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QUANTIFICATION OF PHYTOCHEMICAL AND METABOLOMICS PROFILING OF THE NIGERIAN'S BOTANICAL APHRODISIAC Microdesmis keayana (MICRODESMIS) J. LEONARD (PANDACEAE) ROOT

Ojatula Adekunle Orimisan

ABSTRACT

Microdesmis keayana is commonly known as microdesmis and is used in South-Western Nigeria as an aphrodisiac. Despite its extensive traditional usage, the bioactive constituents of this plant's roots are yet to be explored thoroughly. The present study was carried out to actuate the chemical components of Microdesmis keayana root by quantitative phytochemical screening and gas chromatography-mass spectrometry (GC-MS). Sixty grams of the powdered roots was sequentially extracted by ethanol and later tested for preliminary quantitative phytochemical screening and further subject to GC-MS analysis. The results showed the presence of alkaloids (17.85±0.48), flavonoids (6.17±0.27), tannins (6.17±0.27), steroids (5.53±0.1), saponins (9.25±0.02), phenols (3.01±0.11) and cardiac glycoside (3.41±0.13) in the extract. The GC-MS analysis revealed the presence of 14 major compounds of different chemical class relevant to the National Institute of Standards and Technology (NIST) library. The findings indicated that the studied plant possesses therapeutic compounds that could improve a person's health, and therefore justifies its traditional usage in the management of male sexual dysfunction and other reproductive disorders.

Keywords: Aphrodisiac activity, disorders, gas chromatography-mass spectrometry, Microdesmis keayana, phytochemical screening.

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1. INTRODUCTION

The use of plants for curative measures dates back to the birth of mankind on earth. Medicinal plants are frequently used in variance inevitable aspect of mankind, be it medical, industrial, agricultural, nutritional, environment and a great many of the other sustainable fields. The relevancy of the medicinal species in health sustainability is of a global interest in making use of the medicinal herbs. These species and their pharmaceutical values are introduces in pharmacopoeia (Fatemaeh *et al*., 2017); having been subjected to scientific research and investigation. Scientific research and investigation on medicinal herbs, remains distinct position in the precise identification of active ingredients, which usually contributes to the proposition of predictions regarding the medicinal value of specific species (AzadBakht, 2000). The botanical aphrodisiac, *Microdesmis keayana* (J. Leonard) (synonymous *Microdesmis puberula*), belongs to the family, Pandaceae. It is known as 'Apata' (Yoruba (Ikale/Ilaje) –Western Nigeria); and has being in use extensively, among the local population, as an aphrodisiac to relieve sexual dysfunction, boost libido and enhances fertility in male. The common name of *Microdesmis keayana* is Microdesmis, it is a dioecious shrub growing up to 3-6 m high, and is widely distributed in the western part of Africa from Senegal east to south-western Nigeria (Burkill, 1997). According to oral communication and the information collected from the village physicians, herbalist, herb sellers and those engaged in self-medication in Ilaje local government area of ondo state, Nigeria, the root of *M. keayana* is widely used to curtail male sexual dysfunction and other related ailments. The leaves, which are practically alternate, distichous, ovate, stipules linear and simple are commonly taken orally or applied, sometimes together with twigs sap as enema to treat diarrhea. The infusion of the leaf is taken to induce menstruation and as an abortifacient in Liberia, Nigeria and Sierra Leone (Neuwinger, 2000). A decoction made from the leaves, or leafy twigs or ground young leaves is used as a steam bath or wash to treat rheumatism or migraine in Cote d' Ivoire and Ghana (Cunningham, 1993).

The use of plant products or materials in ethnomedicine is increasing globally. The World Health Organization has also pointed out that about 80% of the world's population rely heavily on herbal medicinal products for the treatment of various health challenges (WHO, 2004). These products are being prepared as decoction, infusions, extracts, or pastes with easily accessible liquids such as alcohol, water, and milk. In olden days itself the importance of medicinal plants have been discovered. At that time there was no synthetic medicines, they have been using only the herbal medicines to treat all ailments. From this one can understand that plants are rich in medicinal properties and they are very useful in human health and wellbeing. Nowadays, much attention is focused on the vast botanical resources of Africa and their use as alternatives and complementary sources of medicine. This is likely to be as a result of the putative salutary effect of most Africa plants that is attributed to the

presence of secondary metabolites. Medicinal plants have constituted the source of health care all over the world since time immemorial and thus remain the mainstay of drug discovery (Beyene and Deribe, 2016); this is believed to be as a result of the presence of certain plant chemicals (phytochemicals). Phytochemicals which may also be referred to as phytonutrients/phytoconstituents are present in diverse kinds of plants which are consumed as essential components of both human and animal diet where they have marked physiological effects (Awotedu *et al*., 2019). The bioactive principles of note in plants are alkaloid, flavonoid, tannins, saponins and phenolic compounds; this active principles, alongside the vitamins and minerals have been implicated to contribute to their various physiologic, metabolic and protective effects (Awotedu *et al*., 2019).

The metabolic state of an organism depends on its genome, proteome and exposome (environment). Thus, metabolomics is the study of metabolites profiles. It utilizes mass spectrometry methods to analyze many different metabolites in a biological sample. Hence, secondary metabolites or products are heterogeneous group of natural metabolic products that are not essential for vegetative growth of the producing organisms, but they are considered differentiation compounds conferring adaptive roles, for examples, by functioning as defense compounds or signaling molecules in ecological interactions, symbiosis, and so on (Markley *et al*., 2017). The multitude of secondary metabolites secretions is harvested by human kind to improve their health (antibiotics, enzymes inhibitors, and antitumor), and widen the pyramid of healthy nutrition. They are sources of antioxidant and antimicrobial agents (Markley *et al*., 2017).

Wild vegetation are potential sources of these phytochemicals and antioxidants that play a vital role in health promotion, especially in the rural populations, which have better access to these plants. These phytochemicals are responsible for many biological effects, including antioxidant, anti-inflammatory, antimicrobial, and anticancer activities (Tabuti *et al*., 2003), and therefore, they may find therapeutic applications in formulation of various pharmaceutical drugs. Medicinal plants appears to be rich in secondary metabolites, widely used in traditional medicine to combat and cure various ailments, thus, the increasing demands. Traditional medicine occupies a central place among rural communities of developing countries for the provision of health care in the absence of an efficient primary health care system. The existence of traditional medicine depends on plant species diversity and related knowledge of their use as herbal medicines (Tabuti *et al*., 2003).

The bioactive components responsible for medicinal activities of any plants can be identified by various analytical biological techniques such as gas chromatography-mass spectrometry. Gas chromatography- mass spectrometry (GC-MS) is used as a technique that serves a broad range of applications aimed at sample identification, quantitative determination or both. The sample identification (qualitative analysis) needs a high degree of selectivity whereas quantitative analysis requires high accuracy (the precision and trueness) (Fialkov *et al*., 2006). GC-MS is one of the valuable tool for the identification of phytochemical compounds. It combines two

analytical techniques to a single method of analyzing mixtures of chemical compounds. Gas chromatography separates the components of the mixture and mass spectroscopy analyses each of the components separately. It is the best technique to identify the bioactive compounds/constituents of long chain hydrocarbon, such as alcohols, acids, esters, alkaloids, steroids, amino and nitro compounds (Azhagumurugan and Rajan, 2014; Baskaran *et al*., 2016). The first step in investigating the presence of metabolites in any medicinal plants is by phytochemical screening that gives a broad idea on the nature of chemical constituents (Konig and Hochmuth, 2004). To identify the compound, processing data from GC-MS must fulfil two criteria which includes; correct determination of mass spectrum of individual compounds; and accurate calculation of the abundance of chromatographic peaks corresponding to those compounds in each sample. Moreover, for sample introduction into GC-MS, there are three considerations. Firstly, the constituent of the sample must be volatile and secondly the analytes must be present at concentration which is appropriate to it. Thirdly, while injecting the sample, it must not degrade the separation (Fialkov et al., 2006). The source material, *Microdesmis keayana*, was reported indigenously, to be a plant of strong aphrodisiac potentials (Erhabor *et al*., 2015), but so far there is no enough research performed on determination of the quantitative chemical composition of its root in literature.

Hence, in continuation to the on-going project on the survey of medicinal plants used as aphrodisiacs in South-Western Nigeria, this study therefore, aimed to investigate the bioactive constituents of the studied plant with the view to justify its ethnomedicinal usage.

2. MATERIALS AND METHODS

2.1. Sampling of *Microdesmis keayana*

The samples of the plant material (root) was collected from Digbolu Camp-area of Ikoya Land, Okitipupa local government area of Ondo State, Nigeria during the month of January, 2020, at 10:00 AM. The collected plant was authenticated by a Botanist at the OSUSTECH Herbarium of the Department of Biological Sciences, Faculty of Science, Ondo State University of Science and Technology, Okitipupa, Nigeria, where voucher specimen are kept. The roots of *Microdesmis keayana*, were detached from the rest of the plant after which they were washed with clean tap water thrice to eradicate debris, and later oven-dried to a constant weight at 30˚C for 1 week. Thereafter, the dried roots were then milled to a homogenous powder using an electric blender (Polymix PX-MFC 90D, KINEMATICA AG, Luzern, Switzerland).

2.2. Plant extraction

About 60 g of the powdered roots was extracted in 1000 ml of ethanol (99.99%) and placed on an orbital shaker (Labcon laboratory service [Pty], South Africa) for 24 h. The extract was later filtered using a Buchner funnel and Whatman No. 1 filter paper. The resulting filtrate was concentrated to dryness using a rotary evaporator (Heidolph Laborata 4000, Heidolph instruments, GmbH and Co, Germany). The final extract

was weighed to determine the yield (4.54%) and then stored at 4˚C in a refrigerator for further studies.

2.3. Determination of preliminary quantitative phytochemical of *M. keayana* root

Phytochemical constituents such as alkaloids, flavonoids, saponins, tannins, steroids, phenol, and cardiac glycosides were screened quantitatively. The method described by Trease and Evans (1989) was adopted to assay for the quantitative phytochemical in the roots of *M. keayana*.

2.3.1. Estimation of Saponin

The sample was ground and 20 gm of the sample put into a conical flask followed by the addition of 100 ml of 20% methanol. It was then heated over a hot water bath for 4 hours with continuous stirring at about 55˚C. The mixture was filtered and the residue re-extracted with 200 ml of 20% methanol. The extract was reduced to 40 ml over water bath at about 90˚C. The concentrate of the extract was washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the sample was dried in the oven to a constant weight. Saponin content was calculated as percentage.

2.3.2. Estimation of Alkaloids

5 gm of the sample was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in methanol was added and covered and allowed to stand for 4 hrs. The solution was then filtered and the extract was concentrated on a water-bath to one-quarter of the original volume. Concentrated ammonium hydroxide was added drop-wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide and then filtered. The residue if present is the alkaloid which is dried and weighed. **2.3.3. Estimation of Phenols by Spectrophotometric Method**

The fat free sample was boiled with 50 ml of methanol of the phenolic component for 15 minutes. 5 ml of the extract was pipetted into a 50 ml flask, followed by the addition of 10 ml of distilled water. 2 ml of ammonium hydroxide solution and 5 ml of concentrated amylalcohol were also added. The sample was made up to mark and colour developed was measured after 30 minutes at 505 nm under room temperature.

