
Buyers advice and number of months from flowering	2	1.67
Size, texture and maturity period	3	2.50
Texture and colour change	5	4.17
Colour , size of fruit and advice from experts	3	2.50
Wait for fruits to fall from the tree	6	5.00
Colour change and shaking seeds inside the fruit	3	2.50
Keep one fruit to see if it will ripen	2	1.67
Use of Harvesting ring/gauge	1	.83
<b>Total</b>	<b>120</b>	<b>100.0</b>

**3.2.11 How Farmers Harvest Avocado Fruits**

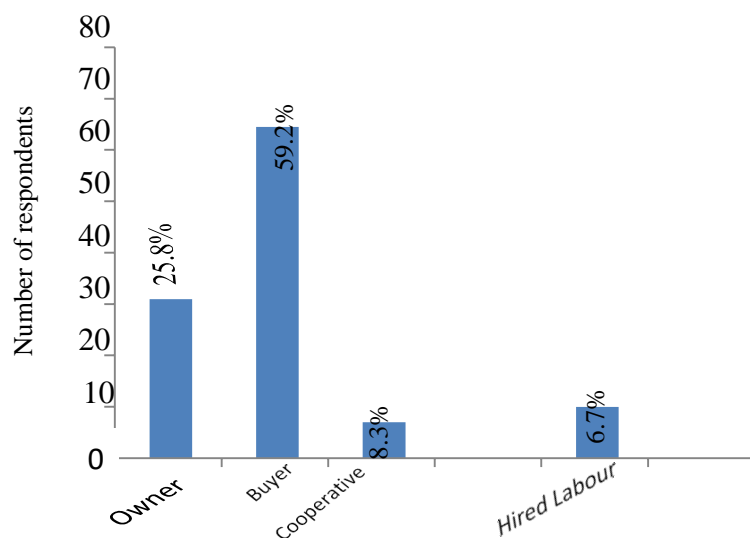
Farmers use various harvesting methods (Table 3.12). The most popular, being climbing the tree, hand picking and placing the fruits in the basket with 55.0% of the respondents. This is the best method to avoid damage of the fruits. However, the inner side of the basket should be made of soft material. Some respondents use crude methods of harvesting avocado fruits such as picking the fallen fruits on the ground (2.5%) and shaking the trees (5.8%). Avocado fruits harvested in this manner deteriorate fast and become unmarketable.

**Table 3.12 How Farmers Harvest Avocado fruits**

Avocado Harvesting	Number of respondents	Percent
Use hooks for the ones afar off and handpicking	23	19.2
Use stick rod for harvesting	11	9.2
Climbing trees, hand picking and placing in a basket	66	55.0
Picking the fallen fruits from the ground	3	2.5
Hook sticks and scissors	8	6.6
Climbing and shaking the tree	7	5.8
Use hooks and buckets	2	1.7
Total	120	100.0

**3.2.12 Who Harvests Avocado Fruits**

Majority of respondents (59.2%) indicated that the avocado buyer takes charge in the harvesting of the quantity of fruits required. The 25.8% of the respondents who harvest their avocado fruits are comprised of respondents who are not in avocado marketing cooperative groups, those who grow indigenous varieties that are not highly marketable and respondents who sell their avocado in local markets. Some avocado growers (8.3%) rely on members of their cooperative groups to assist in the harvesting of the fruits while 6.7% of the respondents hire labour for the activity, (Figure, 3.3).



**Figure 3.3 Harvesting of avocado fruits**

**3.2.13 Marketing of Avocado**

Majority of farmers (50.8%) sold their avocado to export markets through middle men. A few respondents (10.8%) do not sell the avocado but use it as food for household. A substantial number of respondents (23.3%) sell their avocado fruits in the local markets (Table 3.13).

