Production Practices, Post-harvest Handling, and Application of some neglected Plants of Nutritional Importance in Traditional Farming Systems of Benishangul-Gumuz Region of Ethiopia

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Abstract

Background: In Ethiopia, particularly in the Benishangul-Gumuz region, there are numerous underutilized plants like figl (*Raphanus sativus*), girgir (*Eruca sativa*) and karkade (*Hibiscus sabdariffa*) which are cultivated and consumed only by the local communities. However, information on production practices, postharvest handling, and utilization trends of these plants is limited.

Objective: Assess the production, handling, and utilization pattern of figl, girgir, and karkade in the Benshangul-Gumuz region of Ethiopia.

Methodology: A cross-sectional household survey was used to collect primary data from 274 producers and 30 users using a semi-structured questionnaire. The data were analyzed using SPSS (Version 20.0) software package.

Results: The results showed that about 46% of farmers produce figl and girgir for food, medicine, and income generation. More than half of the farmers produce karkade for beverage and medicine. About 93% of the respondents showed that, edible parts of figl and girgir could attain commercial maturity within 15–35 days. However, calyces of karkade takes 121–150 days. Most of the farmers consume leaves and roots of figl and leaves of girgir as local salads while 84.31% use dried calyces of karkade for making a beverage. About 94% of the farmers allocated less than 0.25 hectares of land for the production of figl and girgir while 81% of them allocated this amount of land for the production of karkade. The majority (80%) of them are not getting extension services for the production of figl, girgir and karkade, and 53% lament that there is no market linkage for these crops.

Conclusions: Figl and girgir play significant roles in mitigating food insecurity because they reach commercial maturity within a short period and the possibility of cropping about five cycles throughout the year, particularly in marginal lands with agronomic practices accessible to farmers. Therefore**,** future research should incorporate packages of farming technology including propagating the crops at research centers, adaptation trial across different agro-ecology, improving of agronomic practices, variety registration and promotion.

Keyword: Calyces; Figl; Girgir; Karkade; Leaves; Roots

1. Introduction

The global population depends entirely on a few staple crops for food, medicine and other associated purposes. Even though globally there are a lot of various edible plant species that can be used as fruits, leaves, whole plants, flowers, seeds, pods, tubers, roots, shoots, bulbs, gums, rhizomes, barks and stems (Kiran *et al*., 2019). Dependence on a limited number of plant species is not adequate to sustainably feed the rapidly increasing population of the world, which is estimated to reach 10 billion by 2050 (UN, 2017). The over-dependence on staple crops coupled with the global population increase exerts pressure on land, water, natural resources and energy for food production to attain food and nutrition security. Current crop production levels have decreased due to the lack of investments in agricultural inputs, degradation of natural resources, high postharvest losses, climate change effects, disease, and pest infestations (Stathers *et al*., 2013). Ultimately, this has led to food and nutrition insecurity in developing countries.

A food system-based intervention that encompasses diversification of food resources has high potential to

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offer an affordable, reliable, and sustainable strategy for promoting food and nutrition security. The promotion of diversified cropping systems in poverty-stricken and drought-prone farmer communities are helpful for the betterment of livelihoods. One way of providing food diversity and supply of relatively less-costly food alternatives is to commercialize the production and utilization of underutilized indigenous plant species. Neglected and underutilized plant species further offer an inexpensive source of essential nutrients and bioactive compounds with antioxidant capacity vital for human health and wellbeing (Dias and Ryder, 2011). Underutilized indigenous plant species continue to play an important role in the subsistence and economic resource poor people throughout the developing world, particularly in the agrobiodiversity-rich tropics. Despite their potential for dietary diversification and the provision of micronutrients such as vitamins and minerals, they continue to attract little research and development attention. Alongside their commercial potential, many of the underused crops also provide important environmental services, as they are adapted to marginal land and climate conditions.

The western part of Ethiopia, particularly Benishangul-Gumuz region, is one of the least developed and food insecure hot spots (Guyu and Muluneh, 2016) but, endowed with many underutilized plants such as figl (*Raphanussativus* L.) and girgir (*Eruca sativa* L.) categorized under vegetable of *Brassicaceae* (*Cruciferae*) family. The karkade (*Hibiscus sabdariffa* L.) is classified under herb of the *Malvaceae* family, in addition to use as foods and beverages, as industrial food color (dye) is underutilized crop in Ethiopia (Keyata *et al*., 2021). Originally, these underutilized plants come from the border of Sudan and their names are derived from Arabic Sudanese language and named as figl, girgir and karkade in Berta, Amhara and Oromo ethnic groups. The English language name of figl, girgir and karkade are radish, rocket and roselle, respectively. Since the Benishangul-Gumuz region of Ethiopia is bordered to the Sudan, the cultivation of these vegetables are expanded through this border. Currently, these crops are adapted to some parts of Benishangul-Gumuz region, Ethiopia.

The 2017 reports of Benishangul Gumuz Regional Government of Agriculture Office highlighted that these plants have unique properties in terms of high climate adaptability, as evidenced by their early commercial maturity and ability to grow and produce high yields in marginal soils (BGRGAO, 2017). The report also showed that these plants are tolerant of pests, diseases, and drought incidences as compared to other indigenous plants consumed in the region. Furthermore, the report also indicated that the dried calyx of karkade is used to make hot and cold beverages commonly consumed during festival seasons, family, religious celebrations, and medicinal purposes. The leaves of girgir are used as a vegetable whereas the leaves and roots of figl are used in salad or cooked vegetable preparations (Keyata *et al*., 2020).

Research report from other countries showed that calyces are significant sources of β-carotene, vitamin C, iron, carbohydrates, and fiber (Chinatu *et al*., 2016). The seed of karkade is rich in fats, protein, fiber, calcium, and potassium (Keyata *et al*., 2020). The calyces of karkade have the potential for use as a natural food colorant (Shruthi *et al.,* 2016). The girgir leaves are noted for isothiocyanates, flavonoids, antioxidants, calcium, iron, potassium, and sodium (Elsadek, 2014). The leaves of figl are significant sources of calcium, vitamin C and phenolic antioxidants (Goyeneche *et al*., 2015).

The production practices, post-harvest handling and utilization trends of figl, girgir and karkade are unique in the region because they can be cultivated on marginal lands and are used for food, beverage as traditional medicine and for income generation. Due to these properties, the three plants are considered as future plants for climate-smart agriculture to contribute to the food and nutrition security efforts of the country (Keyata *et al*., 2020). It is, therefore, imperative to study and promote the production and consumption of these underutilized plants. Due to a lack of sufficient scientific data about the production practices, postharvest handling and utilization trends of the unexploited plants of figl, girgir and karkade the crops are not widely cultivated for consumption in the country. In view of this, in this paper, the documentation on indigenous knowledge on production, postharvest handling and use of the three crops in Homosha, Kurmuk, and Sherkole districts of Assosa zone, Benishagul Gumuz region, Ethiopia is reported. Finding of this research will contribute knowledge on the many functions/benefits of these crops for consumers, biodiversity conservation, nutritionists, and for the scientific community. The finding will help to create awareness among the scientific community for wider consumption of underutilized edible plants in a versatile way in the recipe development of traditional foods and industrially processed products to contribute to the household and national food security in the country. The policy makers will use the information as an input to develop the crops in the country.