2.3.4. Estimation of Flavonoids

10 mg of the plant sample was extracted repeatedly with 100 ml of 80% aqueous methanol at room temperature. The whole solution was filtered through whatman filter paper No. 42 (125 mm). The filtrate was later transferred into a crucible and evaporated into dryness over water bath and weighed to a constant weight.

2.3.5. Estimation of Tannins

200 mg of the sample was weighed into a 50 ml plastic bottled. 50 ml volumetric flask and made up to the mark. Then 5 ml of the filtrate was pipette out into a test tube and mixed with 2 ml of 0.1M FeCl3 in 0.1N HCl and 0.008M potassium ferrocyanide. The absorbance was measured at 120 nm within 10 minutes.

2.3.6. Estimation of Steroids

The extract (1 g) was marcarated with 20 ml ethanol and filtered. To the filterate (2 ml). 2 ml of chromagen solution was added and the solution left to stand for 30 minutes. The absorbance was read at 550 nm.

2.3.7. Estimation of Cardiac Glycosides

The extract (1 g) was marcarated with 50 ml of distilled water and filtered. To the filtrate (1 ml). 4 ml of alkaline pirate solution was added. The mixture was boiled for 5 minutes and allowed to cool. The absorbance was read at 490 nm.

2.4. Gas chromatography-mass spectrometry analysis

The GC-MS analysis of the ethanol extract of *Microdesmis keayana* root was carried out using an Agilent 7890 GC system equipped with an Agilent 5977A Mass selective detector system (Chemetrix [Pty] Ltd., Agilent Technologies, DE, Germany) with a Zebron-5MS (cross-linked 5% - phenyl methyl polysiloxane) column (HP-5 fused silica 30 m x 0.320 mm x 0.250 µm film thickness). The instrument was operated at injection temperature (250˚C), ion source temperature (280˚C), and pressure (48.745 kpa). The carrier gas used was GC-grade helium (99.999% purity) at a flow rate of 36.262 cm/s, and about 1 µL sample injections was used. The oven temperature was initially started from 40˚C (held for 1 minute) and then ramped to 240˚C at 3˚C/minute.

2.4.1. Identification of Components

Identification of components was conducted using the National Institute of Standard and Technology library source. The mass spectrum of individual unknown compound was achieved by comparing their retention times with those of the known compound in the software database library.

2.5. Data analysis

The data obtained in chemical contents were analysed by one way ANOVA and values were regarded significant at $p < 0.05$. Results expressed as means and standard error of mean.

3. RESULTS

3.1. Phytochemical assay

In the present study; phytochemical components detected were analyzed quantitatively in the laboratory by the common methods using chemicals, and the result shown in Table 1. Alkaloids ($17.85^{a}\pm0.48$), flavonoids ($6.17^{c}\pm0.27$), saponins ($9.25^{b}\pm0.02$), tannins ($6.17^{c}\pm0.27$), steroids ($5.53^{c}\pm0.1$), phenols ($3.01^{d}\pm0.11$), and cardiac glycoside ($3.41^{d}\pm0.13$) were found in valuable quantity in the root extract of this plant (Table 1).

2.2. Gas chromatography-mass spectrometry analysis

From the GC-MS analysis of *Microdesmis keayana* roots, the spectral chromatogram (Figure 1), showed 14 peaks, revealing the presence of fourteen (14) compouds (phytochemical constituents) in the medicinal quality of the plant. Peak area,

retention time and molecular formula were used for the confirmation of phytochemical compounds. The active principles with their retention time (RT), molecular formula (MF), molecular weight (MW), chemical structure and peak area in percentage are presented. GC-MS analysis of ethanol extract of *Microdesmis keayana* roots revealed the existence of 1,2,3-Propanetriol, Octodecanoic acid, Tridecanoic acid, Hexadecanoic acid, 9,12-Octodecanoic -1-ol, 10-Octadecenoic acid, Docosanoic acid, 1,3-Propanediol, n-Decanoic acid, 1-Fluorodecane, Trans-Dodec-5-enal, 9-Tetradecenal, Pentadecanoic acid, and 13-Tetradecenal (Table 2). The peak report TIC (total ion chromatogram) of the fourteen (14) identified compounds by GC-MS analysis of *M. keayana* root is shown in Table 3.

Table 1.Preliminary quantitative phytochemical analysis of *M. keayana* root

Phytochemicals	**Composition (%)**
Saponins	9.25^{b}±0.02
Phenols	3.01^{d}±0.11
Alkaloids	17.85^{a}±0.48
Tannins	7.65^{c}±0.04
Flavonoids	6.17^{c}±0.27
Cardiac glycosides	3.41^{d}±0.13
Steroids	5.53^{c}±0.1

*Data expressed as mean ± SEM; means with different superscripts differs significantly
at $p < 0.05$.

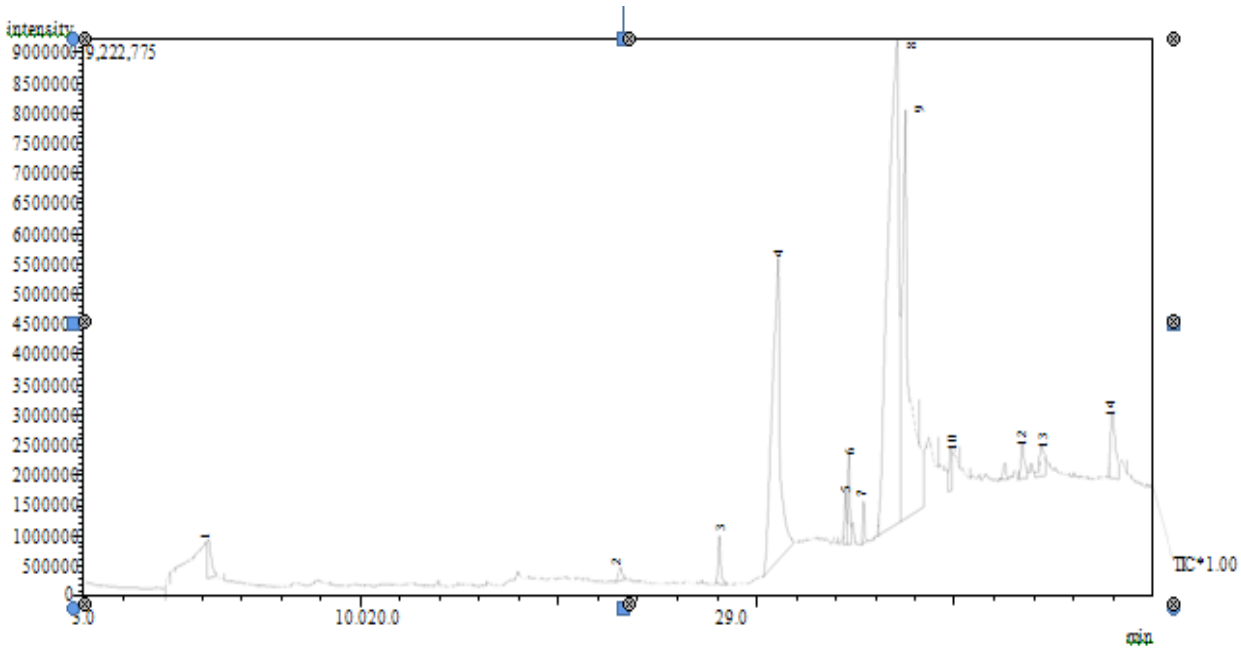
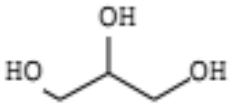
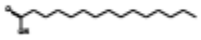
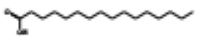
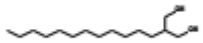
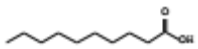
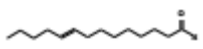


Figure 1. GC-MS spectral chromatogram of *Microdesmis keayana* root

Table 2.The major phytocompounds detected in the ethanol root extract of *Microdesmis keayana* by gas cromatography-mass spectrometry analysis

Sr. no.	Name of Compound	Molecular Formula	Molecular weight	Chemical structure	Bioactivity
1	1,2,3-Propanetriol	$C_3H_8O_3$	92		Antimicrobial (Alagammal *et al*., 2012)
2	Octadecanoic acid	$C_{18}H_{36}O_2$	284		Antioxidant (Baskaran *et al*., 2016)
3	Tridecanoic acid	$C_{14}H_{28}O2$	228		Antioxidant (Baskaran *et al*., 2016)
4	Hexadecanoic acid	$C_{16}H_{32}O_2$	256		Antimicrobial, and antioxidant (Rai *et al*., 2016)
5	9,12-Octodecanoic-1-ol	$C_{18}H_{34}O_2$	266		No activity reported
6	10-Octadecenoic acid	$C_{19}H_{36}O_2$	296		Antibacterial (Azhagumurugan and Rajan, 2014)
7	Docosanoic acid	$C_{23}H_{46}O_2$	354		No activity reported
8	1,3-Propanediol	$C_{15}H_{32}O_2$	244		Antibacterial (Baskaran *et al*., 2016)
9	n-Decanoic acid	$C_{10}H_{20}O_2$	174		No activity reported in literature
10	1-Fluorodecane	$C_{10}H_{21}F$	146		Antimicrobial (Baskaran *et al*., 2016)
11	Trans-Dodec-5-enal	$C_{12}H_{22}O$	182		Antipyretic, and Antioxidant (Rai *et al*., 2016)
12	9-Tetradecenal	$C_{14}H_{26}O$	210		No reported activity in literature

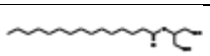
13	Pentadecanoic acid	$C_{18}H_{36}O_4$	316		Hypocholesterolemic (Baskaran *et al*., 2016)
14	13-Tetradecenal	$C_{14}H_{26}O$	210		No reported activity in literature

Table 3.Peak report TIC identified by GC-MS analysis of *M. keayana* root

Peaks	R.Time	I.Time	F.Time	Area	Area%	Height	Height%	A/H	Mark
1	6.076	6.050	6.258	4249356	1.20	655969	2.35	6.48	V
2	16.494	16.408	16.658	1499185	0.42	211585	0.76	7.09	
3	19.018	18.925	19.225	3813529	1.07	804415	2.88	4.74	S
4	20.519	20.133	20.908	71456333	20.11	5041697	18.03	14.17	
5	22.211	22.150	22.250	3030585	0.85	900460	3.22	3.37	V
6	22.302	22.250	22.358	5640404	1.59	1547529	5.53	3.65	V
7	22.673	22.600	22.767	2277975	0.64	712895	2.55	3.20	
8	23.523	22.967	23.608	155367724	43.72	8053710	28.80	19.29	
9	23.738	23.608	24.200	85746097	24.13	6808121	24.35	12.59	V
10	24.876	24.817	24.917	3442516	0.97	733749	2.62	4.69	V
11	26.254	26.108	26.333	1623654	0.46	283781	1.01	5.72	
12	26.696	26.583	26.833	3575456	1.01	592333	2.12	6.04	
13	27.178	27.008	27.275	3850536	1.08	507870	1.82	7.58	V
14	28.968	28.825	29.142	9796705	2.76	1106121	3.96	8.86	
				355370055	100.00	27960235	100.00		

