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Status of Production and Marketing of Ethiopian Sesame Seeds (*Sesamum indicum* L.): A Review

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Abstract

Sesame (*Sesamum indicum* L.) is an important crop produced in Ethiopia for oilseed production and it was ranked first in total production from oil crops during 2013. The objectives of the study were to review the status of production and productivity, marketing, oil extraction and purification methods of Ethiopian sesame seeds, and to indicate the gaps, opportunities and set future recommendations. The study indicated that three varieties namely; T-85, Kelafo-74 and Mehado-80 are dominantly produced in Ethiopia for export purpose. Ethiopia exports majorly the raw seed to China and Japan. The demand for export is mainly determined by the colour, taste, purity and dryness of the seeds, while the opportunity to export refined sesame oil to Europe, USA and other countries are not well established. On the other hand, Ethiopia is the net importer of refined oil for soybean and palm. The quality of sesame seed oil is determined by the compositions of fatty acids. Sesame oil has a high content of favoured linoleic and oleic acids which contain antioxidant which prolongs the shelf-life of both the oil and other food fried in the oil. In addition, after extraction of oil the mill contains high protein for human food and animal feed. The few refineries like Addis Modjo and crushing or refinery unit of MULAT are the good prospects to export refined oil to developed countries; however, the quality standard of the industries should meet the international standard to be competent in the market. In the future, organic seeds and refined oil are good prospects for Ethiopian industries for export. Sesame crop production status and oilseed production, marketing and its future prospects are discussed.

Keywords

Ethiopia, Fatty Acid, Marketing, Oil Content, Sesame Seeds

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1. Introduction

Sesame (*Sesamum indicum* L., 2n = 26), which belongs to the *Sesamum* genus of the Pedaliaceae family, is one of the oldest oilseed crops and is cultivated in tropical and subtropical regions of Asia, Africa and South America (Zhang *et al*., 2013). Sesame production was recorded in the Middle East and India since 4000 years ago. About 60% of the world's sesame production was from Myanmar, India, China, Ethiopia and Nigeria during 2011 (http://www.factfish.com/statistic/sesame%20seed,%20production%20quantity) and Ethiopia is among the top 5 world's producers of sesame seed, linseed and also an important producer of Niger seed (Wijnands *et al.,* 2007; http://www.epospeaeth.org/index.php/ethiopian-sesame-and-oilseeds: accessed date December 14/2013). The production of sesame is for oil and margarines. Sesame seeds are used whole or processed to produce oil and meal while in Africa sesame seeds are made into porridges and soups (Gooding *et al*., 2000). The quality of oil is determined by the fatty acid compositions of the total oil. Its oil is used for salad and cooking dishes.

In Ethiopia, the production of sesame is both by small and large scale farmers; and it is an important crop and export commodity. The total area, production and productivity

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during 2013 were 0.299 million ha, 0.220 million tonnes and 0.735 t ha^{-1}, respectively; and the total area and production were increased by 61.23 % and 17.91 %, respectively, while the total productivity was decreased by 27.23 % when compared with in 2008 (CSA, 2008; 2013). Sesame ranks first in total area and production from oil crops during 2013; and Tigray, Oromia, Amhara and Benshangul Gumuz regions are the major producers in Ethiopia. Due to its importance as a major export commodity the area coverage and production has increased in the last consecutive years in Ethiopia. There is an enormous potential to expand sesame seed production in Ethiopia through cultivation of additional new land. The government is enhancing the investment in the oilseeds sector with an extended package of incentives. Through transfer of technology and the provision of inputs, the increment of production and yield will be achieved strongly. Availability of Virgin fertile new areas which can be cultivated on large scale + cheap and abundant labor are the key indicators of the future potential http://www.epospeaeth.org/index.php/ethiopian-sesame-and-oilseeds: accessed date December 14/2013). In spite of the growing demand for sesame seeds and oil in Ethiopia, the productivity, production and oil extractions methods are traditional. Though Ethiopia is among the top 5 sesame seeds producers in the world, the potential benefit that could be obtained is below the optimum due to the use of traditional technologies and/or unavailable high-level sesame oil seed processing/refining industries in the country. Hence the objectives of the study were to review the status of production and productivity, and marketing, oil extraction and purification methods and other by-products of Ethiopian sesame seeds, and to indicate the gaps, opportunities and set future directions.