2. Materials and Methods

2.1. Description of the Research Areas

A survey was conducted in Homesha, Kurmuk, and Sherkole districts of Assosa Zone, Benishangul-Gumuz Regional State, Ethiopia (Figure 1). Assosa Zone is located at 10.07°N and 34.53° E, 1417m above sea level, and receives an average annual rainfall of 1316 mm. The area experiences annual minimum and maximum temperatures of 19°C and 35°C (NMSA, 2018). The three districts (Homesha, Kurmuk, and Sherkole) were selected purposely as focus study sites from the seven rural districts of the zone based on more extensive productions and utilization of figl, girgir, and karkade.

The total human population in Homesha, Kurmuk and Sherkole districts are 27,616, 21,140 and 31,260, respectively (CSA, 2017). The number of households in the Homesha, Kurmuk and Sherkole districts are 3,336, 5,914 and 4,382, respectively (Benishangul Gumuz Regional Governmental Agricultural Office, 2017). Data from the district agricultural offices showed that the total households involved in the production of the three plants were estimated 140 in Homesha, 350 in Kurmuk, and 380 in Sherkole.

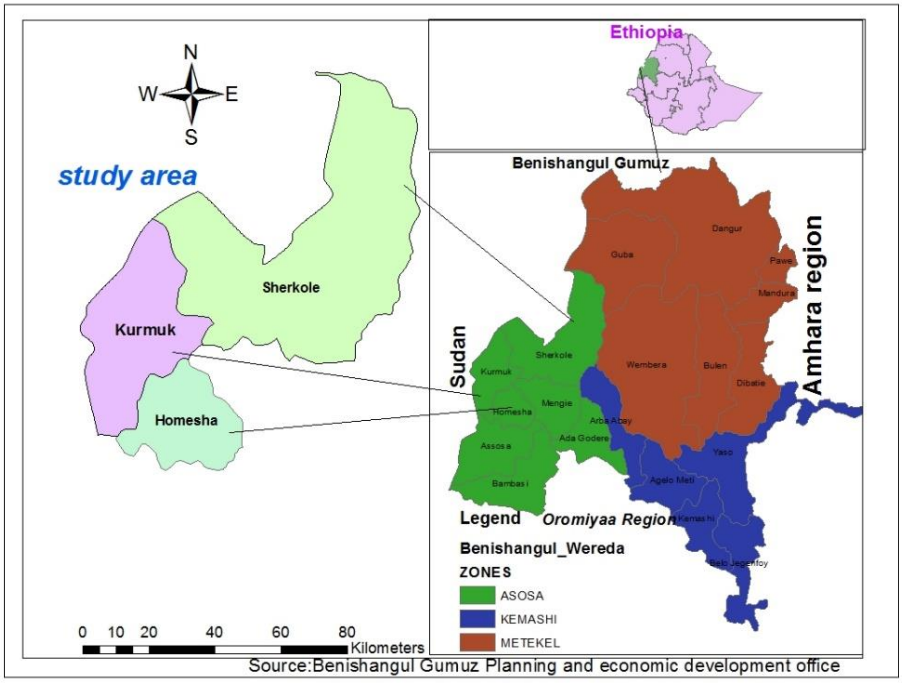

Figure 1. Map of the Research areas.

2.2. Sample Size Determination

For users, ten respondents were selected based on a snowball sampling technique from each district of the study area. Thirty respondents were also randomly selected as targeted users. However, the total number of producers considered for this study was calculated according to Yamane (1967) method with 95% confidence level and ± 5% precision, as shown below.

$$n = \frac{N}{1 + N(e)^2} = \frac{870}{1 + 870(0.05)^2} = 274$$

Where, e = precision, N = total number of farmers who produce figl, girgir, and karkade, n = total sample size obtained from total producers.

2.3. Research Design and Sampling Techniques

A cross-sectional survey was carried out from November 2018 to January 2019 at the selected districts to assess the production, handling, and utilization practices of the underutilized plants. In a multi-stage sampling technique, a specific one was selected purposely based on the production trends of the plants. In the first stage, the snowball sampling technique was used in selecting users who are purchasing and using the edible parts of the crops from the market. In the second stage, a simple random sampling technique was applied to select producers who produce and use the three plants. Finally, based on the proportion ratio needed in each district, a random proportional sampling technique was used.

2.4. Data Collection Procedures

2.4.1. Individual interview

A semi-structured questionnaire was developed to study producers' socio-demographic, production and postharvest handling practices, and utilization trends of the plants. Enumerators with fluent in understanding of the local language were selected and trained before data collection. The questionnaire was pre-tested using pilot interviews with producers and users.

2.4.2. Focus group discussion

A total of three focus group discussions (FGDs), each having ten members, were held. Producers with extensive expertise in the production, handling, and utilization practices of the three plants were included in the FGDs. The discussions were focused on production, post-harvest handling, and utilization procedures.

2.5. Data Analysis

The data were analyzed using simple descriptive statistics (including frequency, mean, and percentage) using SPSS (Version 20.0) software package.

3. Results and Discussions

3.1. Socio-demographic Characteristics of the Participant

The socio-demographic characteristics of the participants showed that most of the participants were male and in the age range of 31–60 years. Almost half of the respondents had no formal education, and nearly all were married (Table 1).

Table 1. Demographic characteristics of respondents who produce figl, girgir and karkade.

Variable	Frequency	Percentage
Sex		
Male	254	93
Female	20	7
Age		
<20	4	2
20-30	23	8
31-40	61	22
41-50	88	32
51-60	72	26
>60	26	10
Educational level		
No formal education	116	42
Grade 1–6	132	48
Grade 7–12	25	9
College certificate and above	1	0.4
Marital status		
Married	254	93
Single	7	2
Widowed	13	5
Family size		
<3	19	7
3–5	38	14
5–7	67	24
>7	150	55

3.2. Production Practices

In terms of production, about half of the respondents were producing figl and girgir for use as food, medicinal plant, and as an income source (Table 2). The studies conducted elsewhere shows that figl is produced for food and medicine (Banihani, 2017) whereas girgir is produced for food (Siomos and Koukounaras, 2007). The findings of this study also indicate that more than half of the respondents use karkade for making beverage and medicine. Consistent with these results of this study a study conducted in Sudan revealed that karkade is widely cultivated for beverage, medicine, flavoring and as a coloring agent for food and drinks (Mohamed *et al.*, 2012).

