



Report, analysis and selection of suitable fruit species to be introduced into production

(activity 1.1.)

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Introduction

The goal of this report is to identify the best strategies leading towards diversification of local fruit production in Arba Minch Zuria woreda. A broad literature review has been done and further supplemented by personal field observation as well as preliminary surveys. All this collated information has been analysed resulting in the selection of eligible crops/varieties to be implemented in the field. In general, this will not only enrich the fruit production but also helps to increase the food security of local communities. This advocates the necessity and importance of this activity within the project “Arba Minch Fruit Value Chain, Gamo zone, SNNPR, Ethiopia”.



From the tree nursery (right) to the final diversified products on the market (left).

General overview

Fruits undoubtedly play a significant role in human life by contributing to people's food security as well as generating additional/main source of income for the household. A well-balanced diet covers not only the sufficient caloric intake, rather it is about the specific nutritional content of the meals – how are the macro and micronutrients compiled into one inseparable unit. This is why malnutrition (deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients) and hidden hunger (micronutrient malnutrition) are so dangerous, especially in the developing countries (IFPRI, 2016; WHO 2020). Fruit consumption is therefore not only suppressing hunger, but it also helps people to stay healthy. World Health Organisation (WHO) places low fruit and vegetable consumption among its 20 risk factors in global mortality, just behind the better-known killers such as tobacco use and high cholesterol levels (WHO, 2003).

Monotonous diet along with the lack of awareness of its consequences for human health is one of the biggest issues threatening the Ethiopian population (Demissie et al., 2009). However, due to the diverse climate, altitude levels and rich water sources, Ethiopia offers great conditions for cultivation both tropical/subtropical and temperate fruits (Yirgu, 2018). The main cultivated and exported fruit crops are banana, citruses, mango, avocado, papaya and grapes. Even though the total fruit production in Ethiopia is estimated around 500,000 t/year, less than 5% is exported and even on the local level, people are still not consuming fruits habitually (Girma et al., 2016; Honja et al., 2016). In most parts of the country, the daily food intake consists of cereals (teff, corn) together with legumes (lentils, beans, peas) or cereals, tubers/stems (taro, cassava, sweet potatoes, ensete) with legumes/dairy products without additional portions of fruits and vegetables. Perhaps even more impending is the general perception that this kind of diet is adequate (Demissie et al., 2009). FAO estimates that Ethiopians eat less than 100 grams of fruits and vegetables per day, which is comparable to a medium-sized carrot and stand for less than a quarter of the recommended fruit and vegetable daily portion (WHO, 2003; WHO/FAO, 2005).

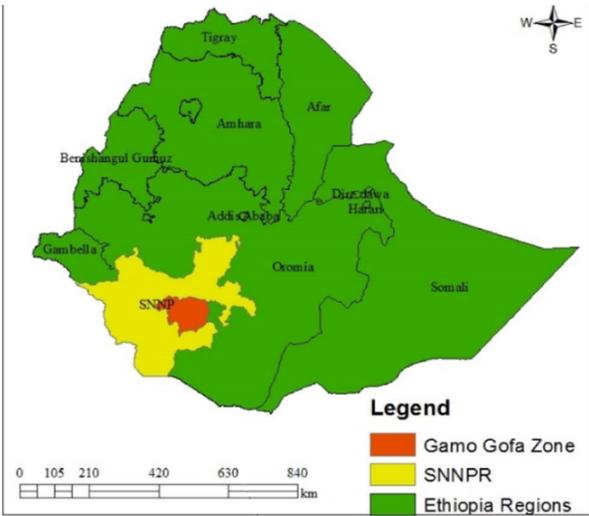


The most common fruit species on the Arba Minch market – banana, mango, avocado, gishta and papaya.