2. The Origin and Cultivation of Sesame

While sesame seeds have been grown in tropical regions throughout the world since prehistoric times, traditional myths hold that their origins go back even further. According to Assyrian legend, when the gods met to create the world, they drank wine made from sesame seeds. These seeds were thought to have first originated in India and were mentioned in early Hindu legends. In these legends, tales are told in which sesame seeds represent a symbol of immortality. From India, sesame seeds were introduced throughout the Middle East, Africa and Asia. Sesame seeds were one of the first crops processed for oil as well as one of the earliest condiments. The addition of sesame seeds to baked goods can be traced back to ancient Egyptian times from an ancient tomb painting that depicts a baker adding the seeds to bread dough.

3. The Biology of Sesame Crop

Sesame is an annual self pollinating plant with an erect, pubescent, branching stem, and 0.60 to 1.20 m tall. The leaves are ovate to lanceolate or oblong while the lower leaves are trilobed and sometimes ternate and the upper leaves are undivided, irregularly serrate and pointed (Felter and Lloyd, 1898: cited in Morris, 2002). The flowers are tubular, pendulant, bell shaped, and two lipped with a pale purple or rose to white color and 1.9-2.5 cm long. The flowers are borne on short glandular pedicels, and one flower is produced at each leaf axil and the lower flowers usually bloom 2 to 3 months after planting with continuous blooming until the upper most flowers are open. The fruit is an oblong, mucronate, pubescent capsule containing numerous small, oval, and yellow, white, red, brown, or black seeds (Morris 2002; Geremew *et al*., 2012).

4. Adaptation of Sesame Crop

Sesame is grown in hot and humid climate with temperature around 27 $^{\circ}$c and annual precipitation of 625-1100 mm. The crop is intolerant to water logging or poor drainage and excessive rain fall (MARD, 2008). Ethiopia has altitudes from below sea level up to 4500 meter above sea level with different climate zones which enables to grow a wide variety of oilseeds crops. Sesame is grown from sea level to altitudes of 1500 meters with uniformly distributed rainfall of about 500-800 mm and temperature of 25- 30 Celsius. All the sesame growing areas fulfill the above condition and in particular the north and north western parts of Ethiopia (http://www.epospeaeth.org/index.php/ethiopian-sesame-and-oilseeds: accessed date December 14/2013). The crops are grown on soil types ranging from fertile soils to sandy soils.

5. Sesame Genetic Resources and Diversity in Ethiopia

Ethiopia is one of the centers of biodiversity for several oilseeds (sesame seed, Niger seed, mustard seed, pumpkin seed, sunflower, rape seed, castor seeds, ground nuts) which can be considered as specialty high value seeds on the international market. The presence of wide altitudinal range (-120 m to 4600 m a.s.l.), substantial temperature, edaphic and rainfall differences created a wide range of agro-ecological conditions that provided sustainable environments for a broad range of life forms. As a result, Ethiopia is considered as one of the richest genetic resource centres in the world. The presence of weedy or wild forms of sesame (*S. alatum*; 2n=26 and *S. latifolium,* 2n=32) in Ethiopia shows that it is indigenous to this country. There are some

collections of sesame conserved in IBC/Ethiopia and some of the improved varieties are selections from the local collections (e.g. Kelafo-74 and Abasena) (Demissie *et al.*, 1992). Genetic diversity studies were done by different researchers on Ethiopian sesame collections in different times (Endale *et al*., 2011; Alemu *et al*., 2013, Desawi *et al*., 2014, Hika *et al*., 2014; Hika *et al*., 2015) and the reseachers reported that phenotypic and genotypic variations have been detected in the spcific populations studied. Endal *et al*. (2011) studied 50 populations of Ethiopian sesame using SSR markers and ample amount of genetic varitions were reported. Alemu *et al*. (2013) reported that significant gentic varition were detected using ISSR markers among six farmers' varieties of sesame from Northern Ethiopia indicaing that Ethiopia has ample genetic resources of sesame which coud be utilized for improvement progarms.