As an underutilized plant, the land allocated for producing figl, girgir, and karkade was small. About 94% of the respondents allocated less than 0.25 ha of land to produce figl and girgir. The size of land allocated for this purpose is lower than the land allocated for the production of cabbage in Gurage (0.94ha), Hadiya (1.49ha) and West Showa Zone (3.83ha) of Ethiopia (Emana *et al.*, 2015). Most of the respondents allocated less than 0.25 ha of land for the production of karkade. This finding is somewhat similar to the size of land allocated for the production of karkade, which ranged between 0.04 ha to 3.45 ha (Ogunsola *et al.*, 2018).

Concerning production experience, more than half of the respondents practiced production of both figl and girgir for more than ten years. Most of the respondents indicated they produced karkade for more than ten years. Farmers in Nigeria have more experience (20 and 68 old) with 10 to 54 years of farming of the crop (Ogunsola *et al.*, 2018). Most of the producers responded that they planted figl and girgir under both rain-fed and irrigation schedules. However, all the farmers reported that they practice the cultivation of karkade only during the rainy seasons. The study conducted in Sudan indicated that karkade is grown mainly by traditional farming methods, exclusively under rain-fed conditions (El Naim and Ahmed, 2010).

Most of the respondents indicated that they produce figl and girgir from three to five times per year. However, in the focus group discussion, it was indicated that figl and girgir could be produced more than five times per year. All the farmers responded that karkade could be cultivated only once a year during the rainy season. A similar result was reported in the karkade plant elsewhere (Ansari *et al.*, 2013).

Table 2. Production of figl, girgir and karkade among surveyed housed hold in the study area.

Variable	N (%)	
	Figl and girgir (n = 274)	Karkade (n = 274)
Purposes of production		
Food	19(7)	-
Food and Cash Crop	83(30)	-
Food and Medicine	40(15)	-
Food, Medicine and Cash Crop	125(46)	-
Food, Medicine, Cash Crop and Cultural Ceremonies	7(3)	-
Beverage and Medicine	-	150(55)
Beverage, Medicine and Cash Crop	-	20(7)
Beverage, Medicine and Cultural Ceremonies	-	28(10)
Beverage, Medicine, Cash and Cultural Ceremonies	-	76(28)
Estimated land allocated for the production		
<0.25 ha	275(94)	222(81)
0.25 ha	14(5)	48(18)
0.75 ha	3(1)	4(1)
Production experience		
1–3 years	26(9)	17(6)
3–5 years	40(15)	31(11)
5–10 years	61(22)	31(15)
>10 years	147(54)	186(68)
The production system		
Rain-fed	32(12)	274(100)
Irrigation	62(23)	-
Rain-fed and irrigation	180(66)	-
Production frequency		
1	-	274(100)
2	65(24)	-
3	83(30)	-
4	51(19)	-
5	75(27)	-

Note*: N = frequency.*

3.3. Challenges of Production and Marketing

Concerning the production problems of figl, girgir and karkade (Figure 2), most of the farmers indicated that there is no extension service from zone, regional and federal levels during the production of these underutilized plants. In addition to this, the lack of improved varieties and unavailability of seeds were reported to pose problems. The focus group discussion also confirmed that there is no government support regarding the production of the crops. The seed is not readily available like seeds of other staple crops, which are widely cultivated in the study area such as sorghum, maize and groundnut.

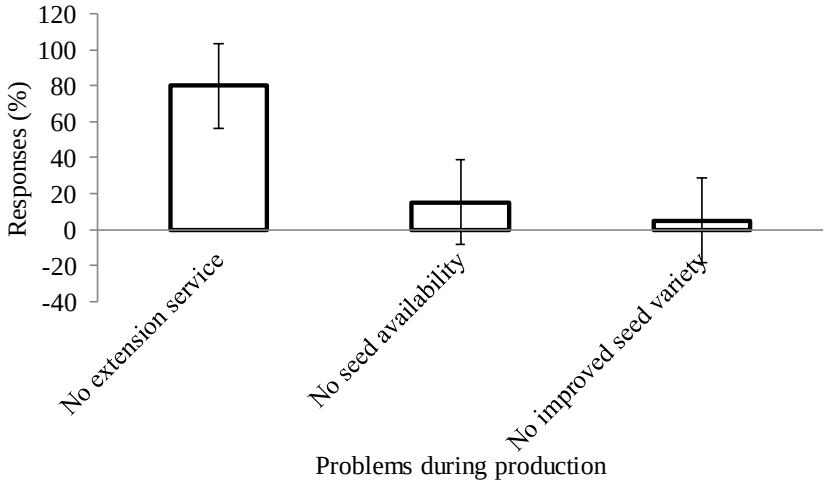

Figure 2. Challenges during the production of figl, girgir and karkade among the surveyed households in the study area.

Regarding the marketing problems of figl, girgir and karkade (Figure 3), more than half of the farmers reported that there is no market linkage. Furthermore, lack of access to market information, transportation problem and distance from the rural market center were also reported. The results obtained from the focus group discussion also indicated that there is no market linkage across zonal, regional and federal levels.

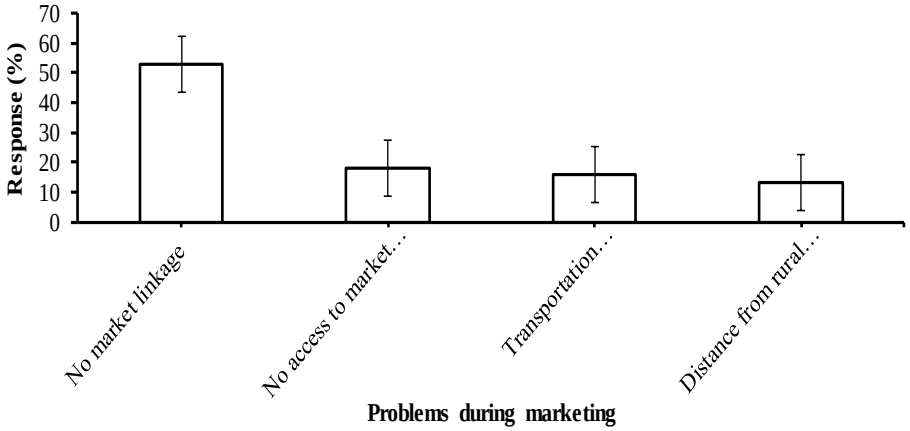

Figure 3. Challenge during the marketing of figl, girgir and karkade among the surveyed households in the study area.