Arba Minch

Arba Minch Zuria is a district (woreda) in the Gamo administrative zone of the Southern Nation, Nationalities and People's Region (SNNPR). It is bordered by Dirashe special woreda (south), Bonke (west), Dita and Chenchu (north), Mirab Abaya (northeast), Oromia Region (east) and Amaro special woreda (southeast) (Getaneh, 2019). The whole district is classified as a semiarid zone within the Southern Ethiopian Rift Valley system. Typically, the climate of the woreda is influenced by two big lakes Abaya and Chamo and the Nechisar National Park located in between (Endale and Bitane, 2020; Getaneh, 2019). Arba Minch, the biggest city of the district and the second-largest in SNNPR after Awassa, acquires about 70,000 inhabitants and is located around 500 km south from the capital city Addis Ababa. Arba Minch extends in the altitude of about 1,278 m.a.s.l., while the climate is tropical, classified as "equatorial savannah with dry winter" (Aw) by the Köppen-Geiger system (Kottek et al., 2006). Rainfall distribution is bimodal with the rains occurring mostly in March, April and May and between September and November (Kebebew, 2018). The average precipitation level is about 800 mm per year, whereas the mean temperature fluctuates around 21.8 °C (Climate Data, 2020).

The whole woreda is known for its high potential in tropical/subtropical fruit cultivation. It contributes by 10 - 15% to the overall national fruit production which makes Arba Minch one of the highest productive districts in the whole country (Gamo Zone Office of Agriculture, 2020). Despite, the results of Demissie et al. (2009) showed that 55% of SNNPR inhabitants do not cultivate fruits and 11% do not see them regularly on the markets. Moreover, most children (35%) did not eat any fruit over the week preceding the survey. These numbers are, for sure, alarming. Especially young children and woman are vulnerable to micronutrient deficiencies coming from the monotonous diets. E.g. Vitamin A deficiency remains the major preventable cause of childhood blindness, it increases the risk of premature childhood mortality from infectious diseases as well as developing diet-related chronic diseases later in life (WHO, 2003). Vitamin C, an important antioxidant, plays a myriad of functions in optimal health and illness prevention. Prolonged deficiency may result in scurvy-related periodontitis, characterized by swollen bleeding gums and the opening of previously healed wounds (Carr and Rowe, 2020).



The upper maps show localization of SNNPR, Gamo Gofa zone and Arba Minch Zuria woreda. The lower map marks the position of the two main experimental plots - Kolla Shara tree nursery and Chano Mile Training Center, both of them neighbouring the Arba Minch city.

However, the eating habits of the local people seem to be changing for the better nowadays. Three-four decades ago, maize, cotton, sweet potatoes and sorghum were the main crops cultivated in the district, considered as dominant sources of livelihood together with fishing. Currently, due to the increasing demands for fruit and fruit products, the cereal-based subsistence farming started to be transformed into more market-oriented systems of irrigated banana, fruit trees and vegetable farms. Yirgu (2018) reported that mango and banana are by the farmers perceived as the two most important crops cultivated in Abaya-Chamo basin, while over 50 % of the respondents reported that income from fruit farm raised household food security status and enabled them to enhance the living standards too.

Fruit production in Arba Minch district

As previously mentioned, in terms of fruit production, Arba Minch Zuria belongs to the most productive Ethiopian districts. The major cultivated fruit species there are banana, mango, avocado and papaya (Table 1) (Baredo, 2013). Bananas can be generally considered as the most advanced fruit crop in terms of their cultivation, post-harvest processing and marketing. Even though mango is treated as the second most important, its management, value addition and marketing channel is still not well-developed or simply lacking. According to a study inventorying the plant production of local households, there are 6-7 mango and 4-5 avocado trees belonging to one homestead on average (Baredo, 2013). Both species occur mainly in form of local varieties with no specific name and mostly unknown agronomic requirements. About 81 % of farmers use only the local varieties of mango, 19 % used both improved and local and no one focused solely on the improved trees (Honja et al., 2016). Compared to improved varieties, the local mangoes are more fibrous and dispose large kernels (low pulp/kernel ratio). Starting in 2004-2008, different fruit varieties of mango (Kent, Tommy Atkins, Apple mango) and avocado (Hass, Ettinger, Fuerte) have been introduced in the district, both grafted and non-grafted (Endale and Bitane, 2020; Gamo Zone Office of Agriculture, 2020). However, the established fruit orchards are said to receive no proper management, mainly due to the lack of knowledge, skills and financial constraints of the farmers. Also, the acquiring of the improved planting material seems to be complicated because it is available only in specific extension centres, whereas the seedlings of the local varieties are commonly achievable on the markets (Honja et al., 2016). Agronomic practices such as pruning, decent tree spacing or use of organic fertilizers are not commonly seen in the field. Moreover, because of inappropriate maintenance, some of the trees are extremely tall, making fruit harvesting even more complicated (Endale and Bitane, 2020; Gamo Zone Office of Agriculture, 2020). Major constraints faced by the smallholders focusing on fruit production are presented in Table 2.