6. Past and Present Breeding Efforts in Ethiopia

Sesame improvement work has been initiated by lowland oil crop improvement program and handled by Werer Agricultural Research Centre of Ethiopia since long ago while other Ethiopian agricultural research centres such as Bako Agric. Research Centre is recently started the improvement aspects of varieties for higher productivity with tolerant to the major foliar diseases (OARI, 2006). It has been shown that different 20 improved varieties were released at different times for production (Geremew *et al.*, 2012). The first variety, Kelafo-74, was registered in 1976 (MARD, 2008). The improvement aspect was targeted to the higher seed yield and oil content and no work has been done regarding the oil quality content which is determined by the fatty acid compositions of the total oil. There is a genetic variation for total oil content and different fatty acid compositions of this crop. Currently three varieties are produced and exported; T-85; Kelafo-74 and Mehado-80 in Ethiopia (Table 2). More productive sesame cultivars that have been adapted by breeding are expected to be the major strategy for increasing yield and establishing stability in Ethiopia.

Table 1. Oilseed production for the year 2008 and 2012 in Ethiopia (CSA, 2008 and 2013).

Oilseed Crops	Total area (in 1000 ha)		Total production (in 1000 ton)		Productivity (t/ha)	
	2008	2013	2008	2013	2008	2013
Noog (Guizotia abyssinica)	285.236	285.303	159.820	220.211	0.56	0.772
Sesame (Sesamum indicum)	185 .912	299.724	186.773	220.216	1.01	0.735
Linseed (Linum usitatissimum)	152.129	95.582	169.856	87.946	1.12	0.920
Groundnut (Arachis hypogaea)	40.198	79.947	44.685	1,12.089	1.11	1.402
Rape seed (Brassica carinata)	34.584	44.041	47.721	62.450	1.38	1.418
Safflower (Carthamus tinctorius)	8.999	-	8.074	-	0.90	-
Sunflower (Helianthus anus)	-	11.526	-	8.347	-	0.724

Table 2. Main export types of Ethiopian sesame seeds (Wijnands *et al*., 2007; Geremew *et al*., 2012).

Varieties	Local name	Market name	Characteristics	Yield potential (t/ha)	% oil content	Maturity days	Main applications
T-85	Hair Hair	Humera	Whitish larger seed, sweet taste, sweet aroma, high productivity	0.80 - 1.0	42-45	100-115	Bakery, Tahini, Confectionery
Kelafo-74	Delelo	Gonder	White, good uniformity of seed	1.0 - 1.20	42-46	110-120	Bakery
Mehado-80	Wollega	Wollega	Small seed, not so sweet	1.50 - 2.20	41-44	100-110	Oil

7. Agronomic Practices for Sesame Production in Ethiopia

7.1. Soil Fertility

Most oil crops including sesame are not responsive to management levels such as inorganic fertilizers, and ploughing frequencies. However, sesame crop is sensitive to high rainfall and water logging conditions. Sesame crop grows on fertile (organic soil with relatively high temperature with moderate rainfall). Sesame grows on deep soil types since the tap root penetrates deep into the soil. High temperature and higher relative humidity will result in poor performance of the crop because of high leaf disease pressure.