4. DISCUSSION

The medicinal values of plants, *Microdesmis keayana* for instance, lies in the bioactive phytochemical constituents that are non-nutritive chemicals that produce definite physiological effects on human body and protect them from various diseases. Plants defend themselves from pathogens and other herbivorous enemies by elaborating a variety of bioactive secondary metabolites that may have multiple molecular sites of action. Accordingly, exploitation of these useful plants has spread rapidly to safeguard increasing population from various pathogens and ailments. Phytochemical screening can help to reveal the chemical constituents of the plant extract and the one that predominates over the others. It may also be used to search for bioactive agents for starting products used in the partial synthesis of some useful drugs (Evans, 2002). The quantitative phytochemical screening of the plant root ethanol extract showed the detection of major metabolites (saponins, alkaloids, phenols, flavonoids, tannins, steroids and cardiac glycosides) that were reported to be useful phyto-therapeutically. The phytochemical analysis conducted in this study, reveals quantifiable concentrations of alkaloids ($17.85^{a}\pm0.48$), flavonoids ($6.17^{c}\pm0.27$), saponins ($9.25^{b}\pm0.02$), tannins ($6.17^{c}\pm0.27$), steroids ($5.53^{c}\pm0.1$), phenols ($3.01^{d}\pm0.11$), and cardiac glycoside ($3.41^{d}\pm0.13$) (Table 1). Other phytoconstituents of biochemically active compounds in *M. keayana* roots have been reported, these include 1,2,3-Propanetriol, Octodecanoic acid, Tridecanoic acid, Hexadecanoic acid, 9,12-Octodecanoic -1-ol, 10-Octadecenoic acid, Docosanoic acid, 1,3-Propanediol, n-Decanoic acid, 1-Fluorodecane, Trans-Dodec-5-enal, 9-Tetradecenal, Pentadecanoic acid, and 13-Tetradecenal (Table 2). Several phytochemicals have been implicated in enhancing sexual functions in male rats, and so many bioactivities. For example, saponins in *Fadogia agrestis* and *Tribulus terrestris* as well as alkaloids in *Pausinystalia yohimbe* and *Microdesmis kearyana* have been shown to be responsible for aphrodisiac activity (Ernst and Pittler, 1998; Gauthaman *et al*., 2002; Yakubu *et al*., 2005 and Zamble *et al*., 2008).

Plants have been used for therapeutic, religious, cosmetic, nutritional, and beautification purposes since ancient times and humanity of all civilization are familiar with their usage. Herbs have been used prevalently as home remedies to treat diseases like diabetes, cough, cold, arthritis, stomachache etc., in several countries of Asia, Africa, Europe, and beyond. They contain phytochemicals that possess beneficial effects in health maintenance, management of diseases, and alleviating the harmful effects of toxic substances.

This study was designed to investigate and document the bioactive compounds present in the root of *Microdesmis keayana* for scientific validation of its phytotherapeutic agent as claimed in the folkloric medicine. Plants are the richest sources of secondary metabolites with varying biological activities. These secondary metabolites are the important source with variety of structural arrangements and properties (Kumari *et al*., 2016). Metabolite profiling in plant species was done by gas chromatography-mass spectrometry method for last few years. But only a limited number of plant research laboratories have gas chromatography-mass spectrometry. The identified compounds exhibits many biological properties (Table 2). GC-MS

analysis of phytoconstituents in plants gives a clear picture of the pharmaceutical value of that plant. Thus, this type of GC-MS analysis is the first step towards understanding the nature of medicinal properties in this medicinal plant, and type of study will be helpful for further detailed study. Further investigation is needed to identify the pharmacological importance and phytochemistry of *Microdesmis keayana*.

The available literature supports that the identified compounds (secondary metabolites) of *Microdesmis keayana* root possess several biological activities like antimicrobial (Alagammal *et al*., 2012), antioxidant (Baskaran *et al*., 2016; Rai *et al*., 2016), antibacterial (Azhagumurugan and Rajan, 2014), antipyretic (Rai *et al*., 2016), and hypocholesterolemic activities (Baskaran *et al*., 2016). Owing to the biological activities of the plant-derived metabolites, as observed in the ethanol extract of *Microdesmis keayana* root, many source material of plant origin have becomes field of great scientific interest, and further study of these phytoconstituents may prove the medicinal importance in future.

GC-MS is the best techniques to identify the constituents of volatile matter, long chain, branched chain hydrocarbons, alcohols acids, esters, etc. Mass spectrometry becomes a vital tool in the hands of the organic chemists and biochemists because of its potential to supply the definitive, qualitative and quantitative information on molecules based on their structural compositions. Gas chromatography attached to a Mass Spectrometer (GC-MS) enables mixture of small molecules mainly organic compounds of low molecular weight (<600) which can be analysed (Thomas *et al*., 2013; Salido *et al*., 2016). Recently GC-MS analysis is increasingly applied for the analysis of medicinal plants and this technique prove to be a valuable method for the analysis of non-polar components and volatile essential oil, fatty acids, lipids and alkaloids (Xie et al., 2013). Plants produce diverse phytochemicals known as secondary metabolites. It is well known that plants produce these metabolites to protect themselves from pathogenic attacks. The structures of the various phytochemicals which contribute to the medicinal activity of the ethanol extract of *Microdesmis keayana* root are shown in Table 2. The findings from the study were found to be rich and confirm the therapeutic application of this botanical.

5. CONCLUSION AND RECOMMENDATION

The present study reveals useful information about phytochemicals and phytocompounds contained in the root extract of *M. keayana*. From the results, it was found that the detected phytochemicals possessed valuable concentrations, and it can be deduced that medicinal plants are natural reservoirs of several phytonutrients and compounds which are inevitable and essential to life in general. The phytochemical constituents of ethanol extract of *Microdesmis keayana* root revealed by quantitative screening and gas chromatography-mass spectrometry analyses depicts their importance in folklore and phytopharmaceutical. Therefore, further studies should be

carried out on the extensive and detailed bioactivity of the identified phytocompounds coupled with safety in effecting healing.

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Impact of COVID-19 on Democratic Election and Development of Ethiopia

Sileshi Fentahun Alem

ABSTRACT

The purpose of this paper is to address the major impacts of the COVID-19 pandemic on the sixth general election and democratic development of Ethiopia. The data were drawn from pertinent publications as well as official websites of organizations and synthesized in thematic content analysis. As a major finding, COVID-19 less impacted the overall election process and credibility. Yet, restrictions on major democratic rights, such as freedom of movement and assembly; court system closure; and women's and children's domestic violence were severe impacts of COVID-19 during the lockdown period. Moreover, in human capital development, about 26 million children, 77% of whom are primary school students are affected by school closures; and 1.6–2.4million jobs were lost. Thus, the paper concluded that, though radical opponent political parties understated the credibility of the election by stating election postponement as the main argument, Ethiopia held a relatively democratic election after passing a decision of election postponement owing to the pandemic. So far, human capital and the infant economy were severely impacted by the pandemic, since the vast attention of the government was relied upon on COVID-19 response measures. Thus, to cope with an unforeseen crisis like COVID-19, the government should work on technological advancement to easily handle periodic elections, education, health and economic systems.

Keywords: COVID-19, Democratic Election, Election Postponement, Development

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1. INTRODUCTION

The outbreak and spread of COVID-19 impacted democratic election of Countries. General elections and referendums in 2020 were placed in a high dilemma on holding or postponing periodic elections by fear of technical difficulties, low voter turnout and legitimacy concerns (Lindsay, 2020). Besides, about 70 countries and districts postponed predetermined election schedules between February 21 and August 31, 2020 (Asplund, 2020).

COVID-19 was emerged in Ethiopia when the country was under political cross-roads and the ruling Prosperity Party made efforts to reconfigure the ethnic based Ethiopian Revolutionary Democratic Front (EPRDF). The sixth general election came into dilemma after the first case was recorded on 13 March 2020.

Socio-economic development of Ethiopia was also victimized by the pandemic. About $1.64 billion was shifted for COVID-19 multi-sector response. Whereas, National Election Board of Ethiopia (NEBE) requested 1.1 billion ETB ($30 million) extra budgets from the country's insufficient budget (Abdu, 2021). The health, education and public sectors were also challenged by the pandemic.

Thus, this paper aims to discuss the impact of COVID-19 on the democratic election and development of Ethiopia. It is expected to contribute to the efforts of democratization and governance system of the country by discussing the major issues of democratic election, human capital development and economic governance of the country along with the pandemic impacts. Therefore, the paper is expected to critically synthesize the main arguments in the area and provide apparent answers to the following questions. What is the impact of COVID-19 on the sixth general election of Ethiopia? How COVID-19 impacts the democratic development of Ethiopia?

2. MATERIALS AND METHODS

Secondary data were drawn from published journal articles, reports and newspapers from pertinent websites. Official websites of the national and international organizations were also used as sources of evidence. The data was qualitatively synthesized using a thematic content analysis approach based on the major themes of impacts of COVID-19 on democratic election and the democratic development of Ethiopia.

3. RESULTS AND DISCUSSION

3.1 Impacts on Democratic Election

3.1.1 Overview of Election and COVID-19 in Ethiopia

After EPRDF took the political thorn, Ethiopia held five less uncompetitive general elections in 1995, 2000, 2005, 2010 and 2015. It resulted in three years of public protests, which began immediately after the 2015 election. Almost close to thirty years, Ethiopia has been under electoral authoritarianism through ethnic-based political parties. To change this worst scenario, the so-called reformist government led by Abiy Ahmed tried to open up political and civic space which was salivated Ethiopians to hold their first democratic election. The sixth general election for the Federal Parliament and State Councils, considered as a litmus test for the ruling Posterity Party. Later, it was held on June 21, 2021, after twice postponement owing to the outbreak of COVID-19, political and logistic troubles (Zemelak, Yonatan, Beza, & Berihun, 2021).