3.4. Harvesting and Postharvest Handling Practices

Most of the respondents indicated that figl and girgir, attains commercial maturity within 15-35 days (Table 3). Similarly, a study conducted in Romania showed that the leaves of girgir reached commercial maturity within 25 days (Varga *et al*., 2012). In Brazil, figl is harvested within three to six weeks (Lima *et al*., 2015). The early commercial maturity in the study area may be associated with the warm weather of the region as compared to other production areas in the country. Most of the respondents reported that the commercial maturity for calyces and seeds of karkade were from 121 to 150 days after sowing. In Iran, edible parts of karkade were reported to be harvested in 180 days (Ansari*et al*., 2013). The variations in the duration of maturity of the plants may be influenced by plants' genetic difference, agronomic, and climatic differences of the growing areas.

The high percentage of the farmers witnessed that the maturity of figl is determined by the color of leaves (dark green) and roots (whitish). Similar results were reported for the maturity of roots and leaves of radish grown in Korea, when the roots became white while the leaves remained green in color (Chandra *et al*., 2018). Similarly, the maturity of the leaves of girgir is determined based on the color and the size of leaves. A study conducted in Italy also showed that the leaves of girgir (*Eruca sativa*) reached commercial maturity when

the leaves showed a dark or bright green color (Mastrandrea *et al.*, 2015).

The majority (58%) of the producers asserted that the maturity of calyces and seeds of karkade is determined when the pod becomes dry and open, and then calyx part is separated from the pods and seeds. Consistent with this suggestion, Castro *et al.* (2004) highlighted that harvesting calyces of karkade commences when the seed capsules are ready to open, approximately 15–20 days after blossoming.

More than half of the respondents indicated that edible parts in figl and girgir are harvested in the morning hours to avoid wilting and withering of the leaves. Similarly, reports were documented in Korea, where figl harvesting is done in the early morning when the atmospheric conditions are cold (Chandra *et al.,* 2018). Most of the respondents revealed that calyces and seeds of karkade are harvested any time of the day. However, the results obtained from the focus group discussions (FGDs) depict that the harvesting of calyx parts of karkade takes place in the morning to minimizes breakage and shattering losses, which can be incurred due to direct exposure to sunlight.

Regarding the storage method of edible parts of the three plants, all the respondents showed that there was no storage mechanism for the edible parts of figl and girgir for future utilization. However, respondents from FGDs stated that the raw roots of figl could stay two to three days without any deterioration. On the other hand, the fresh leaves are easily spoiled after one day of storage. The leaves of figl and girgir wilt very fast and show changes in coloration from green to yellow, mainly because of the degradation of chlorophyll. Lack of adequate cooling facilities reduces the storage potential of the harvest that prompts immediate cooking after harvesting. A study conducted in Italy also indicated that after the leaves of girgir were harvested, color changes occurred from dark or bright green into yellow, due to loss of chlorophyll, which leads to yellowing, and a general loss of visual quality (Mastrandrea *et al.*, 2015).

Table 3. Post-harvest handling practices of figl, girgir and karkade among surveyed household.

Variable	N (%)		
	Figl (n = 274)	Girgir (n = 274)	Karkade (n = 274)
Duration of maturity		-	
15-35	254(93)	255(93)	-
36-55	20(7)	19(7)	-
90-120	-	-	112(41)
121-150	-	-	162(59)
Determination of maturity edible parts			
Color	120(44)	64(23)	158(58)
Size	105(38)	130(48)	-
Width and length	49(18)	80(29)	-
Pod become dry and open			116(42)
Harvesting methods			
Manual	274(100)	274(100)	274(100)
Harvesting period of the edible parts			
Anytime	115(42)	115(42.0)	236(86)
morning (before noon)	155(57)	155(57)	35(13)
Afternoon	4(1)	4(1)	3(1)
Storage of edible parts after harvest			
Home consumption	274(100)	274(100)	-
Store sometimes for further use	-	-	274(100)
Packing materials			
Basket	14(5)	14(5)	19(7)
Plastic	79(29)	79(29)	-
Sack	108(39)	108(39)	164(60)
Basket and sack	73(27)	73(27)	56(20)
Plastic and sack			35(13)

Note*: N = frequency.*

Calyx of karkade has relatively low moisture content upon harvesting that can favour long-term storage. The data showed that most of the respondents indicated dried calyces of karkade could be stored for seven to twelve months at ambient temperature (Figure 4). A response from FGD shows that the dried calyces of karkade can be stored for up to 24 months at room temperature under good storage conditions. The respondents indicated that they store calyx of karkade in anticipation of better market prices and upcoming cultural and religious purposes. Similar observations were reported in Niger, where calyx of karkade is stored for one to two years with limited insect infestations

(Boureima *et al.*, 2015). Producers also indicated that, after the content is extracted from the calyces of karkade, the product can be kept safe for three to five days at ambient temperature. The delay of the spoilage might be attributed to the presence of antimicrobial and antioxidant agents in the calyces.

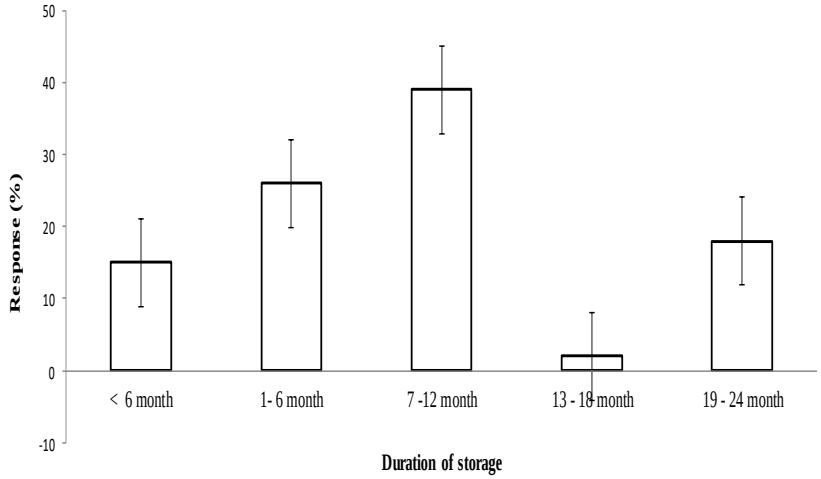

Figure 4. Storage duration of karkade calyces among the surveyed households in the study area.