7.2. Cropping System

Sesame is frequently produced as sole crop. However, sesame and other oilseed crops are sometimes intercropped and /or boarder cropped with sorghum or tef and other cereal crops in North Shewa and South Welo, Central Ethiopia mainly for diversification of production as well as to increase income value by farmers. In such cases, the intercropped crops have mutual benefits. When sesame is intercropped with sorghum the seeds are less prone to shattering since the sorghum plants is used as shade materials. On the other hand the compatibility for intercropping varies with varieties. For

instance brown seeded sesame is more suitable and productive than white seeded sesame when intercropped with sorghum (Geleta *et al*., 2002).

7.3. Seed Rate, Sowing Date and Harvesting

In Ethiopia, research recommended seed rate is 5-7 kg/ha for row planting and 7-10 kg/ha for broad cast planting. The best time for sowing period is found to be from beginning of June to Mid July when cultivated as rain fed crop. Maturity depends on the weather condition and it usually varies from 90 - 105 days. Mid October to November is the usual harvesting time. Harvesting begins when two third of the plant and seed pods turn yellow. Closed capsules, determinate growth habit and resistance to shattering are important conditions for mechanized harvesting in sesame production (Geremew *et al*., 2012). Sesame is very sensitive to weed investation at early staege. The critical time for weed competion for sesame is 4 weeks after emergence.

7.4. Diseases and Pests

It is the crop most intolerant to leaf diseases. However, there are varieties with resistant reaction to different disease causing pathogens. Sesame is susceptible to diseases such as wilt and charcoal rot caused by *Fusarium oxysporum* f. sp. *sesami* (FOS) and *Macrophomina phaseolina* (MPH), respectively. The FOS, is a soil borne, root pathogen colonizing xylem vessels and blocking them completely to effect wilting. MPH infects at all growth stages plants, show a poor seedling establishment, and reduced vigor and productivity of older plants. These pathogens may cause heavy yield losses in sesame ranging from 50 to 100%, if management is not taken to control (El-Bramawy, 2006). Different management methods such as management of irrigation and fertilization regimes and application of systemic fungicides have been recommended to reduce disease effects. The use of resistant genotypes is the most desirable control method because it provides a practical, long-term, and environmentally benign means of limiting the damage from these diseases (Wang *et al.* 2001).

In addition, there are severe biotic stresses, such as bacterial blight (*Xanthomonas campestris* pv. sesami), phyllody (Mycoplasma-like organism), Powdery mildew (*Oidium erysiphoides*), Alternaria leaf spot (*Alternaria sesame*) and Cercospora leaf spot (*Cercospora sesame*), which are the common sesame diseases registered in Ethiopia; Caused by mycoplasm-like organisms and transmitted through Jassid (*Orosius albicinctus*) bacterial blight – very common in humid and high rainfall areas, transmitted by infected seeds and phyllody – is a highly destructive disease. Sesame leaf roller or webworm (*Antigasta catalaunalis*) is also an important and widespread insect that damages sesame in Ethiopia.

Pests attack the crop in all stages of its development. The most important storage pests of sesame in Ethiopia are the red flour beetle (*Tribolium confusum*) and rice moth (*Corcyra cephalonica*). These are cosmopolitan insect pests that attack a range of stored products. The crucial period for weed competition is about four weeks after emergence.

8. Ethiopian Sesame Seed Types and Qualities

Ethiopia has high quality sesame seed varieties suitable for wide range of applications.

1. Whitish Humera Type: has good aroma, sweet taste, and high oil content; and good demand in the world market & known for its top quality. It is also used as a reference for grading in the international market.
2. Wollega Type: which is mixed /brownish, has high oil content and is used for crushing (http://shellacepc.com/products/sesame-seeds/accessed date: June 2015).

9. Seed Systems

Seed multiplication and certification are important aspects of commercially produced crops. The basic and pre-basic seeds for sorghum, groundnut and sesame were not multiplied at Ethiopian Seed Enterprise, due to unsuitable seed multiplication sites existing so far (high land, midland and lowland sites) (Gebeyehu *et al*., 2001). The seed systems are from local market in the small scale farming communities. Therefore informal types of seed exchange method are the dominant one where there is no certified seed exchange processes.