- **Efforts of NEBE to Held Election Amid the Pandemic**

After intense institutional reform, the board made election assessments and forwarded three assumptions about its potential impact on the election. Primarily, COVID-19 might increase social tension and economic hardship, which could boost the risk of electoral violence; subsequently it would necessitate the use of new measures and standards as part of election operations. Finally, fear of it might impact the level of participation of citizens. Likewise, infrastructures of on-line voter registration, postal

voting, electronic voting etc. were unavailable (National Election Board of Ethiopia (NEBE), 2020)

Consequently, NEBE put two scenarios as electoral response measures to the pandemic. In scenario one, the board must hold elections without implementing special measures; at the second scenario, COVID-19 would continue to be present and NEBE would organize elections under restrictions. In both scenarios' election activities, time and budget would be impacted. In scenario one, the total additional budget needed to organize elections was 139,349,918 ETB ($4,098,527) with 10 months required for preparations. Conversely, conducting election under the second scenario would require an additional budget of 2,512,926,536 ETB ($73, 909,604) and a total of 13 months. The assessment contributes to evidence based decision-making to the government regarding with the fate of the election.

3.1.2 Election Postponement: a Debatable Political Agenda

The outbreak of COVID-19 hampered democratic election events across the globe. It created dilemmas for state authorities by which both holding and postponing elections. Postponing, might perceive the government as continued oppressively; while holding elections could undermine electoral legitimacy.

Holding an election during the pandemic faced technical glitches, low voters turnout and legitimacy challenges. Dominican Republic & North Macedonia faced low voter turnout. In Poland 2020 presidential election, mail-in voting results delays in receiving ballots. Yet, release of misinformation by unsuccessful parties about the virus affects election credibility (Lindsay, 2020).

Postponing elections also caused reputational, political, financial and legal risks. Postponing without immediately putting the new election date worsens the democratic process. For instance, Election in Chad had been postponed five times since 2015 and again postponed due to the COVID-19 outbreak. Somalia has not

conducted a direct popular vote since 1969 and the pandemic also affects the wish of Somalia's democratic election (Asplund, 2020).

In the case of Ethiopia, COVID-19 emerged when the country was under political turning point. After three years public protest, Abiy came in to power in 2018 and made a political reform on electoral Board and promised to undertake credible election (Ayele, 2021). However, NEBE declared suspension long-awaited August 2020 general election postponement with prime rationale of public health risk of COVID-19.

Election postponement posed a constitutional dilemma, since the Constitution does not provide clear direction on how to exercise authority after postponement once the term of the current Parliament is completed in early October 2020. On April 30, 2020, the parliaments endorsed the resolution of rescheduling the sixth general election and hold the elections 9 to 12 months after health authorities determine it is safe. In the meantime, Parliament, State Councils, Federal and State executives continued governing the country (Zemelak, Yonatan, Beza, & Berihun, 2021).

Ethiopian lawyers and politicians across the globe were invited and debated on the legitimacy of the current government beyond its constitutionally specified term. Here, Constitutional Commission of Inquiry (CCI) proposed four exit mechanisms including caretaker government, declaration of state of emergency (SoE), constitutional amendment, and constitutional interpretation. Professionals made intense discussion and came up with their justification, which is the first time in Ethiopia's history. After intense discussions, the parliament decided on interpretation of the Constitution interpretation option (Mengie, 2021). However, the decision is yet the slightest tricky response to the crisis at hand, given the limitations of the other possible exit mechanisms which polarized politics in the country.

- **Pros and Cons of Election Postponement and Constitutional Interpretation**

There were intense arguments on election postponement, constitutional interpretation and legitimacy of the government. The main opposition parties widely accepted the emergency order and advised the government to stop the spread of the virus by warning the government do not use the emergency decree for repression (International Crisis Group, 2020).

As proponents of Election postponement argued, it gave an opportunity for the government to strengthen multi-party democracy and national solidarity. It also prevented smaller parties from election campaign challenges under COVID-19 restrictions. Civil Society Organizations (CSOs) able to reach greater number of voters (IRI and NDI, 2021). Thus, postponing elections can be a reasonable option for democracy advancement in Ethiopia.

On the reverse, some political parties believed election postponement was driven by the ruling party by the fear of losing voice in the vote and have more time to suppress opposition activities (Østebø, Terje, & Kjetil, 2021). Specially, Tigray Regional State opposed indefinite election postponement and illegitimacy of executive and legislative branches of the government. Later unilateral regional electoral commission was established and held a regional vote on September 2020; even if the House of Federation rejected election results as no legal effect (Mengie, 2021; IRI and NDI, 2021). Afterward the election, the Federal Government imposed sanctions of withholding Federal grants and personal protective equipment. It seems how public health was used as an instrument for power struggling among politicians.

3.1.3 Implications on Election Credibility

The sixth general election can be evaluated its credibility in line with effects of COVID-19.

3.1.3.1 Implications on Electoral Observers Engagement

Owing to the pandemic travel restrictions and security issues, international election observers' like the Limited Election Observation Mission for Ethiopia could not

physically deploy observers on the Election Day and forced to engage in remote observation by using regional experts from Ethiopia (IRI and NDI, 2021). However, NEBE filled the gap by CSOs where the largest independent citizen observer effort made by CSOs Coalition which deployed 3,000 observers from 175 CSOs and cover about 10% of the polling stations. Besides, NEBE accredited 169 CSOs for voter education and 46 local CSOs to observe the election with deployment of 44,560 Election Day (National Election Board of Ethiopia, 2021). It was taken as a major success since the general election was inclusive of the actors of democracy.

3.1.3.2 Implications of COVID-19 on Election Process and Results

The impacts of the pandemic on election can be discussed at various election stages.

Candidate Registration: To conduct COVID-19 friendly candidate registration, NEBE tried to improve the law of signature submission process; and parliamentary candidates were not required to collect signature. Candidate registration time originally scheduled from February 15 to 28 was extended to March 4 on the appeal of the political parties. When the registration began, 9,505 candidates from 46 political parties were registered in 674 constituency offices across the country (IRI and NDI, 2021). The chairwoman of the board also assured the registration process was successful (National Election Board of Ethiopia, 2021). Thus, measures taken by the NEBE reduced the impacts of COVID-19; and almost no appeal was indexed on the impact of the pandemic on the registration process.

Voters Education: The activities of CSOs mostly concentrated in Addis Ababa and large urban centers. Voter's face to face education meetings were limited to 50 individuals per session, caused by the pandemic protective measures. Voter education via radio and TV were relatively few due to its high cost (IRI and NDI, 2021). Hence, the pandemic hampered one of the activities of the electoral process.

Election Results: Election Day was largely peaceful, with the only limited adherence to COVID-19 protocols for public safety. Official statements of Chairwoman of the

Electoral Board as well as the Africa Union Election observation preliminary reports assured that overall pre-election and Election Day processes were credible except for some logistic, security, and COVID-19 protocol challenges (Africa Union , 2021). However, Chatham House (2021) criticized the credibility of the election as imperfect, and does not fortify Ethiopia's transition, since 18% of House of Peoples Representative seats in the parliament are not included in the first round of voting due to COVID-19 election postponement driven` conflicts in Tigray.

Voters Turnout: NEBE planned to engage 50 million voters, establish 50,000 polling stations and dispatch 250,000 election officials. However, 38,234,910 (76.469%) voters were registered, 40,365 (80.73%) polling stations opened and 152,700 (61.08%) officials were deployed (National Election Board of Ethiopia, 2021). Budget shift to protective measures and inconsistencies put as a reason for the pitiable achievement of each target. But the board estimated voter turnout was high (90%). Thus, since the election was carried out under pandemic and security problems, it is possible to argue that it was relatively credible.

3.2 Impacts on Democratic Development

3.2.1 Impacts on Human Capital Development

COVID-19 adversely impacted the governance of human capital with respect to the health of citizens and educational advancement. Conversely, the pandemic had silver lings for digital technology and research opportunity.

Impacts on Health: Poor health care service created fertile ground for the spread of COVID-19. The health system could not cope with a large-scale crisis; it's promptness to deliver routine health services was rated at 55% of the requirements in 2018 (EPHI, 2018). In 2016, only 2 % of clinics had oxygen delivery devices, and which would be hard for COVID-19 chronic treatments. Besides, Ethiopia has a meager health care workforce with a population density of around 0.96/1000, which is 5 times below the minimum threshold of 4.45 per 1000 set by the WHO (Africa

Union , 2021). Until 17 September 2020, 1,311 health care workers were infected by the pandemic (Alemu, 2021). Thus, for Ethiopia having a limited number of health services and professionals, the impact of the pandemic is too serious.

COVID-19 also impacted psychological health of citizens. The disruption of social institutions which is unique features for Ethiopians, such as *edir*, *ekub*, *mahiber*, mourning, wedding and worship led to social crisis of depression and anxiety (Girma, 2020). Reproductive health services, especially pregnant women, were challenged to get prenatal health care services owing to the priorities of medical resources to prevent the pandemic (UN Women Ethiopia, 2020). Besides, gender based violence including rape and domestic violence were raised by about 25% during the lockdown period.

Health cannot be separated from political issues, whether in a pandemic or not. In Amhara, Oromia and Tigray Regional States, the government's COVID-19 response was subject to politicization and securitization (Østebø, Terje, & Kjetil, 2021). As the political opposition increased, the government authorities and the public paid less attention to the pandemic mitigating protocols.

Impacts on Education: COVID-19 resulted in school closures across the world; and about 89% of the world's student population had been disrupted. Schools in Ethiopia were shut down on 16 March 2020 and affected about 26 million children (77% of whom are primary school pupils). Poor technological infrastructure and design of the education system magnify the problem, mainly for those children live in rural areas (UNDP, 2020). It also created risks of abuse like early marriage and child labor. The table below illustrates the number of children influenced by the pandemic.

Table 1. The number of children affected by the pandemic crisis

Level	Male	Female	Total

Pre-primary	1,676,156	1,546,097	3,222,252
Primary	10,654,351	9,392,006	20,046,357
Secondary	1,526,653	1,293,482	2,820,135
Grand Total	13,857,160	12,231,585	26,088,744

Source: Extracted from UNDP (2020).

School closures also resulted in a cut in school feeding programs and affected children's nutritional status. It is estimated that in Addis Ababa, approximately 560,000 primary school students no longer receive their meals due to the pandemic.

Impacts on Governance system: The government took the exceptional step of instituting remote working for Federal and Regional institutions. For instance, in Prime Minister Office and in Ministry of Education 64% of employees out of 289; 87% of employees out of 1544 were forced to work at home respectively (UNDP, 2020). The shifts to remote working raises a major challenge of ensuring effective service delivery in a situation when there are no standard operational procedures and protocols for this type and scale of operation.

Imperative Silver Linings of COVID-19: People benefited from its difficulty; created research opportunities, technological transformation, reading culture and family discussion time (Girma, 2020). Scientific journals welcomed researchers to do more on COVID-19. It also restricts physical contact and gives the chance for digital technologies of video-conferencing and telemedicine. Reading culture chiefly literate people got a chance to read more. Most families get the chance for discussion time with their families and able to know the behavior of their children and intervention mechanisms.