Improved varieties of mango and avocado (left) together with bananas (right) may bring even higher income in Arba Minch Zuria woreda than coffee, the typical Ethiopian cash crop.

Table 1. Major fruits cultivated in Arba Minch Zuria, listed according to their relative importance.

Fruit species	Cultivation area (ha)	Production (t/year)	Productivity (t/ha)	Harvesting time
Banana	16,985	424,625	25	All year round
Mango	880	26,412	30	Nov-Jan; Jun-Jul
Avocado	175	4,375	25	Feb-Apr
Papaya	170	5,115	30	All year round

Based on: Endale and Bitane, (2020); Gamo Zone Office of Agriculture, (2020)

The harvesting itself hides many obstacles which may not be visible for the first glance. The harvest usually starts after the first fruit-dropping, showing the principal maturity index (in both mango and avocado species). Most of the farmers harvest ripe mango fruits, resulting in shorten shelf-life and faster fruit deterioration. The harvest is mainly done by handpicking or using a stick. Hand-picking is far gentler, protecting the fruits from mechanical damage than harvesting with the pole. On the other hand, it is also very laborious and time-consuming method (Endale and Bitane, 2020; Honja et al., 2016). The only post-harvest processing usually practised by the farmers is grading and sorting, drying, cleaning, and standardizing of the fruits before their delivery to the traders (Honja et al. 2016). Due to improper handling, inadequate storage, lack of packaging and lack of harvest technical knowledge, producers and traders are facing about 20-30% of mango losses. Even though the country is experiencing such a huge loss of fruits, very little emphasis has been given to post-harvest handling so far (Girma et al., 2016).



Losses in mango production illustrate the urgent need for the development of postharvest processing methods.

Almost all the farmers involved in fruit cultivation are also selling their products (in the raw state). The annual revenue from mango trade can reach about 12,550,000 ETB (\approx 262, 000 EUR) without any value addition (Baredo, 2013). Therefore, there is a big potential for implementation of food processing/preservation techniques such as drying, canning or juice making, which may seriously affect

and uplift the final income generated from the sale. Until now, the food processing is mostly limited to fresh juice production from mango, avocado, papaya and gishta (*Annona muricata*) (Endale and Bitane, 2020; Gamo Zone Office of Agriculture, 2020). This carries a lot of risks because without pasteurization the juices are vulnerable to myriads of foodborne diseases such as diarrhoea and dysentery (Wedajo and Kadire, 2019). Even though there were a few attempts from companies (EtiFruit, Africa Juice) to start a larger-scale juice production in the district, or at least to get some fruit supply from the local farmers, these tries never lasted for a longer time (Gamo Zone Office of Agriculture, 2020).

Table 2. Major constraints in fruit production faced in Arba Minch Zuria woreda.

Category	Problem
Agronomic practises	Lack of knowledge, skills
	Limited access to improved varieties
	Expensive inputs – fertilizers, pesticides
	Pests and diseases
	Irrigation
Post-harvest handling	Lack of knowledge of the preservation methods
	Harvest of unripe fruits
	Improper storing
	Lack of materials, capacities
	Product quality
Marketing	Predominant focus on the local market
	Low farm-gate prices
	Only few merchants in the area
	Lack of additional value (raw products only)

Based on: Endale and Bitane, (2020); personal observation

Rationale

Bananas are of the greatest fruit production focus in the district, mainly by middle-size/large-scale farmers and various organizations (OVOP, Lante, Irish Aid, GIZ), thus improved varieties are already being successfully implemented in the field (Endale and Bitane, 2020; Gamo Zone Office of Agriculture, 2020; Yirgu, 2018). From the other important fruit species grown in the woreda, papaya is a part of nearly every homestead and some field trials have been also started already close to Arba Minch. Therefore, we decided to shift our attention to the two different topics – diversification of the current fruit offer by the introduction of new species and implementation of improved varieties of the major fruit crops.