Concerning the packaging materials of three plants, most of the respondents use sack bags during transportation of consumable parts of figl and girgir, whereas few of the respondents used both baskets and sacks. The focus group discussion revealed that edible parts of figl and girgir are packed using plastic bags, baskets, and sacks. The packaging materials used for figl and girgir are like the ones used in the Northern part of Ethiopia to pack leafy vegetables such as cabbage, lettuce, spinach, and swiss chard a basket, plastic materials, and nets (Rahiel*et al.*, 2018). Also, in the studies it was reported that fruits, root and tuber crops were packed in sacks, wooden boxes, and polyethylene bags. Most of the respondents used sack bags for the packaging calyces of karkade. In Brazil, it was reported calyces of karkade can be packed in glass and polypropylene plastic bags (Piovesana and Noreña, 2019).

More than half of the respondents used human labour to transport figl, girgir, and karkade, and a few of the study participants use both human labour and donkey carts (Figure 5). Similar results were reported from Dire Dawa, in the Eastern part of Ethiopia, where the mode of transport for horticultural crops from farm to temporary storage or the market rely on human labour, donkey, mule, and horse carts, camel, three-wheel vehicle, and trucks (Kasso and Bekele, 2018).

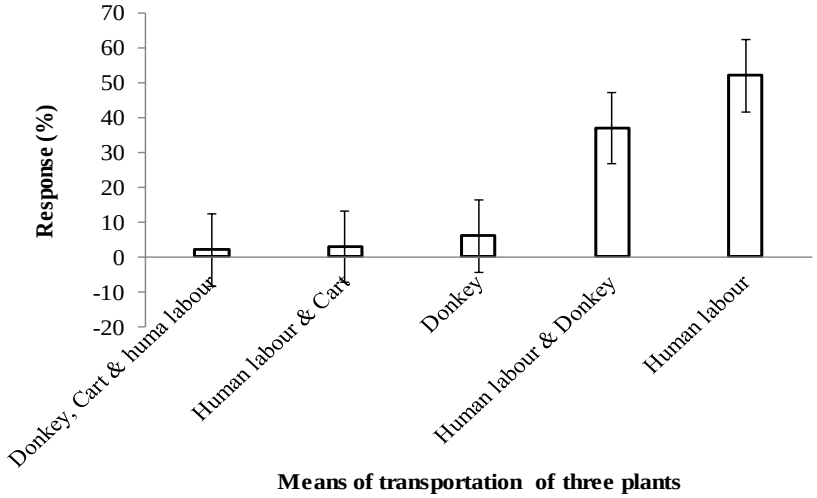

Figure 5. Types of transportation used for figl, girgir and karkade among the surveyed households in the study area.

3.5. Utilization trends of the plants

All (100%) of the respondents indicated that they consume the leaves and root parts of figl, but girgir is preferred for consumption as leaves (Table 4 and Figure 6). The same was confirmed during FGD with producers of the plants. Studies in India also showed that respondents preferred leaf and root parts of figl (Dongarwar *et al.*, 2018). In Greece, girgir leaves are used in popular dishes to make salad (Doulgeraki *et al.*, 2017).

Figure 6. Edible parts of figl and girgir growing in Benishangul Gumuz Region; figl leaves (A), figl roots (B) and girgir leaves (C).

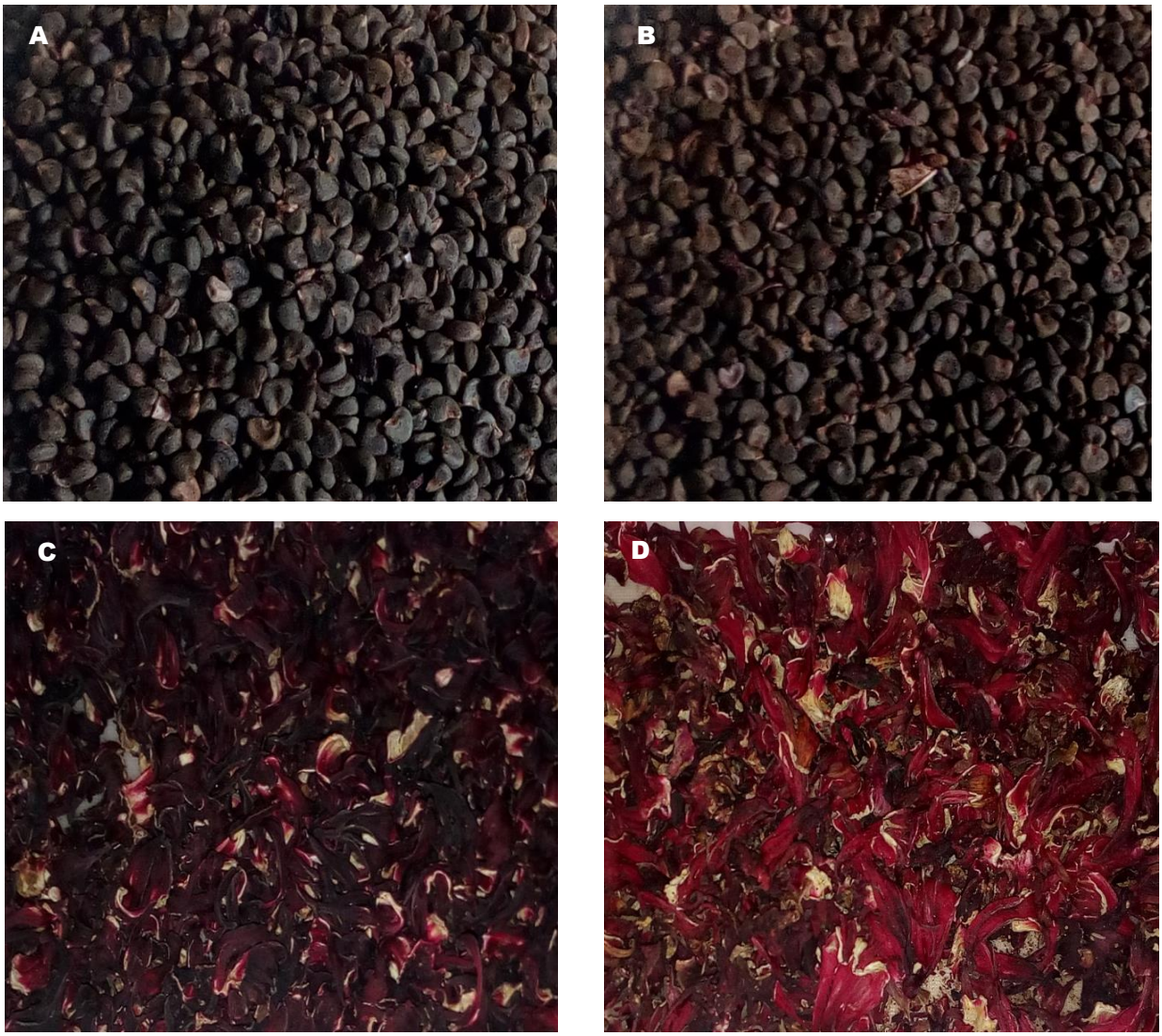

Figure 7. Edible parts of karkade growing in Benishangul Gumuz Region; karkade brown seeds (A), karkade brown red seeds (B), karkade brown calyx (C) and karkade brown red calyx (D).