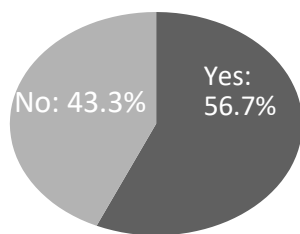
**Table 3.13 Marketing of avocado**

Markets	Frequency	Percent
Export market through middlemen	61	50.8
Local market only through middlemen	28	23.3
Both export and local markets	18	15
Used at home, no selling	13	10.8
Total	120	100

**3.2.14 Membership of Farmers’ Cooperatives**

A total number of 68 respondents (56.7%) are members of avocado marketing cooperatives (Figure3.4). However, 43.3% of farmers who grow indigenous avocado varieties that are not attractive to buyers, had not joined the farmers’ cooperatives.

**Member of cooperative**



**Fig.3.4** Members of avocado marketing cooperatives

**3.2.15 Benefits for being a member of a marketing cooperative**

Respondents identified many benefits that accrue from being a member of avocado marketing cooperative (Table 3.14). Majority of respondents (64.7%) observed that prices are usually better and there is assurance of market for the fruits.

**Table 3.14 Benefits for being members of a marketing cooperative**

<b>Benefits</b>	<b>Frequency</b>	<b>Percent</b>
Access loans from the bank	3	4.4
Better prices and assured markets	44	64.7
Improved bargaining power	5	7.4
Market and extension services provided	4	5.9
Trainings, purchase of inputs ,market and harvesting provided	4	5.9
Collective sales and payment of bonus	3	4.4
Transport facilitation is provided	5	7.4
Total	68	100.0

**3.2.16 Utilization of Avocado at the Household Level**

All respondents utilized avocado as food but in different ways (Table 3.15). However, it was observed that respondents are not aware of the many other ways of utilizing the avocado fruit.

**Table 3.15 Utilization of Avocado at the household level**

<b>Utilization of avocado</b>	<b>Number of respondents</b>	<b>Percent</b>
Eat with food	64	53.3
Eat the fruit	47	39.2
Spread on bread	2	1.7
In food and bread spread	7	5.8
Total	120	100.0

**3.2.18 How Respondents Use Proceeds Obtained From Avocado Enterprise**

Avocado enterprise is the source of income for almost all of the respondents. Farmers utilize the proceeds in different ways. Majority of respondents use income obtained from avocado to pay school fees, buy food, clothes and for household upkeep. Other respondents use the income to purchase several assets such as television sets, water tanks, and livestock. Others use the income for building and also for running their homes (Table 3.16).

**Table 3.16 How Respondents Use Proceeds Obtained From Avocado Enterprise**

<b>Observations</b>	<b>Frequency</b>	<b>Percent</b>
Paid school fees	8	6.67
Bought livestock and farm inputs	10	8.33
Increased household income	9	7.50
Built a house and paid school fees	12	10.00
Source of income and food	25	20.83
Bought a plot and paid school fees	1	0.83
For school fees, food security, clothing and household upkeep	36	30.00
Payment of hospital bills and food stuffs	3	2.50
Pay household labour and for household upkeep	14	11.67
Bought a TV set	1	0.83
Bought water tank and paid school fees	1	0.83
Total	120	100.0