3.2.2 Impacts on Economic Development

3.2.2.1 Escalated Electoral Cost

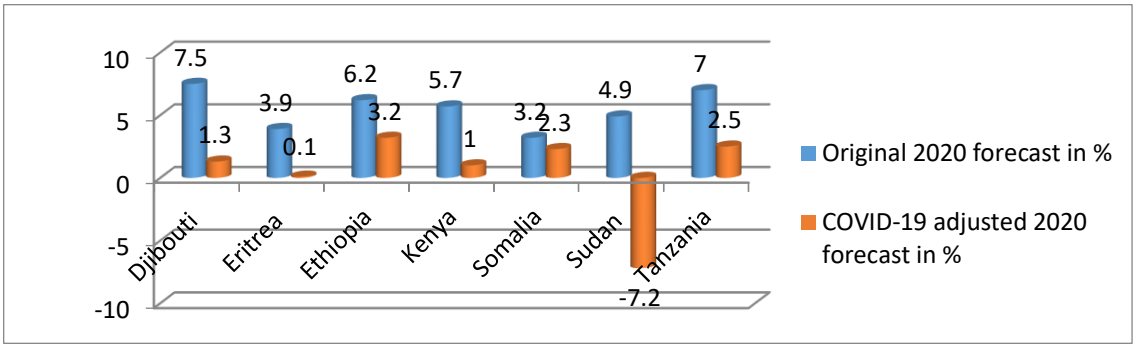
The emergence of the pandemic pushed the election process and needed to mobilize additional resources to combat its spread. Countries carried out elections amid the pandemic financed additional budget for safety procedures. South Korea's April elections cost an extra $16 million; Indonesia and Ukraine, have also budgeted tens of millions of additional dollars for protective measures (Lindsay, 2020). In Ethiopia, before the pandemic strike, NEBE demanded the House of Peoples Representatives 3.7 billion ETB and approved only 2.5 billion ETB. However, after the postponement of the elections, the Board demanded additional 1.1 billion ETB (0.23% of the country's budget for 2020/2021) budget to manage the election process (Abdu, 2021). It shows that how the pandemic created a budget burden on the poor economy of Ethiopia.

3.2.2.2 Holing Back Economic Efficiency

Economic growth of countries was challenged by the pandemic. Agricultural exporter countries like Ethiopia and Kenya affected by COVID-19. Besides, compared with the 2020 growth scenario in Africa, between 5 and 29 million people have been pushed below the $1.90 per day extreme poverty line. In developing countries, extreme poverty rose to 35% (UNCTAD, 2020). In Ethiopia in 2020/21, 31 million people were estimated to live below the poverty line as compared with 2019/2020 of 26 million people (Alemayehou, 2020).

In East Africa, the growth forecast of the IMF and World Bank indicated that all countries in the table below experienced slowdown GDP growth in 2020. Ethiopia's GDP fall from 6.20% of original 2020 forecast to 3.20% COVID-19 adjusted forecast.

Figure 1 Adjusted growth forecasts in East Africa with COVID-19



Source: (Africa Union , 2020) adopted from IMF & World Bank

Likewise, in Ethiopia, $1.6 billion (1.6 % of GDP) was required for pandemic response and an extra $3 billion needed to reverse its effect at the end of 2020 (The Africa Report, 2020). It also victimized the labor market where 10% to 15% lost of employment (1.6-2.4 million jobs) mostly temporary and unskilled labor in urban areas (UNDP, 2020). The hospitality sector accounts for 8% of the total employment also collapsed by travel bans.

The impact of the COVID-19 seemed broader than the health impacts. It created three critical economic hurdles, the burden of external and domestic debt (30% and 27% of GDP respectively), foreign currency misery and slowdown in remittances. Besides, Ethiopian Airlines, the biggest foreign exchange company contributed over 5% of Ethiopian GDP in 2019 lost over $550 million revenue between January and April 2020 (Alemayehou, 2020). Thus, the government forced to adjust fiscal and monetary policies and supported the business sector with VAT refunds to businesses. National Bank of Ethiopia also accessed 15 billion ETB liquidity facilities for private banks to support businesses, tax debt forgiveness for 3,099 taxpayers as well as for all dues up to Ethiopian Fiscal Year 2014-15 and tax exemption for importation of products. Thus, the pandemic challenged the infant economy of Ethiopia.

4. CONCLUSION AND RECOMMENDATION

After the alleged reformist government took the political thorn, Ethiopians were salivated to carry out the sixth general democratic election. Yet, the election was

officially postponed owing to the chief rationale of COVID-19 Outbreak; which later contributed to discrepancy among opponent political parties and the ruling party. However, the inclusive participation of high skilled legal experts at the consultation session on the outlet of legitimacy problems created a new democratic culture in the country. Besides, postponement allowed enough time for preparation for NEBE, political parties and increased democratic engagement of CSOs. Thus, it is feasible to argue and conclude that the outbreak of COVID-19 less impacted democratic election since election postponement was made by taking expert advises from Ministry of Health, Ethiopian Public Health Institute and NEBE.

However, human capital development and economic governance were negatively impacted. The economic sector was sluggish down due to the COVID-19 outbreak, lockdown, restrictions and response measures. Thus, the government should work to advance technology based institutional capacity buildings on democratic, public and economic institutions. Specific initiatives like online voter education, election campaign, online voter registration and voting, video-conferencing; online education, telemedicine, e-commerce and related technologies shall be taken into consideration to cope up unforeseen crisis like COVID-19.

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Remodeling Job Creation and urban employment Policy: Unemployment factors, Hardship, Coping and self employment scenario in Ethiopian Urban Centers

Efa Tadesse Debele

ABSTRACT

Urban unemployment scenario has been attracting attention of policy makers and researchers. Unemployment is considered as critical social problem which signifies the attention so far given to its remedial measures is inadequate. This paper aims to compensate research gap and practical possible intervention that more likely address the problem if it is properly investigated and implemented accordingly. Researcher set main objectives that more probably answer questions associate with urban unemployment patterns. In view of those major factors of unemployment, hardship that unemployed face, coping strategies unemployed use and scenario of self employment in urban centers were adequately emphasized. Data of this research was taken from central statistics agency of Ethiopia and the data was tested that it has been proven suitable for statistical analysis. This study is the summary of detailed analysis that done before by researcher. Researcher aimed to produce concise concept note and empirical finding summary.

Keywords: Unemployment, factors, hardship, coping, self-employment.

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1. INTRODUCTION

Unemployment rate is the number of persons who are unemployed as a percent of the total number of employed and unemployed persons (i.e., the labour force) (Bolton, 2016). Amenu et al. (2019) affirmed that unemployment is the most challenging economic problem facing the government. Fitsum (2014) states that the phenomenon of unemployment is one of the major social problems of most urban centers of Ethiopia. Muhdin (2016) shows that unemployment rate varies among regions, sex, marital status and education level.

Despite articulating problematical aspects of unemployment (Fitsum, 2014; Muhdin, 2016), fundamental causes of unemployment were not well known. But Amenu et al. (2019) identified region, sex, marital status and educational status as major estimators of unemployment. Furthermore, among estimators of unemployment female category was proved to be significant predictor of urban unemployment (Bicakova, 2010). Literacy status and self employment as well as unemployment scenario has been significantly associated (Poschke, 2018). Yet challenges behind employment or structural factors were not emphasized.

Marital status make a difference between married and unmarried in terms of accessing job and suffering from negative sides of unemployment ((Earle et al, 2000;Broussard et al., 2012; Ayres, 2013;Meer, 2014; Amenu et al., 2019). The finding of this study indicates that some individuals are more likely multiply disadvantaged in urban unemployment situation when compared to their counterpart.

In addition to structural unemployment, self unemployment contributes its own significant role for prevalence of unemployment rate. Many factors assumed to impact scenario of urban self unemployment. More importantly financial shortage, lack of work place, unfair opportunities and poverty related problem are major factors hinder development of self employment (Earle et al., 2000; Muhdin, 2016; John et al., 2006; Debele, 2019, pp. 259). Gender factors and literacy status more importantly influence extent of urban unemployment (Vipond, 1984; Bakare, 2011; Bolton, 2016; Debele, 2018; Tombolotutu et al., 2018; Amenu et al., 2019).

Structural unemployment rate is closely associated with unavailability of job opportunity and insufficient vacancy but high number of job seekers ((Debele, 2017; Poschke, 2018). Rampant joblessness exposes victim to many challenges and sufferings. Major challenges which more likely affect normal life of unemployed persons are wandering for vacancies and absence of safe work (Shita et al., 2018).

Unemployed persons deal effectively with unemployment difficulties in different ways. The major single factor that widely unemployed persons deal with difficulties associates with unemployment is family support (Lorenzini et al., 2010). Finding

confirms that unemployed persons suffer a lot by being without job which reinforces them to engage in different survival strategies.

1.1.Why of this Study: Statement of the Problem

Urban unemployment patterns were not well substantiated. Self employment constraints were not well identified implying that self unemployment factors need to be assessed. Other employment barriers were not studied suggesting that structural unemployment factors are important to be investigated well. So far studies did not examine coping mechanisms of unemployed persons. Estimators of self employment trend not indicated.

1.2.Substantive Focuses of this Research were:

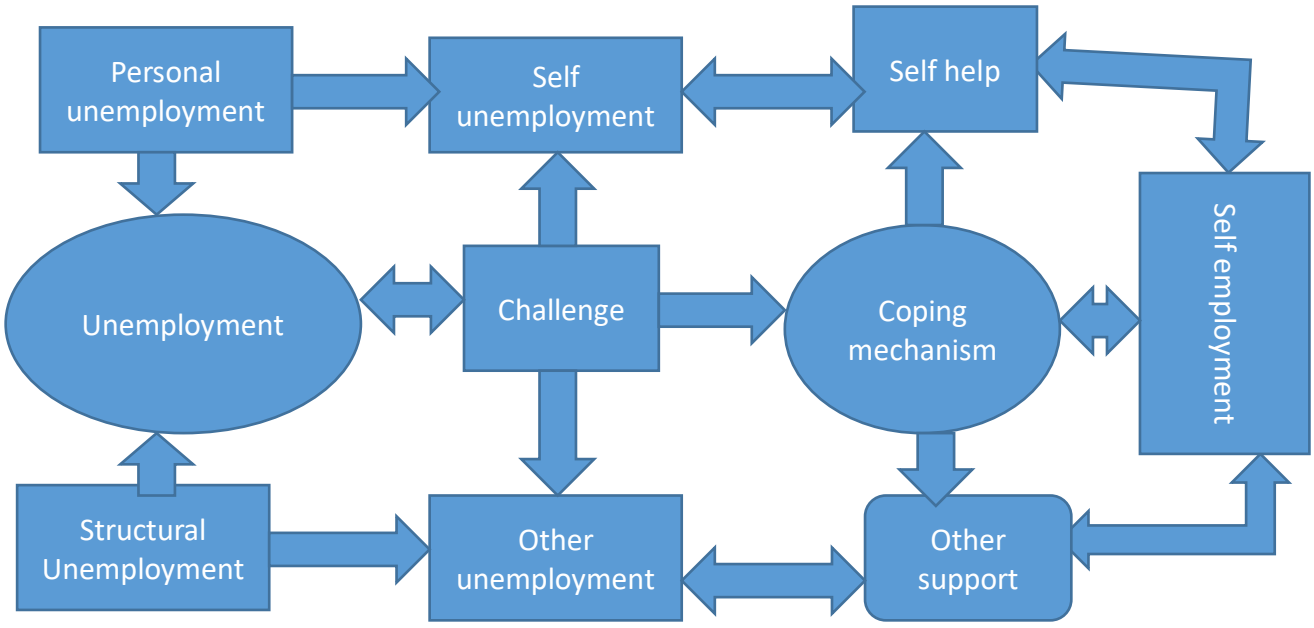
To describe the overall socio-demographic characteristics of respondents

To identify factors associated with self employment and structural employment

To examine challenges and coping mechanisms related to urban unemployment

To analyze patterns of variables associated with urban unemployment

1.3.Analytical framework



1.4.Conceptual Framework

The term unemployment refers to a situation when a person who is actively searching for employment is unable to find work. Unemployment is a term referring to individuals who are employable and actively seeking a job but is unable to find a job. The condition of one who is capable of working, actively seeking work, but unable to

find any work. Unemployed means not having a paid job not being employed. A person who's described as unemployed is typically out of work and looking for a job. Unemployment occurs when someone is able to work and wants to work but is unable to find employment. Unemployment occurs when someone is willing and able to work but does not have a paid job. In short, unemployment=willing +employability+jobless.