Most of the respondents indicated that they used the calyx of karkade to make beverages. Some of the producers stated that they used both the calyx and seeds of karkade (Figure 7). Similar results were reported from Indonesia (Aryanti *et al.*, 2019*)*. Most of the respondents reported that leaves and roots of figl and leaves of figl were used as a source of food and medicine. Similar results were reported in China that edible parts of both roots and leaves are used for both food and medicine (Dongarwar *et al.*, 2018). Most of the respondents used calyces of karkade for beverage, medicinal purposes, and cash crop. The users also confirmed that edible parts of the calyces of karkade are used for a drink on cultural ceremonies (during wedding), New Year and religious (Mewulid, Eid al-Fitr and Arefa) celebrations, and for medicinal purposes. A report from Sudan shows that the dried calyces could be soaked in water to prepare a colorful cold drink or boiled in water for a hot drink or tea (Mohamed *et al.*, 2012). The same responses were recorded from both focus group discussions, which indicated that the seeds of karkade are used to make a stew or directly consumed after boiling. The oil content of the seeds could add more flavor and taste to the stew. The seeds of karkade are used for the extraction of edible oils in Saudi Arabia (Shaheen *et al.*, 2012).

However, in the study area, some respondents indicated that they used it as an ingredient to make local stew or used it after boiling, but there is no practice of edible oils production indicated. In future, the experience from other countries can be used for the

extraction of edible oils from seeds of karkade in Ethiopia.

All the respondents indicated that the leaves of figl along with other leaves, roots, tomato and onion by mixing with oil and salts) or in roasted or cooked vegetable form are consumed. Besides, the leaves also are cooked together with onion, tomato, beans, groundnut, okra, and meat with the addition of different spices. Similar observations were reported from studies conducted in Iran, which showed that roots and tender leaves of figl are eaten raw in salads (Ghasemian *et al.*, 2016). This report also indicated that edible parts of both leaves and roots could be used in a cooked form and even pickled in brine. Most of the respondents use dried calyces of karkade for tea and juice preparation (Figure 8). The same result was obtained from the FGD and interview of users.

Figure 8. Traditional tea and juice beverage from calyces of karkade in the Benishagul Gumuz region; tea (A) and juice (B).

The response from users also showed that calyx part of karkade is used by newly delivered pregnant mothers and peoples with cough infections. Calyces and seeds part of karkade is an industrial raw material commonly used in different forms for beverages and foods, respectively. The extract from calyces is frequently used in the production of jelly, jam, juice, wine, syrup, gelatin, pudding, cake, ice cream, and flavoring (Mohamed *et al.*, 2012). The experiences from other countries are good input to produce a variety of calyces of karkade products in Ethiopia.

The traditional processing methods of edible parts of the three plants, most of the respondents indicated that they slice and chop the leaves and roots before they mix with a brine solution for 30 min. The prepared slices are consumed with the addition of onion, sliced tomato, and oil. Similar practices were reported from Iran (Ghasemian *et al.*, 2016). However, some of the respondents indicated they use both raw and mildly cooked forms. All the respondents indicated that the same traditional processing methods are used for both hot and cold beverage preparation (Table 4). The same was confirmed during FGD with producers and users of the plants.

Table 4. Utilization trend of figl, girgir and karkade among surveyed household.

Variables	N (%)		
	Figl (n = 274)	Girgir (n = 274)	Karkade (n = 274)
Edible parts			
Roots and leafs	274(100)		
Leafs		274(100)	
Calyx			165(60)
Calyx and seeds			109(40)
Uses of edible parts			
Food	43(16)	48(18)	
Food and medicine	118(43)	116(42)	
Food, medicine and cash crop	113(41)	110(40)	
Beverage	-	-	82(30)
Beverage and medicine	-	-	75(27)
Beverage, medicine and cash crop	-	-	117(43)
Food/beverage prepared from edible			
Local salad(leaves+roots+tomato+oil+salt)	274(100)	274(100)	-
Cold drink (Juice)	-	-	13(5)
Hot drink (Tea)	-	-	30(11)
Hot and Cold drink	-		231(84)
Food/ beverage processing steps from edible parts			
Raw	229(84)	229(84)	-
Both raw and blanched (mild heat)	45(16)	45(16)	-
Hot drink (Tea) (boil the water first and then add boiled water to calyx for few minutes and then filter it and add one or two spoons of sugar to one cup of tea).	-	-	274(100)
Cold drink (Juice) (adds the dried calyx into water for one day and filters it. Add sugar to make sweet and drink it)	-	-	274(100)

Note*: N = Frequency.*

3.6. Medicinal Values

The traditional medicinal benefits of the three plants are presented in Table 5. All the respondents believe that the plants have high medicinal values. Respondents indicated that figl could be used to treat abdominal and liver problems, malaria, and typhoid fever and used as an appetizer and cough suppressor. In addition to these, a few of the respondents believe the use of the plants offers a remedy against gastric ulcers, headache and improves blurred eye vision. For girgir, most of the respondents showed that the plant is used to treat malaria and typhoid fever. It cures abdominal and liver associated diseases. Some of them believed that the plant is used to treat headache, eye vision, and gastric problems. The study reported from India showed that leaves of figl (*Raphunus sativus*) is the traditionally medicine plant used to treat pain and inflammatory disease. Whereas leaves of girgir (*Eruca sativa*) reported from Saud Arabia have anti-secretory, cytoprotective, and anti-ulcer activities (Alqasoumi *et al.,* 2009).

Most of the respondents believed that karkade calyx of the plant species also helps in preventing anaemia. A few of the study participants indicated that the beverage could be used as an energy drink. Contrary to this finding, in Indonesia, consumption of roselle (*Hibiscus*) extract combined with iron tablets showed significant increases in haemoglobin levels in pregnant women compared to the use of iron tablets alone. The study conducted in Ghana also revealed that *Hibiscus sabdariffa* meal improves women's iron status of child-bearing age with time and is protective of stunting among toddlers during the dry/lean season (Kubuga *et al*., 2019). A study conducted in India showed that drinking beverage made from karkade calyx protects from cold and cough (Suresh and Ammaan, 2017). This may be attributed to the fact that calyx of karkade consists of vitamin C, which helps to boost the immune system of the body, and facilitates the absorption of iron and thus strengthens the body's resistance to infection (Khalid *et al*., 2012). Anthocyanins and pro-anthocyanidins in the clayx are the two main bioactive compounds that might be responsible for lowering blood pressure (Wahabi *et al*., 2010).