10. Market Systems

Market studies on Ethiopian oilseeds sector are scarce. Characteristics such as colour, oil content, fatty acid compositions, taste and so on are hardly known (Wijnands *et al*., 2007). Oilseeds are the second Ethiopian export commodity and sesame seed is the main oilseed export product. Japan is importing Ethiopian sesame seed through China, however the Japanese oilseed refineries seek well cleaned and sorted according to the colour of sesame seed. The buying price of sesame for export is largely determined by the evenness of colour, taste, dryness and purity. Hulled seeds and bleached hulled seeds have a higher market value than untreated seeds. The purity of the sesame seed is

specified in terms of such as 99-1. The 99 in the figure means that in each 100 grams of sesame seed, no more than 1% contains impurities such as dirt, branches, stones, etc. The 1 indicates no more than 1% is black seeds.

Over the last two decades, the quantity of sesame traded on the world market has more than doubled. Japan, the European Union, South Korea, the USA and Egypt were largest importers, while India, Sudan, Guatemala, China, Myanmar, Ethiopia and Nigeria (Comtrade database, United Nations Statistics Division website, Wijnands *et al*. (2007) were major suppliers to the world market. The supply from some producing countries, such as China, has been in relative decline over the past few years, despite a general increase in demand for the crop. The main reason for this decline is attributable to the fact that other more remunerative crops compete with sesame for the limited amount of agricultural land and the shortage of labour.

11. Oil Content, Fatty Acid Compositions and Nutritive Values

Sesame seeds are highly valued for their high content of sesame oil, an oil that is very resistant to rancidity. Sesame seeds are the main ingredients in tahini and the Middle Eastern sweet treat, halvah. Open sesame—the famous phrase from the Arabian Nights—reflects the distinguishing feature of the sesame seed pod, which bursts open when it reaches maturity *(http://www.whfoods.com/index.php: accessed date December 2013).*Sesame oil has desirable physiological effects, including antioxidant activity, and blood pressure- and serum lipid lowering potential (Zhang *et al*., 2013).

Sesame oil has high content of favoured linoleic acid ($C_{18}H_{32}O_2$) and a particular feature is that it contains an antioxidant which prolongs the shelf-life of both the oil and other foods fried in the oil (Gooding *et al*., 2000). Moreover, after oil extraction the meal is rich in protein and in addition to use the protein as the feed rations, the meal is milled to produce protein-rich flour mixed with other ingredients for human consumption (Ashri, 1989; Cited in Gooding *et al*., 2000). It has been observed that the oil content and fatty acid composition vary among different accessions of sesame crop. It has been reported that oil content is significant and positive correlation with stearic and oleic acids while negative correlation with palmitic and linoleic acids (Were *et al*., 2006). The same authors reported that for some accessions of sesame consistent oil content and high or low variation in the levels of oleic and linoleic acids. Germplasms or varieties with high oleic and linoleic acids are important for extraction of cooking oils since it has good shelf-lives. There could be negative correlations between the different fatty acids (e.g. oleic and linolenic acids in linseed) that could be exploited in breeding strategy to improve one fatty acid at the expense of others (Adugna *et al*., 2004). Arslan *et al*., (2007) reported that seed oil content ranged from 46.2% to 62.7% for sesame genotypes and the mutants had lower seed oil content than the normal while the oleic fatty acid was higher for the mutant groups.