1) Mango (*Mangifera indica* L., Anacardiaceae) is one of the most lucrative fruits in the region, both in terms of its nutritional value, mainly vitamin A content (Table 3), as well as marketing/value-adding potential. So far, food preservation techniques such as drying and canning are not commonly used by smallholders nor cooperatives in the district. The fruit processing is limited to fresh juice production which may be, due to poor hygienic conditions, quite hazardous for human health (Wedajo and Kadire, 2019; Weleni and Naygaro, 2017). Based on the field experiments conducted by Mendel University in the Chamo Mile Training Center (MZV, 2018), five different improved varieties of mango were identified (Kalinová, 2019). Among them, Tommy Atkins and Apple Mango were selected as the best choice for enhancing the local fruit production. Long shelf-life, optimal fruit mass ratio (pulp/kernel) and low fibrosity of the flesh are the key properties making these varieties the most suitable both for the home consumption as well as for the sale. Moreover, both varieties seem to be well suited for further food processing methods such as juice production, canning or drying (Morton, 1987). The next step is to prepare the seedlings and disseminate the improved planting material among the farmers involved in the project. Appropriate training on the mango cultivation and management may be provided by experts from Melkassa Research Center and Arba Minch University, Department of Horticulture.



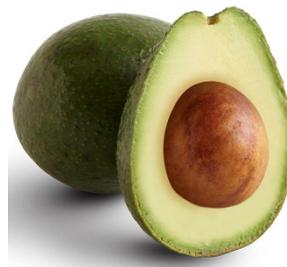
The most suitable mango varieties for the local production – Tommy Atkins (left) and Apple Mango (right).

2) Avocado (*Persea americana* Mill., Lauraceae) has been selected based on its high importance for the local producers, large demands on the local markets and relatively poor accessibility usually based on the imports from other districts, despite the suitable cultivation conditions directly in Arba Minch Zuria woreda (Endale and Bitane, 2020; Gamo Zone Office of Agriculture, 2020). Moreover, the fruit has one of the highest energetic values and is especially rich in fat and minerals such as potassium and zinc (Table 3). The lipids are predominantly composed of monounsaturated fatty acids (mostly oleic and linoleic acid) advisable for human health (Dreher and Davenport, 2013). Similar to the mango, avocado fruit has two major ways of utilization in Ethiopia – fresh juice production (popular “spris”, mixtures of mango, avocado

and papaya/gishta); and raw fruit consumption, mainly in the form of vegetable salads. Improved avocado varieties are even more scarce than in the mangoes, therefore we would like to start by introducing one of the worldly most popular, as well as accessible varieties of Hass and Fuerte avocado. Gwen is a dwarf variety, yet the most productive one. Morphologically it is quite similar to the Hass avocado, however, its nutty flavour and buttery texture are said to be even better. Maluma is a variety originally discovered in South Africa. Despite its relatively slow growth, the tree is known for its high productivity. Monroe is one of the largest varieties which fruits can weight over 900 grams. Typically, the avocado has a firm flesh and is quite resistant to cold.



a)



b)



c)



d)

The recommended avocado varieties: a) Hass; b) Gwen; c) Maluma; d) Monroe.