Table 5. Medicinal values of Figl, Girgir and Karkade among surveyed household.

Variable	N (%)		
	Figl (n = 274)	Girgir (n = 274)	Karkade (n = 274)
Do you know the medicinal value			
Yes	274(100)	274(100)	274(100)
Types of diseases treat it			
Abdomen	100(36)	44(16)	-
Abdomen and hepatic	74(27)	75(27)	-
Abdomen, appetizer and cough	30(11)	20(7)	-
Gastric, headache, eye vision	24(9)	41(15)	-
Malaria and typhoid fever	46(17)	94(34)	-
Anaemia (deficient blood)			249(91)
Anaemia and energy drink			25(9)
Edible part used to treat disease			
Leaves	2(1)	274(100)	-
Roots	5(2)	-	-
Leaves and roots	267(97)	-	-
Calyx		-	274(100)
Dose for Male, Female, Children and Adult			
Unknown	274(100)	274(100)	274(100)

Note*: N = frequency.*

4. Conclusions

The potential of underutilized plants figl, girgir and karkade in line with production practices, post-harvest handling and utilization trends towards food and nutrition security in the Benishangul Gumuz Regional State of Ethiopia were assessed. The survey result showed that figl and girgir are mainly produced for food, medicine and income generation, while karkade is used for beverage and medicine. The result also indicated that the leave and roots of figl and leaves of girgir reach maturity within one month for household consumption and market purpose. Based on this context, the findings imply that figl and girgir can help in mitigating the problems of food and nutritional insecurity mainly because the two crops reach commercial maturity within a short period and can provide more than five cropping cycles throughout the year, particularly in marginal lands with affordable agronomic practices. Calyces and seeds of karkade are harvested between four to five months for beverage and local stew preparation, respectively. Besides, the seeds of karkade are mostly used by farmers for seedling purposes except in some communities for stew preparation. But the reports in other countries show that the plant seed is a potential source of protein and fat, which is used to complement low energy density to mitigate protein energy malnutrition. These unexploited plants (figl, girgir and karkade) are not widely cultivated for consumption in the country. It could be concluded that these neglected and underutilized species offer the potential to diversify not only the human diet, but also increase food production levels, and, thus, enable more sustainable, resilient agriculture and horticulture-food systems. To exploit the potential of neglected plant species, harmonized attitudes on the national level have to be assimilated that consequently demand the involvement of numerous multi-stakeholders. Therefore, stakeholders at different levels should take part in conducting research in agronomy, breeding, protection, ecology and extension activities synergistically in order to boost the production and productivity, handling practices, utilization and commercialization of the three neglected plant species. Future research should incorporate packages of farming technology including propagating the crops at research centers and promote their cultivation by farmers in areas where the agro-ecology is suitable. Also, it is important to note that these plant species are adapted well in areas with high precipitation and humidity as well as marginal lands. Finally, it is required to have strategies to bring neglected plants out of their niche role. Thus, development of policies for the promotion of neglected plants and their barriers against mainstreaming of these plants should be primarily well known and then analyzed.

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6. References

Alqasoumi, S., Al-Sohaibani, M., Al-Howiriny, T., Al-Yahya, M. and Rafatullah, S. 2009. Rocket "Eruca sativa": A salad herb with potential gastric anti-ulcer activity. *World Journal of Gastroenterology,* 15(16):1–8.

Ansari, M., Eslaminejad, T., Sarhadynejad, Z. and Eslaminejad, T. 2013. An overview of the roselle plant with particular reference to its cultivation, diseases and usages. *European Journal of Medicinal Plants*, 135–145.

Aryanti, N., Nafiunisa, A. and Wardhani, D.H. 2019. Conventional and ultrasound-assisted extraction of anthocyanin from red and purple roselle (*Hibiscus sabdariffa*L.) calyx and characterization of its anthocyanin powder. *International Food Research Journal,* 26: 529–535.

Banihani, S. A. 2017. Radish (*Raphanussativus*) and diabetes. *Nutrients, (*99): 1014.

Boureima, S., Moussa, B. and Lowenberg-DeBoer, J. 2015. Analysis of the profitability of pics bags for the storage of Roselle grains *(Hibiscus sabdariffa)* in three regions in Niger. *Department of Agricultural Economics Purdue University*, 1–32.

Chandra, D., Lee, J. S., Choi, H. J. and Kim, J. G. 2018. Effects of packaging on shelf life and postharvest qualities of radish roots during storage at low temperature for an extended period. *Journal of Food Quality*, 2018:1–12.

Castro, N.E.A.D., Pinto, J.E.B.P., Cardoso, M.D.G., Morais, A.R.D., Bertolucci, S. K.V., Silva, F. G.D. and DelúFilho, N. 2004. Planting time for maximization of yield of vinegar plant calyce (*Hibiscus sabdariffa* L). *Cienciae AgroTecnologia,* 28: 542–551.

Central Statistical Agency (CSA). 2017. Population Projection of Ethiopia for All Regions at Woreda Level from 2014–2017, Central Statistical Agency (CSA), Addis Ababa, Ethiopia.

Chinatu, L.N., Akpan, A.N., Echereobia, C.O. and Harriman, J.C. 2016. Assessment of chemical composition of flower, variability, heritability and genetic advance in *Hibiscus sabdariffa*. *Journal of Biology and Genetic Research*, 2:15 23.

Dias, J.S. and Ryder, E. 2011. World vegetable industry: production, breeding, trends. *Horticultural Reviews*, 38: 299–356.

Dongarwar, L. N., Kashiwar, S. R., Ghawade, S. M. and Dongarwar, U. R. 2018. Varietal performance of radish (*Raphanussativus L.*) varieties in black soils of Vidharbha- Maharashtra, India. *International Journal of Current Microbiology of Applied Science,* 7:491-501.

Doulgeraki, A. I., Efthimiou, G., Paramithiotis, S., Pappas, K. M., Typas, M. A. and Nychas, G. J. 2017. Effect of rocket (*Eruca sativa*) extracts on MRSA growth and proteome: metabolic adjustments in plant-based media. *Frontier in Microbiology,* 5(8):1-9.

El Naim, A. M. and Ahmed, S. E. 2010. Effect of weeding frequencies on growth and yield of two roselle (Hibiscus sabdariffa L) varieties under rain fed. *Australian Journal of Basic and Applied Sciences,* 4:4250-4255.

Elsadek, M. 2014. Chemical constituents of *Eruca sativa* and treatment activity against paracetamol inducing hepatic injury in experimental rats. Egypt. *Journal of Nutrition and Health*. 9:73-84.

Emana, B., Afari-Sefa, V., Dinssa, F. F., Ayana, A., Balemi, T. and Temesgen, M. 2015. Characterization and assessment of vegetable production and marketing systems in the humid tropics of Ethiopia. *Quarterly Journal of International Agriculture,* 54(2):163-187.