Sesame contains up to 60% oil of a very high quality and up to 25% protein (Bedigian *et al*. 1985: Cited in Ashri, 1998). In the international market, its demand comes from the oil industry and the confectionary sector. Seed oil content is the most important parameter for determining the suitability of sesame seeds for oil extraction, while seed coat color determines quality for the confectionary market (Ashri, 1998). Sesame seed is rich in amino acids, especially methionine, cystine, arginine and leucine. Sesame seed contains little vitamin A, but it is rich in vitamin E. Sesame seeds are used for decorating bread and cakes. Ethiopian sesame oil contains a significant amount of fatty acids, mainly linoleic (39.3-59%) and oleic (32.7-53.9%) acid, and palmitic (9-11%) and stearic (5-10%) acid (Geremew *et al*., 2012). Sesame oil is unique among vegetable oils due to the presence of natural antioxidants such as sesamin and sesamolin and their derivatives (sesamol and sesaminol), which provide a significantly long shelf life and stable characteristics. Sesame oil is mostly used for cooking purposes. Sesame oil is also used in soaps, paints, perfumes, pharmaceuticals and insecticides. The cake produced after the extraction of oil from un-hulled seeds is an excellent protein feed for poultry and ruminants (Pathak *et al*., 2014).

12. Sesame Oilseed Processing Industries in Ethiopia

Most of the oil seeds are crushed locally without refining. The oilseed crushing and refining industry produces for the domestic market. Most of the oil is consumed as crude oil and Ethiopia is the net importer of refined oil, mainly refined soybean and palm oil (Wijnands *et al*., 2007). Refined oil is mainly used in urban regions; and the production of refined oil in Ethiopia is very limited (20 000 tons). Addis Modjo, crushing or refinery unit of MULAT are among the better oil refining industry in Ethiopia and they are the potentials for European oil buyers. However, the smaller crushing plants do not meet the European standard of refined oil and their technologies need improvement. Lack of finance, little demand for high quality in the domestic market and the costs of quality systems hamper developments (Wijnands *et al*., 2007).

Since, sesame oil is very quality as opposed to other oil crops; it is profitable and less costly if there is oil processing factories in the county which can label the products for local and international markets. There should be investment for processing of products in Ethiopia in order to make the product more competent in the international market. On top of that sesame and other oil crops demand less inorganic fertilizers it is possible to produce organic products from these crops.

13. Opportunities for Specialty Foods from Ethiopian Sesame

Sesame is used in wide range of applications (Wijnands *et al*., 2007). The most important ones are:

1. Edible oil: The oil is odourless with distinctive nutty sweet flavour. Roasted sesame seed resists rancidity due to the antioxidants formed during seed roasting. Sesame oil is especially important in the Far Eastern cuisine, mainly Japan and china.
2. Confectionery, biscuit and bakery industry: Hulled clear white sesame is required for bakery products.
3. Tahini industry: Tahini, a traditional Middle Eastern paste, is made from hulled sesame seed and is rich in protein.
4. Halva industry: Halva is a sweet made of 50% Tahini, boiled sugar and some other ingredients.
5. Sesame flour and sesame seed sprouts.
6. Pharmaceutical ingredients.

14. Challenges/Gaps

Despite the potential for increasing the production and productivity of sesame, there are also a number of challenges inhibiting sesame production and productivity. Among the many production constraints, the most important include

1. lack of improved and high yielding varieties for different agro-ecologies with desirable agronomic qualities viz. non-shattering, diseases/pests resistance
2. poor seed supply system
3. lack of adequate knowledge of farming and post-harvest crop management
4. Lack of high standard oil processing industries
5. Low soil fertility and pH status
6. Lack of varieties which respond to inorganic fertilizers
7. Lack of companies working on specialty foods
8. Lack of collaboration among breeding institutes and food industries

15. Recommendation and Future Prospects

Sesame oil can be refined and commercialized for special fatty acid contents in the future. On top of that the organic nature of production of the crop in the country may favour for organic food production of oil which is highly attractive and safe for human consumption. Ethiopia can possibly export refined quality oil from sesame in the future. The current breeding system for high oil content of the seed must incorporate also the different fatty acid compositions in quantity and quality in the future. Private companies engaged in oilseed refining from sesame seed should also incorporate the facilities which could be used to analyse the different fatty acid content. The oilseed extraction companies available in Ethiopia are advisable to work closely with the universities and research centres for sesame oilseed analyses especially for different fatty acid contents.

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