1.5.Operationalisation of Key Variables

Personal unemployment dynamics: Gender, educational status and Marital Status. Gender (Males and females) with nominal measurement scale. Educational status was measured by illiterate and literate category which is nominal variable. Another important variable is marital status which can be categorized into married, never married, divorced, widower and widowed that is nominal measurement scale. Major self unemployment factors includes shortage of finance, lack of working place and finance, problem of working place/land, lack of training, Absence /shortage of equipment, lack of finance and training, lack of information, lack of support from family, lack of license, etc. Moreover, major structural unemployment factors include lack of job opportunity, lack of training, lack of experience, absence of field related work, absence of vacancy advertisement, slack period, absence of satisfied work, off season, language barrier, inconvenient working time, low payment/salary, working at distant place, place of work, new working system, etc.

Furthermore, critical challenges that unemployed persons face because of unemployment are discussed as follows. The first and foremost important hardship is income shortage where lack of money and decrease of household asset is common. Shortage of personal income aggravates inability to cover household expense or food insecurity. Unemployed persons suffer from hopelessness and stress as a result of wandering for job without significant attainment. Some unemployed persons face hardship of incapacity to send children to school or affordability problem of covering school expense. The most tragic aspect of unemployment hardship is that it exposes unemployed to different addictions. Moreover, it was found that hunger and lack of clothing is critical hardship of unemployment. It was affirmed that hopelessness and stress are critical aspects of unemployment which in turn leads to isolation from social participation and family dissolution.

Moreover, Researcher identified major coping mechanisms most often associates with difficulties of unemployment. There are two coping strategies that were widely practiced among residents. The first coping mechanism is self help coping mechanisms such as casual work, saving, begging, etc. The second major coping mechanisms that unemployed used to overcome hardship are family support, remittance, support from relatives and friends.

2. Methodology

Prior to deal with substantive aspects of the problem researcher is expected to introduce philosophical foundation of the methodology that essentially supposed to address the problem. Primarily, ontological position of researcher needs clarification. Ontological assumption of the researcher on problem of urban unemployment is causal reality. Causal reality ontologist assumes reality as natural phenomenon. In view of that it concerns about what happen, why happen and is it predictable if the intervention apply? After the question of nature of reality is answered the next question associates with epistemological orientation. Philosophical speaking, epistemology deals with how we know what we know. In this particular topic of the study researcher holds the position of objectivist, empiricist and positivist. These epistemological positions are relevant in this particular research problem. In addition to the above epistemological positions, researcher planned to scaffold the problem under discussion by intersectional approach model.

The methodology of this study deals with organized procedures and techniques that are assumed to accomplish research objectives. Systematization of pillar methods in this study is well structured and designed. The designing of the study all in all quantitatively framed and ordered from its start to its end. This study used survey design which was done by relevant statistical agency for compiling population profile. Researcher extracted this quantitatively collected data from the mentioned agency. In sociological research and other social sciences using available information is common since earlier.

Data was extracted and retrieved from statistical agency in 2018. Researcher selectively extracts important and suitable type of data. Indeed, the then type of data was categorical variables which are nominal and ordinal measurement scales. In course of data analysis researcher employs SPSS version 20 software. Accordingly, descriptive and inferential statistics were major type of statistical analysis.

In this research, conducting the study defensibility is well maintained. More importantly, anonymity of researched and confidentiality of responses well protected. Utilitarian, vulnerable population and practical social problem models were guiding ethical principles of the research. Approved letter was received from AAU. Furthermore, researcher assured consent from CSA.

3. Results and Discussions

Socio-demographic characteristics of respondents were clearly identified. Finding indicates that 46.9% of respondents were males whereas 53.1% of respondents were females. Finding indicates that females are predominantly share larger proportion of urban unemployment rate. This sex ratio difference may suggest that females have either more adaptive capacity in urban life or are reflective of aggregate population sex ratio.

Literacy characteristics of respondents were descriptively analyzed and result shows that 72.3% of respondents were educated whereas 16.2% of respondents were illiterate. Finding indicates that urban unemployment is outweighed by literate group. This may implies that illiterate group is more likely employed whereas literate is less likely employed. This may imply that untrained occupied informal and minor activities. Cultural jobs are given status of hierarchies which associates with respects and privileges. In fact, it was mentioned that the nature of problem understudy was taken for granted which is also true for job status. Culturally people associate any job with certain characteristics or status. A major urban social problem is unemployment which differs by literacy rate.

One aspect of urban unemployment is self unemployment problem. Researcher examined factors that hinder job seekers not to enter employment condition. Respondents stated that they have several constraints to start their own business. Majority of respondents (54.81%) agreed that shortage of finance is critical hurdle to start business. Next to shortage finance, 14.91% of respondents stated that lack of work place or land is their critical problem. The finding indicates that at national level finance shortage and lack of workplace are basic barriers of majority of unemployed persons which hinder them not to start their own business. In addition to the above major constraints, there are minor hindering factors such as training, lack of license, shortage of equipment, lack of information and lack of support from family. Researcher indicated that unless these constraining factors eradicated and intervention is taken promoting self employment is impractical.

3.1.Hardship of Unemployment

Finding indicates that unemployed persons face multiply difficulties associates with urban living costs and related unemployment problems. It was found that 43.52% of respondents reported that their critical hardship of unemployment is associated with decreased household asset and personal income. Moreover, 21.23% of respondents affirmed that their difficulty is associated with inability to cover household expense. Furthermore, respondents stated that inability to send their children to school; family dissolution, getting stress, hopelessness, exposed to different addictions, hunger and lack of clothing, isolated from social participation, wandering for jobs, etc are main challenges that unemployed persons are suffered from.

3.2.Coping Strategies of unemployed people

Finding indicates that majority of respondents (84.73%) reported that family support is their principal coping mechanism they rely on to sustain their livelihood. The second most important self help coping mechanism is casual work (2.5%). Respondents seemed to think that their coping ability is largely dependent on the support of family whereas self help challenge overcoming capacity is shown deterioration. Typical example of the above finding which presents casual work as coping ability symbolizes that individual coping ability is lowered so much. Other

support and self help support for overcoming of unemployment difficulties has different implications. In this regard, casual work, saving from earnings of casual work and begging has been identified as prevailing self help coping strategies of urban unemployed people. On the other hand, deterioration of self help coping ability of unemployment problems reinforced unemployed people to look for other supports. In view of that family support, relatives and friend support, remittance and other social support were major coping mechanisms of urban unemployed people.

It was identified that self help coping mechanisms include self employment effort. Self help employment is influenced by different dispositional and structural factors. Urban self employment scenario has its own patterns. Researcher dedicated to know whether self help employment is differed by gender difference or not. It was systematically conducted that the two variables were examined to check their statistical and substantive association. Statistics showed that self employment status and gender category has statistically significant correlation. Major estimators were chi-square test, significance value and odds ratio. Chi-square test and significance value indicated that self employment status and gender category has association. Correlation coefficient also confirms that self employment status and gender category has casual relationship. This implies establishing correlation and casual relationship between self employment and gender category is not only desirable but also possible. Urban self help employment trend showed that gender category was not sensitive issue while self employment policy was supposed to be advanced and advocated. However, the finding of this paper indicated that so far implemented self help employment need to be remodeled. The remodeling of self help employment is defensible since female predominantly affect self help employment status negatively the potential employment policy need to discriminatorily emphasizes on female category. Females are more successful than males if properly included in self help employment. Research finding indicates that females are keener to produce goods and save money than males which boost individual livelihood and community welfare. Thus, advocating and scaling up female self help employment in urban centers can significantly change hitherto existing self help employment trends. The more emphasis to females self help employment the higher self help employment trend will be and the lower urban unemployment rate will be. This calls for new thinking of remodeling urban self help employment policy.

The most important research question that needs critical analysis and wider evidences to answer is whether urban unemployment differs by literacy level or not. Researcher made effort to know the statistical and substantive relationship between unemployment rate and literacy rate. Finding indicates the higher unemployment rate is more likely associates with higher literacy rate. This implies there is association between unemployment status and literacy status. There is significant difference between literate group and illiterate group in terms of accessing job opportunities. This finding confirms that literate group more likely become unemployed whereas illiterate group are less likely to be unemployed. Given existing situation illiterate

group has more job opportunities than literate group. This associates with comparative advantages and disadvantages of the two groups. Descriptive statistics via chi-square and p-value affirms that literacy rate and unemployment rate has association which is more likely evidential to establish casual relationship between literacy rate and unemployment rate.

Substantive evidence indicates that majority of respondents (88%) reported that they are unemployed due to lack of job opportunity and vacancy unavailability. This magnitude reflects higher percentages of unemployment status are attributed to absence of job opportunity and vacancy in line with qualification of job seekers. On the other hand, only 12% of respondents reported that their unemployment status is attributed to illiteracy situation. This implies structurally generated job opportunities are less inclusive to literate group. Researcher found that some structurally created jobs opportunities favor less educated than more educated persons. It seems that structurally literate group is marginalized in multiply ways. Firstly, literate group is expected to join profession or field related work and culturally constructed to work in higher job status. Secondly, if it is not all in all firms exclude literate group expecting that literate group demand higher payment which in turn diminish profitability of firms. Thirdly, majority of literate group who are job seekers are graduate who have no money but some vacancies are severely accompanied by corruption and rent seeking behavior but graduates cannot afford to pay for commission to attain desirable job option. Finally, literate group increase by significantly higher percentages whereas job opportunities and vacancy availability shows declining. The above justifications profoundly establish the fact that urban unemployment is different among literacy group and literate group employment engagement is lower than illiterate. Thus, finding substantiates that literate group is more likely impacted by urban-unemployment i.e. literacy rate predict urban unemployment. This implies increasing literate group targeted job creation and opportunity can increase urban-employment or decrease unemployment. This calls for remodeling of urban job creation and employment development.