#### **4. DISCUSSION**

##### **Comparing Avocado with other Farm Enterprises**

In the study area, many farmers have ranked avocado higher than other farm enterprises in terms of income generation and contribution to food security. These findings corroborate with the information obtained from Horticultural Crops Development validated report, (HCD, 2020) which reported that Kenya topped Africa’s avocado exports in 2020, and was among the world’s top 10 producers, with Murang’a leading with 31% of total production, followed closely by Kiambu, Nakuru, Kisii, Nyamira, Meru and Bomet counties. Kenya’s exports of avocados hit about 68,000 tons between January and October, 2021, generating KSh14 billion for the country. Volumes of the highly sought commodity in the local and international market went up to 84.5 million kilos from 70.3 million kilograms recorded between January-November 2020 (HCD,2020). In August 2021, Trade Cabinet Secretary announced that Kenya will also start avocado exports to South Korea in March, 2022 as part of the country’s horticulture business expansion strategy (HCD, 2020). According to data from Fresh Produce Exporters Association of Kenya (FPEAK), Kenya is the world’s third-largest producer of avocados. With a market share of 2.1%, Kenya was ranked eight (8) globally in 2019 in export of avocados behind Mexico, Netherlands, Peru, Spain, Chile, Colombia and the United States (FPEAK, 2020). Among the top exporters, the fastest-growing avocados exporters since 2015 were: Colombia (up 1,607%), Dominican Republic (up 424.2%), Morocco (up 206.6%) and Kenya (up 161.5%). The ready market and good prices are the reasons why many farmers in Kenya are abandoning other crops such as coffee, tea and maize to venture into avocado production.

## Challenges in Avocado Production

Although Kenya has 7,500 ha under avocado production yielding about 81,000 tonnes, about 30,000 to 40,000 tonnes are lost to poor pre- and postharvest handling practices; limited superior varieties or planting materials, poor tree crop management practices; poor infrastructure, poor market information, pests (thrips, scales, fruit fly and systates weevil) and diseases (root rot, anthracnose and *Cercospora* leaf spot), and limited utilization of the crop (Nyakangi et al., 2023). All these challenges were experienced in the study area. Water scarcity is currently one of the world's biggest concerns and, with climate change the problem continues to grow larger (Mavuso et al., 2015). Climate plays an important role in avocado production. Extreme climatic conditions and high annual or seasonal variability of climatic parameters worldwide adversely affects productivity. The pattern and amount of rainfall are among the most important factors that affect agricultural systems. Long term rainfall records provide the grower with information about rainfall patterns and variability which aid his/her planning and management of orchards (Lazaro et al., 2001). Water scarcity is one of the challenges reported in avocado production.

## Utilization of Avocado

Avocado is an energetic fruit with high nutritional value and is considered a major tropical fruit. It is rich in protein and contains fat-soluble vitamins lacking in other fruits. It is also rich in Vitamins A and B, and median levels of vitamins D and E. It contains different oil levels in the pulp, thus it is widely used in pharmaceutical and cosmetic industries, and for obtaining commercial oils similar to olive oil (Griesbach, 2005). In addition, this fruit has been recognized for its health benefits, especially due to the compounds present in the lipid fraction, such as omega fatty acids, phytosterols, tocopherols, and squalene (Santos et al., 2014b). Avocado is consumed in various forms in northern South America, Central America and Mexico, as puree salads, seasoned with salt, pepper, vinegar and other condiments, as well as being used in the preparation of other dishes. In Brazil, the ripe fruit is more appreciated, together with sugar, honey and liqueurs, and consumption is influenced mainly by its sensory and nutritional characteristics (Griesbach, 2005).

The avocado pulp contains high lipids content, which makes the pulp the portion of greatest interest. Lipids vary from 5 to 35%, being formed mostly by unsaturated fatty acids (60-84%) (Duarte et al., 2016). In addition to the important major compounds, avocado contains substantial amounts of bioactive compounds such as phytosterols, especially in the lipid fraction, and the main representative is the  $\beta$ -sitosterol (Nikki et al., 2023). Diets rich in phytosterols can lead to the reduction of the total cholesterol and LDL cholesterol.

Avocado seed is underutilized and represents a large portion of the fruit, thus its use can be an alternative to reduce the production cost of edible oil. The seed is also a waste issue of avocado processor. However, the main problem in the use of avocado seeds is the presence of phenolic compounds that exhibit toxicity. Studies have shown that the seeds can be used in feed for monogastric animals after extraction of these substances with ethanol. There is ethno-pharmacological information on the use of seeds for the treatment of health-related conditions, especially in South American countries where avocados are endemic and currently grown on a large scale (Dabas et al., 2013). Current research has shown that avocado seeds may improve



hypercholesterolemia, and be useful in the treatment of hypertension, inflammatory conditions and diabetes. Seeds have also been found to possess insecticidal, fungicidal, and anti-microbial activities. The avocado seeds is rich in phenolic compounds, and these may play a role in the putative health effects (Dabas et al., 2013). The extract may present antioxidant activity. The phenolics levels in seeds vary from 2.3 to 5.7%. In addition to the starch and fiber, there are other non-nitrogenous substances present in seeds, ranging from 5.1 to 13.2% (Salgado et al., 2008a).