3) Gishta (*Annona muricata* L., Annonaceae) is native to South America and the Caribbean region, however, it has been pantropically introduced many years ago. *A. muricata* is a popular species on the African continent, usually known as soursop. The tree easily grows on most types of soil and is not much demanding in terms of climate and altitude requirements. The fruit is quite rich in vitamin C and minerals (Table 3) and its leaves might be used as medicine (Saripalli and Dixit, 2016). In Arba Minch Zuria woreda, gishta is almost solely used for the fresh juice production. The trees are usually scattered around the farmers' compounds without proper management and known origin. Apart from *A. muricata*, there are other *Annona* species such as *A. squamosa* (also cultivated in Ethiopia under the same name "gishta"), *A. reticulata* (custard apple, the most widely grown *Annona* worldwide) and *A. cherimola* (cherimoya, the

most popular and flavourful one) (PROTA4U, 2020). The focus of the project might be twofold – to select preferable gishta trees and focus on their controlled breeding/improving; to try to introduce new *Annona* species which might be even more suitable for the higher altitude and can be of sweeter, thus more preferable, flavour.



a)



b)



c)



d)

The most popular *Annona* species: a) *A. muricata*; b) *A. squamosa*; c) *A. reticulata*; d) *A. cherimola*.

4) Passion fruit (*Passiflora edulis* Sims, Passifloraceae) is a perennial vine typically producing very acidic/semi-sweet fruits, which are increasingly getting popular over the tropics. The fruits are highly loaded with vitamin A and C (Table 3) and consumed mainly in the form of juice, ice cream, jelly or eaten raw (CABI, 2020). Yet, the species is barely known in Ethiopia. Generally, there are two main varieties of passion fruit: purple-fruited type (*P. edulis* f. *edulis*) and yellow-fruited (*P. edulis* f. *flavicarpa*) (PROTA4U, 2020). The yellow variety is usually reported to be more acidic and suitable for juice production, compared to the purple type which is of milder sweeter taste and preferred in the direct consumption. Also, yellow cultivars are considered more resistant to pests and diseases, whereas purple varieties can withstand cooler conditions (CABI, 2020). Preliminary trials in the Chamo Mile Training Center showed that the yellow variety of passion fruit is not only growing well under the local conditions, but it is also regularly bearing fruits which are of desirable taste. Moreover, the local workers, as well as visitors of the centre, seem to be very interested in the species. Apart from the focus on extending the preliminary plots into a

regular planting site, the suggestion is to try to cultivate the purple variety as an option for further diversification of the local fruit production.



Two types of passion fruit - *Passiflora edulis* f. *edulis* (purple) and *P. edulis* f. *flavicarpa* (yellow).

5) Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Naka, Cucurbitaceae) is a herbaceous vine broadly grown and utilized all over Africa, including Ethiopia. However, the demands for its fruits exceeds their market availability in Arba Minch Zuria woreda, thus the melons must be supplemented from other districts. The fruit is used mainly for juice preparation or as a refreshing snack. Muskmelon (*Cucumis melo* L., Cucurbitaceae) exists in many different varieties falling into four basic categories: cantaloupe, honeydew, galia and charentais. It has not yet been introduced to the region (perhaps the whole country), even though the fruits seem to be nutritionally a bit better than the regular watermelons, which consist of 90% water and the rest is carbohydrates (Table 3). Because of the natural habitus of the plant (crawling vine), both melon species are considered as great cover crops and might be utilized in various agroforestry systems as well as for intercropping (PFAF, 2020). Therefore, we would suggest the establishment of experimental plots in the Chamo Mile Training Center where both species may be intercropped e.g. with cereals (sorghum, maize) or even perennials (moringa, *Fabaceae* sp., mango). Based on discussion with vegetable production experts from Mendel University, following varieties of muskmelons were recommended for the field experiment: Piel de Sapo – Mabel F1; Canary melon – Gladial F1, Ducral F1; Galia – Alpes F1, which has already been successfully tested in three different agroecological zones in Ghana. All these hybrids showed prompt resistance against fungal diseases such as Fusarium wilt or Powdery mildew.



a)



b)



c)



d)

Four main categories of musk melons: a) cantaloupe b) honeydew c) galia d) charentais.

All the improved material as well newly introduced species will be propagated and multiplied in the predisposed project tree nurseries in Chano Mile Training Center and newly also in Kolla Shara. The planting material will be obtained in cooperation with Melkassa Research Center, one of the most renowned horticultural centres in Ethiopia (EIAR, 2020), and disseminated among the local farmers under the supervision of experts from Arba Minch University and Gamo Zone Office of Agriculture. The improved varieties of mango and avocado will be mainly propagated by grafting, though air-layering might be another option. The rest of the crops will be planted from the seed/seedling.