4. Conclusion

Based on the above major findings and implications of the research output the following essential points were generated. Researcher found that quantitative research approach is so imperative to address social problems in sensible way. In course of finding factors that make difference among unemployed people used gender category, literacy status and marital status as estimators for measurement of urban unemployment status. Particularly, financial shortage was found to be single major predictor variable of self unemployment. On the other hand, structurally driven unemployment is more likely associated with unavailability of job opportunities and deficiency of relevant vacancy. So far existing job opportunities are not suitable to existing working forces. Researcher concludes that prograduate job creation and job availability is more likely to reverse existing unemployment situation.

Even though there are several challenges that unemployed people suffer from, income is the most significant single factor that negatively affect living situation of jobless people. Finding depicted that unemployed people more likely depend on others to sustain their living and to cope up with difficulties. The most important coping mechanism that majority of unemployed people prefer to depend on and accessible is family support. Family support is the most vital social support that majority of unemployed people tend to use as social protective mechanism against adversity of unemployment.

In nutshell, urban unemployment rate is directly influenced by gender factor, educational factor and marital factor. It was found that females and males are not equally impacting urban unemployment in general and self unemployment in particular. In conclusion, females are more likely to impact self unemployment whereas educated people are more likely to aggravate structurally driven urban unemployment. In other words, females are more predictor of self employment rate than males and educated people are more predictor of structurally driven unemployment. This implies uneducated people have more job opportunities than educated people in urban centers. Level of literacy more likely predict availability of job opportunities and determines degree of employment rate. As extent of literacy level increases availability of job opportunity and likelihood of employment decreases given a practical situation of urban political economy and associated rent seeking behavior. In fact overall results of the study indicate that females, literates and never married unemployed people are multiply disadvantaged.

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STUDY ON RECOVERABLE GOLD FROM THE EFFLUENTS RELEASED BY GOLD ANALYSIS LABORATORIES

Alfred L Mathias[1], Eliamani I Nassari and Kabika M Tibasima

ABSTRACT

In the present study, an attempt has been made to estimate the recoverable gold from waste aqua-regia solution containing gold traces released by gold processing laboratories in Tanzania. One kilogram sample of aqua-regia solution containing 69 ppm of gold was treated with zinc dust, sodium cyanide and sodium hydroxide in stoichiometric quantities. The mass of zinc was optimized keeping the other parameters constant. The resultant solution containing elemental gold in the form of a precipitate was separated by filtration. The amount of unrecovered gold traces present in the filtrate has been assayed by AAS. Basing on the calculations, the recoverable gold was found to be 74.78%, at an optimum mass of zinc. The results obtained were analyzed and reported.

Keywords: Recovery of gold traces, cyanide process, optimization of zinc, aqua-regia effluent.

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1. INTRODUCTION

Gold and silver are extracted from their ores by leaching method where their ores are dissolved in cyanide to form complex compound (Robinson, 2011). Cyanide solution is widely used to track gold from soil and rocks (Fuerstenau, 2016). The cyanide leaching process is carried out by grinding the ore below 75 micrometers and dissolving the gold as $Au(CN)^{2-}$ by adding dilute cyanide solution to obtain slurry above pH 10 (Free 2021). In Merrill- Crowe process, traces of gold are recovered by precipitation method using dilute sodium cyanide solution (Mular, 2011). Traces of gold are also recovered by adsorption method employing carbon adsorbent (Nathaniel, 2008) and by ion exchange method employing modified amine and alkyl phosphorous ester (Kenneth, 2008) where hot concentrated nitric acid is used to dissolves silver and other metal like copper while gold is recovered from the residue (Nathaniel, 2008). The precipitated gold is filtered and refined by electrolysis method (Chi, 2011).

In the current study, traces of gold are found in the discarded aqua-regia solution which is normally released out as effluent by the gold analysis laboratory chosen for our study. Since gold is present in ppm quantity, a new approach is made where addition of zinc is optimized.

2. MATERIALS AND METHODS

2.1 DETERMINATION OF LEFTOVER GOLD IN AQUA REGIA EFFLUENT.

Analar grade chemicals and solvents were used for the preparation of all solutions. 1litre of aqua regia solution was taken into a beaker and 5 mL of di-isobutyl ketone (DIBK) was added and shaken for 5 minutes. It is allowed to stand for 10 minutes.

It was observed that the traces of gold passed into the layer of DIBK at the top of the beaker. It was filtered and the filtrate was analyzed by AAS and the head grade (HG) amount of gold was determined and reported. This accounts to the total amount of gold present in the discarded aqua-regia effluent.

2.2. DETERMINATION OF RECOVERABLE GOLD FROM WASTE AQUA REGIA SOLUTION

2.2.1 Addition of sodium hydroxide

Following the stoichiometric equation, 56 mg of sodium hydroxide was first introduced into 1litrer of the aqua-regia effluent solution and it is adjusted to pH 10 until all the gold is converted to a complex. The reaction taking place during the complex formation is given below.

$$H\,[AuCl_4]_{(aq)} + NaOH_{(S)} \longrightarrow Na\,[AuCl_4]_{(aq)} + H_2O_{(g.}$$

2.2.2 Addition of sodium cyanide

Following the same stoichiometric equation, 36.4 mg of sodium cyanide (CN^-) was added to the above solution. The color of solution turned from orange to brown black indicating the formation of cyanide complex. The reaction taking place can be represented as below.

$$Na\,[AuCl_4]_{(aq)} + CN^-_{(S)} \longrightarrow [AuCN_4]^-_{(aq)} + NaCl_{(aq)}$$

2.2.3 Addition of zinc granules

Again, 22.8 mg of zinc granules was added to this mixture until pale green precipitate was observed indicating the conversion of $[AuCN_4]^-$ to gold(0) as shown in the equation below:

$$[AuCN_4]^-_{(aq)} + Zn_{(S)} + e^- \longrightarrow [ZnCN_4]^{2-}_{(aq)} + Au\,(s)$$

2.2.4 Separation of recoverable gold

The above mixture was filtered by whatman filter paper No.41 to obtain clear tailing solution and precipitate. Tailing solution was then analyzed by using AAS to determine the tailing amount of gold (TG) remained in unrecoverable solution. The

amount of recoverable gold remained in the precipitate was obtained by subtracting tailing grade from head grade values. The efficiency of recoverable gold has been calculated and reported.

Efficiency of recoverable gold = $\frac{\mathrm{HG-TG}}{\mathrm{HG}} x100\%$

Where HG = amount of head grade gold in the initial sample.

TG = amount of tailing grade gold leftover in the unrecoverable solution.

The experiment was repeated until consistent values are obtained. It was observed that the amount of recoverable gold is proportional to the amount of zinc added. Hence, keeping the concentration of NaOH and NaCN constant, the amount of zinc is varied and an optimum value has been found.

3.0 RESULTS AND DISCUSSION

The experimental results were summarized and reported in table No.1. The mass of NaOH and NaCN were maintained as per stoichiometric ratio and that of zinc is varied around the required value. This is probably due to the reason that not all the amount of alkali and cyanide are able to convert the recoverable gold into complexes, but the amount of zinc is able to precipitate the gold.

Volume of aqua-regia sample= 1L, Mass of NaOH = 56 mg, pH=10.00, HG value = 69 ppm

Mass of NaCN = 36.4 mg and process efficiency = $\frac{\mathrm{HG-TG}}{\mathrm{HG}} x100\%$

Table 1: Effect of mass of zinc on recovery process

Sl. No.	Mass of Zn added/mg	TG value	Process efficiency
1	17.02	24.34	64.72

2	18.01	23.40	66.08
3	19.10	22.21	67.81
4	21.01	21.00	69.56
5	22.80	20.01	71.00
6	24.00	14.21	79.41
7	26.01	9.01	86.96
8	28.03	6.04	91.25

4.0 CONCLUSION

Isolation of recoverable gold in the form of precipitate was successful in the present study. From the results obtained it is observed that the amount of zinc added plays an important role in isolating the gold traces from cyanide complex. Though the amount of sodium hydroxide and sodium cyanide are added to aqua regia in the required stoichiometric proportions, an additional quantity of zinc is required to precipitate the gold traces. Mathematical modeling also helped in the determination of optimum amount of zinc required for complete precipitation of gold traces from cyanide solution. This process is found to be more ideal to separate the recoverable gold from the effluents when the head grade values are comparatively higher than those present in the current samples. The numerical optimization of input parameters was done by the help of Statistical Package for Social Science (SPSS) software. The average percentage of isolation of recoverable gold has been calculated and found to be 74.78%. This is achieved at the optimum weight of zinc dust of 22.00 mg. Although, it is not economically feasible to recover the gold by this process, the present study shows the possibility isolation of recoverable gold from laboratories effluents. Characterization of the precipitate and separation of pure gold are the economic factors to be considered for further study.

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Trend and Time Series Analysis of Daily New Case Report on COVID - 19 in Ethiopia: A Two-Year Daily Report Analysis

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ABSTRACT

The outbreak of coronavirus disease was first reported in December 2019 and spreading rapidly across the world, the severity of this pandemic is rising in Ethiopia until January 2022, and it shows up and down fluctuation afterward. It remains a serious economic, political, and social challenge, with disastrous consequences for emerging countries like Ethiopia. Ethiopia has ordered the closure of schools and public gatherings, as well as the implementation of a variety of strict and preventative measures. The study's major purpose was to look at the overall trend of coronavirus disease cases and to build an adequate forecast model. Daily new cases reports of coronavirus disease between 13, March 2020 and 13 March 2022 at the Ethiopian Public Health Institute and the Minister of Health's official website were used for fitting the trend & time series ARIMA model. Trend analysis and Box Jenkins methodologies were employed. The automatic best differencing parameter was identified using R software, different candidate models were compared. A total of 469,184 newly confirmed coronavirus disease cases were reported from 13 March to 13 March 2022. A maximum number of new cases were reported on December 28, 2021, with 5185. A total of 172,576 number of a total number of cases with a minimum of 0 and a maximum of 1829 were reported in the first year. A total of 296,608 number of a total number of cases with a minimum of 14 and a maximum of 5185 were reported in the second year. Quadratic trend analysis and ARIMA (4, 1, 3) were finally confirmed as the optimal model that showed the pattern and modeled to the pandemic. The 60-day forecast showed that total coronavirus disease cases would reach between 469,498 and 483,349 at the end of May 2022. The up and down behavior of the pandemic in the study suggested that different prevention

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mechanisms should be implemented to control and handles the contagious behavior of the pandemic and its devastating effect on economic, social, and political issues of the nation.