Avocado leaves are a pharmaceutical ingredient widely used in extracts for therapeutic purposes, and also as teas in folk medicine (Cecilia et al., 2019), probably due to the diuretic properties. Phytochemicals as orhamnetin, luteolin, rutin, quercetin, and apigenin have been isolated from avocado leaves, which can help prevent the progress of various diseases related to oxidative stress (Owolabi et al., 2010).

In the study area, avocado is mainly grown for income generation and for food security. As a food, it is used as a vegetable accompaniment for starchy meals such as rice, 'githeri' (a traditional meal of maize grains and beans) and 'ugali' (maize meal made from maize flour). It is also used as a smear on bread and in fruit pudding. Consumption of the fruit as puree and smoothie is gaining popularity. Interventions on capacity building regarding avocado utilization would be helpful to growers and consumers of avocado in the study area and largely in Kenya.

## **5.CONCLUSION**

The study found out that avocado is highly valued by farmers where it is grown as it is a source of income and food security. Most challenges faced by farmers are as a result of lack of technical knowledge for instance in proper crop husbandry. It is important that capacity building to all avocado growers be continuously carried out in all aspects of avocado value chain. In addition, the County Governments in the study areas need to invest in cottage industries for processing of avocado fruit. This is an important investment which is lacking in many areas. With cottage industries farmers will have an alternative market for their avocado.

## **ACKNOWLEDGEMENT**

Karatina University funded all aspects of this study and the research team highly appreciates the support accorded by the University management. We also thank the Agricultural Extension officers in Embu –Runyenjes, Murang'a –Kigumo and Nyeri-Tetu for their assistance.

## **REFERENCES**

- 1.Cecilia Castro-López, Israel Bautista-Hernández, María D. González-Hernández, Guillermo C.G.Martínez-Ávila, Romeo Rojas, Adriana Gutiérrez-Díez, Nancy Medina-Herrera, & Víctor E. Aguirre-Arzola, (2019). Polyphenolic Profile and Antioxidant Activity of Leaf Purified Hydroalcoholic Extracts from Seven Mexican *Persea americana* Cultivars, *Molecules*. 2019 Jan; 24(1): 173.
2. Dabas D, Shegog RM, Ziegler GR, Lambert JD (2013). Avocado (*Persea americana*) seed as a source of bioactive phytochemicals. *Curr Pharm Des*. 2013;19(34):6133-40. doi: 10.2174/1381612811319340007. PMID: 23448442.