Table 3. Mean nutritional values of the selected fruits and % of their daily value (DV) intake.

	Mango	Avocado	Gishta	Passion fruit	Watermelon	Honeydew
Energy (kcal/100g)	60	160	66	97	30	36
Carbohydrates (g/100g)	15; 5%	8.5; 3%	16.8; 6%	22.4; 9%	7.6; 3%	9.1; 3%
Sugars	13.7	0.7	13.5	11.2	6.2	8.1
Dietary fiber	1.3; 6%	6.7; 24%	3.3; 12%	10.2; 37%	0.4; 1%	1; 3%
Protein	0.82; 2%	2; 4%	1; 2%	2.2; 4%	0.6; 1%	0.5; 1%
Fat	0.38; 0%	15; 19%	0.3; 0%	0.7; 1%	0.2; 0%	0.1; 0%

Vitamins (mg/100g)						
Vit. A	54 µg; 7%	7 µg;	0; 0%	64 µg; 8%	28 µg; 4%	3 µg; 0%
Vit. C	36.4; 44%	10; 12%	20.6; 25%	30; 36%	8.1; 10%	18; 22%
Vit. B₁	0.028; 2%	0.067; 6%	0.07; 6%	0; 0%	0.033; 3%	0.038; 3%
Vit. B₂	0.038; 3%	0.13; 11%	0.05; 4%	0.13; 11%	0.021; 2%	0.012; 1%
Vit. B₃	0.669; 3%	1.74; 12%	0.9; 6%	1.5; 10%	0.178; 1%	0.418; 3%
Minerals (mg/100g)						
Ca	11; 1%	12; 1%	14; 1%	12; 1%	7; 1%	6; 1%
Fe	0.16; 1%	0.55; 3%	0.6; 5%	1.6; 12%	0.24; 2%	0.17; 1%
Mg	10; 3%	29; 8%	21; 6%	29; 8%	10; 3%	10; 3%
Na	1; 0%	7; 0%	14; 1%	28; 2%	1; 0%	18; 1%
K	168; 4%	485; 10%	278; 6%	348; 7%	112; 2%	228; 5%
P	14; 2%	52; 7%	27; 4%	68; 10%	11; 2%	11; 2%
Zn	0.09; 1%	0.64; 7%	0.1; 1%	0.1; 1%	0.1; 1%	0.09; 1%

Based on: Nutritional Value, (2020); USDA, (2020)

Conclusion

Arba Minch Zuria woreda is one of the most productive Ethiopian districts in terms of fruit cultivation, yet its potential has barely been fulfilled. The farmers rely mostly on the local fruit varieties, they lack the knowledge/skills of appropriate tree management and due to improper harvesting methods, post-harvest handling and inadequate storage, they are generally losing about ¼ of their production every year. Most of the producers rely on the sale of raw products, which are directly consumed, made into fresh juice or transported to bigger cities (Addis Abeba). Food preservation methods such as drying, canning or pasteurization in the juice production thus present a great opportunity how to add value to the products as well as to save the large quantities of fruits which are regularly wasted. Another challenge is to try to raise awareness about the well-balanced diet and the importance of fruit/vegetable consumption among the local communities. Most of the people are not used to eat fruits habitually and, especially, children and women can suffer from various vitamin/mineral deficiencies.

To address these issues within the project activity, we decided to introduce improved varieties of mango and avocado and to diversify the local portfolio of planted fruit crops with new species – passion fruit (both types), melons (water and muskmelons) and *Annona* sp. All these fruits will be/are planted in the experimental plots of Chano Mile and Kolla Shara, which are already well established and ready to facilitate trainings as well as to produce enough seedlings which will later be disseminated among the targeted farmers. To receive certificated planting material, cooperation with Melkassa Research Center

specializing in horticulture production has been established. Together with experts from Arba Minch University (Dept. of Horticulture) ČZU and Mendel University, training on fruit diversification, proper tree cultivation and management will be provided to both farmers and field officers. The rest of the concerns stated above (food processing, post-harvest handling, dietary diversity) will be addressed in the upcoming project activities.

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