Ghasemian, M., Owlia, S. and Owlia, M. B. 2016. Review of anti-inflammatory herbal medicines. *Advances in Pharmacological Sciences*, 2016:1-11.

Goyeneche, R., Roura, S., Ponce, A., Vega-Gálvez, A., Quispe-Fuentes, I., Uribe, E. and Di Scala, K. 2015. Chemical characterization and antioxidant capacity of red radish (*Raphanussativus* L.) leaves and roots. *Journal of Functional Foods*, 16: 256-264.

Guyu, F.D. and Muluneh, W. 2016. Determinants of seasonal food insecurity in the 'green famine' belt of Ethiopia: the case of households in Belo-jiganfoy District, Benishangul-Gumuz region. *African Journal of Food Science*, 10: 278-291.

Kasso, M. and Bekele, A. 2018. Post-harvest loss and quality deterioration of horticultural crops in Dire Dawa Region, Ethiopia. *Journal of the Saudi Society of Agricultural Sciences,* 17: 88-96.

Keyata, E. O., Tola, Y. B., Bultosa, G. and Forsido, S. F. 2020. Proximate, mineral, and anti-nutrient compositions of underutilized plants of Ethiopia: Figl (*Raphanus sativus L.),* Girgir (*Eruca sativa L*) and Karkade (*Hibiscus sabdariffa L*): Implications for *in-vitro* mineral bioavailability. *Food Research International*, *137*, 109724.

Keyata, E.O., Tola, Y.B., Bultosa, G. and Forsido, S.F.2021. Phytochemical contents, antioxidant activity and functional properties of *Raphanus sativus L, Eruca sativa L.* and *Hibiscus sabdariffa L.* growing in Ethiopia. *Heliyon*, *7*(1), e05939

Khalid, H., Abdalla, W. E., Abdelgadir, H., Opatz, T. and Efferth, T. 2012. Gems from traditional north-African medicine: medicinal and aromatic plants from Sudan. *Natural Products and Bioprospecting*, 2:92-103.

Kiran, K. C., Dhanush, C., Gajendra, C. V. and Reddy, B. M. 2019. Diversity and seasonal availability of potential wild edible plants from Vidarbha Region of Maharashtra State, India. *International Journal of Current Microbiology and Applied Science,* 8:1434-1446.

Kubuga, C. K., Hong, H. G. and Song, W. O. 2019. *Hibiscus sabdariffa* meal improves iron status of childbearing age women and prevents stunting in their toddlers in Northern Ghana. *Nutrients*, 11:198.

Lima, E. M. C., Maller, A., Hara, A. T., Rezende, F. C. and Carvalho, J. A. 2015. Efeito de diferentesníveis de água no solo naprodução do rabanetecultivadoemdoistipos de ambientesprotegidos. *Engenhariana Agricultura,* 23:346-354.

Manisha, D., Rashi, K.N., Harini, K., Boggula, N., Bakshi, V. and Sayeed, M. 2020. Assess the anti-inflammatory and analgesic activity of leaves of *Raphanus sativus*–an in-vivo design. *Asian Journal of Pharmaceutical Research and Development*, *8*(5):44-51.

Mastrandrea, L., Amodio, M. L. and Cantwell, M. I. 2015. Modeling ammonia accumulation and color changes of arugula (*Diplotaxistenuifolia)* leaves in relation to temperature, storage time and cultivar. In III International conference on fresh-cut produce: maintaining quality and safety. *Cantwell Acta Horticulture,* 1141(34): 275-282.

Mohamed, B. B., Sulaiman, A. A. and Dahab, A. A. 2012. Roselle (*Hibiscus sabdariffa* L.) in Sudan, cultivation and their uses. Bulletin of *Environment*, *Pharmacology* and *Life Sciences*, 1:48-54.

National Meteorological Services Agency (NMSA). 2018. Monthly report on temperature and rainfall distribution for Assosa zone, regional metrological office, Assosa, Ethiopia.

Ogunsola, K. E., Ogunfunmilayo, A. O., Solomon, S., Oluitan, J. A., Kazeem, S. A., Folorunso, D. O. and Ibrahim, S. 2018. Occurrence and population distribution of plant parasitic nematodes associated with roselle (*Hibiscus sabdariffa L.*) in northern Nigeria. *Agro-Science*, 17:18-26.

Piovesana, A. and Norena, C. P. Z. 2019. Study of acidified aqueous extraction of phenolic compounds from *Hibiscus sabdariffa L.* calyx. *The Open Food Science Journal,* 11:25-34.

Rahiel, H. A., Zenebe, A. K., Leake, G. W. and Gebremedhin, B. W. 2018. Assessment of production potential and post-harvest losses of fruits and vegetables in northern region of Ethiopia. *Agriculture & Food Security*, 7:29.

Shaheen, M. A., El-Nakhlawy, F. S. and Al-Shareef, A. R. 2012. Roselle (*Hibiscus sabdariffa* L.) seeds as unconventional nutritional source. *African Journal of Biotechnology*, 11:9821-9824.

Shruthi, V. H., Ramachandra, C. T., Nidoni, U., Hiregoudar, S., Naik, N. andKurubar, A. R. 2016. Roselle (*Hibiscus sabdariffa L.*) as a source of natural colour: a review. *Plant Archives*, *16*:515-522.

Siomos, A.S. and Koukounaras, A. 2007. Quality and postharvest physiology of rocket leaves. *Fresh Produce*, 1:59-65.

Stathers, T., Lamboll, R. and Mvumi, B. M. 2013. Postharvest agriculture in changing climates: its importance to African smallholder farmers. *Food Security*, *5*: 361-392.

Suresh, V. and Ammaan, M. 2017. Medicinal uses of Roselle (*Hibiscus sabdariffa*). *Journal of Medicinal Plants Studies,* 5:97-98.

United Nations, Department of Economic and Social Affairs, Population Division. 2017. *World Population Prospects: The 2017 Revision, Key Findings and Advance Tables*. Working Paper No.ESA/P/WP/248. United Nations, New York.

Varga, J., Apahidean, A. S., Laczi, E. and Apahidean, A. I. 2012. Studies concerning the sowing period in the arugula (*Eruca sativa Mill.)* plants development. *Acta Universitatis Sapientiae, Agriculture and Environment,* 4:5-10

Wahabi, H. A., Alansary, L. A., Al-Sabban, A. H. and Glasziuo, P. 2010. The effectiveness o*f Hibiscus sabdariffa* in the treatment of hypertension: A systematic review. *Phytomedicine*, 17: 83-86.

Yamane, T.1967. Statistics in an introductory analysis, 2nd Ed., New York: Harper and Row.