3. Chung, S., Sood, A. and Granick, S., (2016). Disproportionate availability between emergency and elective hand coverage: A national trend. *Eplasty*. 16 - 28.
4. Duarte Patrícia Fonseca , Chaves Marcia Alves , Borges Caroline Dellinghausen , Mendonca Carla Rosane Barboza (2016). Avocado: Characteristics, health benefits and uses, OI:10.1590/0103- 8478cr20141516
5. Gyau A (2017). Determinants of participation and intensity of participation in collective action: evidence from smallholder avocado farmers in Kenya, World Agroforestry Centre, UN Avenue, 00100 Gigiri, Nairobi, Kenya.
6. FAOSTAT, (2013). World food and agriculture. Rome: Food and Agriculture Organization of the United Nations.
7. FPEAK, (2020). Avocado exports from Kenya. <https://www.freshelaexporters.com>
8. Griesbach (2005). Avocado growing in Kenya, Publisher: World Agroforestry Centre, Nairobi, Kenya. SBN:9789290591733, 9290591730.
8. Griesbach, J. (1985). THE AVOCADO INDUSTRY IN KENYA. *Acta Hort.* 158, 87-92  
DOI:  
10.17660/ActaHortic.1985.158.9, <https://doi.org/10.17660/ActaHortic.1985.158.9>.
9. Gyau, A., Mbugua, M., & Oduol, J. (2016). Determinants of participation and intensity of participation in collective action: evidence from smallholder avocado farmers in Kenya. *Journal on Chain and Network Science*, 16(2), 147-156. doi:10.3920/jcns2015.0011
10. Horticultural Crops Development Authority (2020). National Horticulture Validated Report, 2020 HCDA, USAID, Nairobi, Kenya.
11. Mavuso, M.S., Manyatsi, A.B. & Vilane, B.R. (2015). Climate change impacts and coping Strategies at Malindza, a rural semi-arid area in Swaziland. *American Journal of Agriculture and Forestry*, 3:86-92.
12. Mulubrhan Amare a, Jane Mariara b, Remco Oostendorp c, Menno Pradhan (2018). The impact of smallholder farmers' participation in avocado export markets on the labor market, farm yields, sales prices, and incomes in Kenya, <https://doi.org/10.1016/j.landusepol.2019.104168>
13. Nikki A. Ford, Paul Spagnuolo, Jana Kraft & Ella Bauer (2023). Nutritional Composition of Hass Avocado Pulp, *Foods* 2023, 12(13), 2516; <https://doi.org/10.3390/foods12132516>.
14. Nyakang'i Clinton , Rebecca Ebere Rebecca, Eunice Marete Eunice, Arimi Joshua (2023). Avocado production in Kenya in relation to the world, Avocado by-products (seeds and peels) functionality and utilization in food products, *Applied Food Research*, 3 (2023), 100275.
15. Oduol, J. B., Mithöfer, D., Place, F., Nang'ole, E., Olwande, J., Kiriimi, L., & Mathenge, M. (2017).
16. Women's participation in high value 104 agricultural commodity chains in Kenya: Strategies for closing the gender gap. *Journal of Rural Studies*, 50, 228-239. doi:10.1016/j.jrurstud.2017.01.005.
17. Owolabi M.A, H. A. B. Coker H.A & S. I. Jaja S.I (2010). Bioactivity of the phytoconstituents of the leaves of *Persea Americana*. *Journal of Medicinal Plants Research* 4(12)
18. Poulton C., Kydd, J and Dorward A. (2006). Overcoming Market Constraints on Pro-Poor Agricultural Growth in sub-Saharan Africa. *Development Policy Review*, 24(3): 243-277.
19. Salgado, J. M., Bin, C., Mansi, D. N., & Souza, A. (2008a). Efeito do Abacate (*Persea Americana* Miller) Variedade Hass na Lipidemia de Ratos Hipercolesterolêmicos. *Food Science and Technology*, 28(4), 922-928. <http://dx.doi.org/10.1590/S0101-20612008000400025>.

- 
- 20.Santos, J. L. F., Ataíde, E. M., Santos, A. K. E., & Silva, M. S. (2015). Edible coatings in avocado post-harvest conservation. *Scientia Plena*, 11, 1-7. Soares, D. G., Andr
- 21.Wasilwa L.A., Njuguna J.K., Okoko E.N. Watani G.W.(2006). Status of Avocado Production in Kenya<sup>12</sup> - 17 November 2006, 10TH KARI Biennial Scientific Conference KARI Headquarters, Kaptagat Road, Loresho, Nairobi, Kenya.Available at [http://www.kari.org/fileadmin/publications/10thProceedings/Poster/Status\\_AvocadoProd n.pdf](http://www.kari.org/fileadmin/publications/10thProceedings/Poster/Status_AvocadoProd n.pdf).