Keywords: - ARIMA, COVID-19, Ethiopia, Forecast, Stationary, Trend

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1. INTRODUCTION

The first human cases of COVID-19, the disease caused by a novel coronavirus causing COVID-19, subsequently named SARS-CoV-2 were first reported by officials in Wuhan City, China, in December 2019 [1]. World Health Organization declared a global pandemic disease after one month of the outbreak pandemic [2]. The pandemic and its devastating impact of the infection were spreading at an alarming rate both domestically and internationally. Consequently, nations across the globe respond swiftly to different mitigation and measures of stringent were enforced such as travel and movement restrictions, gathering prohibitions, generalized or partial lockdown of different social and community activities, hand-washing, and good hygiene promotion [3].

The report of WHO on March 10, 2022, shows that coronavirus cases globally were over 453,833,910 million, causing nearly 6,052,190 million deaths, while approximately 388,054,455 million people recovered from their illness. As of 5 March 2022, a total of 10,704,043,684 vaccine doses have been administered [4]. The report of COVID – 19 cases in the African continent first came in contact with the coronavirus pandemic on February 14, 2020, in the northernmost part, particularly Egypt. Because of this, the different governments of the country in the continent took severe restrictive measures to try to curb the spread of the disease [3].

By the same date, the number of confirmed COVID-19 cases in Africa amounted to 11,257,474 which represented around 3% of the infections around the world and 249,000 cumulative deaths, 10,529,106 total recoveries, and 100,554,471 total tests [5]. South Africa, Morocco, Tunisia, Libya, Egypt, and Ethiopia are among the countries with the most cases in the continent, according to the agency. In the African continent, South Africa had the highest number of cases & deaths, 3,686,556 & 99,681 respectively. Morocco and Tunisia, the second and third most

affected in Africa, recorded new cases (death) reporting 1,161,776 (16,036) and 1,017,907 (28,031) deaths, respectively [5,6].

The overall number of coronavirus (COVID-19) cases in East Africa had surpassed 1.3 million as of March 1, 2022. Ethiopia and Kenya were the most heavily affected countries in the African continent's eastern region, with 469 thousand and 323 thousand cases, respectively [7].

As per the report of the Ethiopian Federal Ministry of Health, the first coronavirus disease (COVID- 19) was confirmed on March 13, 2020, in Addis Ababa, Ethiopia. Consequently, the government of Ethiopia suspended schools, and public transportation, and announces different stringent & prevention techniques [3,8,9]. The minister of health of Ethiopia admitted and promoted using media that OVID -19 pandemic is still a health risk and worry for the population. On 10 March 2022, the report of Ethiopia public health institute revealed the total confirmed cases increased to 469,134 the reported death rate of 7484, 421,411total recovery, with 4,555, 130 total laboratory tests and 26,178,996 total vaccinated since the first COVID – 19 report date [3,8,9].

Individuals infected with the pandemic may have little or no symptoms and the symptoms range from mild symptoms to severe illnesses, and the incubation period of this virus may last 2 weeks or longer. The disease may still be contagion and infectious during the latent & initial period of infection and the virus can spread through respiratory air droplets and close contact from person to person until the material previously held by an infected individual if the materials are not sanitized by sanitizers [10].

In curbing and fighting against the pandemic, it is crucial to be able to identify the rate at which it spreads. Awareness at the level of spread at any given time can help governments plan, and develop public health policies & interventions to deal with the consequences of the pandemic. Creating awareness of the magnitude of the spread, of the vaccine and thus the timing of its peakedness is to be able to accurately predict the number of active cases at any given time in the future [11].

According to research findings, no study with a significant amount of data and a long duration has been undertaken in Ethiopia on COVID-19 trend analysis and forecasting on the daily case reports [12]. The study's purpose was to use time series models to analyze two-year trends in

COVID-19 dissemination, determine the best predictive model, and apply it to the possible prediction occurrence of COVID-19 cases in Ethiopia.

The significance of this study can be to find the best empirical model that has been established for the prediction of newly reported cases of COVID-19, the precision of which helps governors in decision-making to handle the pandemic, vaccine administration, and health system strategies; it can also highlight the trend of reported new cases of COVID-19 in Ethiopia. Finally, this paper explores the forecasting values for 60 days. Therefore, this investigation and forecasting result will play its part to help the government, minister of health, health professionals, policymakers, and the public to adopt new strategies and strengthen existing preventive measures & vaccine administration against the pandemic and can help predict the intended health infrastructure wants in the future in tackling and curbing the devastating problem of the pandemic in the social, economic and political environment of Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of Study Area and Data Source

COVID - 19 daily new confirmed cases were collected from the Ethiopian Public Health Institute (EPHI) and the Minister of Health's official website in Ethiopia. A total of 731 observations on daily numbers of newly confirmed cases for time series modeling of COVID-19 for two years were included in the study from 13 March 2020 to 13 March 2022.

2.2. Data Analysis

The statistical model used in this study is time series. Time series is broadly defined as any series of measurements taken sequentially at different times.

Data Analysis

Test of stationary

Before fitting a specific time series model for time series data, the series must be made stationary. Stationarity occurs in a time series when there is no systematic change in mean (no trend) and if there is no change in the variance of the series. To test the stationarity of the time series data graphical methods (time series plot, autocorrelation function, and partial

autocorrelation function) and hypothesis testing methods like unit root test (Augmented Dickey-Fuller (ADF) and Phillips - Perron (PP) stationary test) were used.

The unit root test was subsequently used to test the stationarity of the series.

H_o: The time series data are not stationary or the data needs to be differenced to make it stationary or the series has a unit root

H_1: The time series data are stationary or the data is stationary and does not need to be differenced [13, 14, 15].

Transformation is the process of changing non-stationary time-series observations into a stationary time-series data set. Non-stationary series can be transformed into stationary series using differencing the data that, given the series Y_t, we create the new series

$$\Delta Y_t = Y_t - Y_{t-1} \quad \text{..... [1]}$$

2.3 Time Series Model

Trend Analysis

Linear and quadratic trend analysis can be used to fit and assess the trend of the new COVID -19 daily reports.

Linear trend equation

$$y_t = \beta_o + \beta_1 t + \varepsilon_t \quad \text{..... [2]}$$

Quadratic trend equation

$$y_t = \beta_o + \beta_1 t + \beta_2 t^2 + \varepsilon_t \quad \text{..... [3]}$$

Accuracy measurements such as mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean squared deviation (MSD) are used to determine the trend line's fitness [13, 14, 15].

Autoregressive Process of Order p, AR (p)

Assume the error term is purely random with mean zero and variance σ^2, then the process y_t is said to be an autoregressive process of order p if:

$$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \cdots + \alpha_p y_{t-p} + \varepsilon_t \quad \text{..... [4]}$$

Where, y_t is series, $\alpha_1, \alpha_2, \ldots, \alpha_p$ are parameters of AR($\alpha_p \neq 0$) [13, 14, 15]

Moving Average Model of Order q, MA (q)

Suppose that ε_t is a purely random process with mean zero and variance σ^2, then a process $y_t$defined by [13, 14, 15]

$$y_t = \varepsilon_t + \beta_1\varepsilon_{t-1} + \beta_2\varepsilon_{t-2} + \cdots + \beta_q\varepsilon_{t-q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [5]$$

Where, $\beta_1, \beta_2, \ldots, \beta_p$ are parameters of MA.

Autoregressive Moving Average, ARMA (p, q)

The order of an ARMA model is expressed in terms of both p for Autoregressive and q for moving average. The model parameters relate what happens in period t to both the past values and the random errors that occurred in past periods [13, 14, 15].

It is given by the following general model:

$$y_t = \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \varepsilon_t + \beta_1\varepsilon_{t-1} + \cdots + \beta_q\varepsilon_{t-q} \quad \ldots\ldots\ldots\ldots [6]$$

Autoregressive Integrated Moving Average ARIMA (p, d, q)

Autoregressive integrated moving average (ARIMA) models are a specific subset of univariate modeling, in which a time series is expressed in terms of past values of itself (the autoregressive component) plus current and lagged values of a "white noise" error term (the moving average component) that consist of an autoregressive polynomial, an order of integration (d), and a moving average polynomial [13, 14, 15].

A process (y_t) is said to be an autoregressive integrated moving average process, denoted by ARIMA (p, d, q) if it can be written as:

$$\alpha(B)\nabla^{\mathrm{d}} y_t = \beta(B)\varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [7]$$

Where $\nabla^{\mathrm{d}} = (1 - \mathrm{B})^{\mathrm{d}}$

To identify a perfect ARIMA model for a particular time-series data, Box and Jenkins (1976) proposed a methodology that consists of the following four phases: model identification, estimation of model parameters, diagnostic checking for the identified model, and application of the model (i.e., forecasting) [14].

2.4 Ljung-Box Q (LBQ) Statistic: The Ljung-Box Q statistic can be employed to check the independence of the residual instead of visual inspection of the sample autocorrelations. A test of the hypothesis can be done for the model adequacy by choosing a level of significance and then comparing the value of calculated x^2 with x^2 critical value. This uses the entire residual sample with the null hypothesis that Ho: $\rho_1 = \rho_2 = \cdots = \rho_k = 0$

The test statistic is calculated using the following equation [8]

$$Q_{(r)} = n(n+2)\sum \frac{\gamma_k{}^2}{n-k} \sim \mathrm{x}^2\ \alpha(k-q) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [8]$$

Where n is the number of observations in the original time series,γ_k^2 is the sample autocorrelation of the residuals at *lag k, q is the number of parameters* and *k is the number of lags.*

Under the null hypothesis of model adequacy, Ljung and Box (1978) show that the Q - statistic approximately follows the x^2(k-m) distribution, where m is the number of parameters estimated. If a model is correctly specified, residuals should be uncorrelated and $Q_{(r)}$should be small (p-value should be large) [16]**.**

2.5 Forecasting

The last step of the ARIMA modeling process is forecasting. In forecasting, the goal is to predict future values of a time series variable, x_{t+k}, k =1, 2 . . . based on the data collected to the present, y= {y_t, y_{t-1}. . . y_1}. Throughout this section, we assume that $\boldsymbol{y_i}$is stationary and that the model parameters are known [13, 14, 16].

Once forecasts are made, some measurements of the accuracy of forecasts are the AIC, root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and so on.

3. RESULTS AND DISCUSSION

3.1. Descriptive Results

Among 4,567,310 total number tests, 469,184 positive cases were confirmed, 421,472 recovered, and 7,486 were dead. Until the study period, 23,960,213 people took the vaccine. The number of daily COVID -19 cases during the two years ranged from 0 to 5185.

Table 1: Summary report on the total number of tests, positive cases, recovery, death, and total vaccinated administered from 13 March 2020 to 13 March 13, 2022, in Ethiopia

Study year	Number of tests	Number of positive cases	Number of recoveries	Number of deaths	Vaccinated people
Year 1	4,567,310	172,576	140,396	2,517	23,960,213
Year 2		296,608	281,076	4,969	
Total		469,184	421,472	7,486	

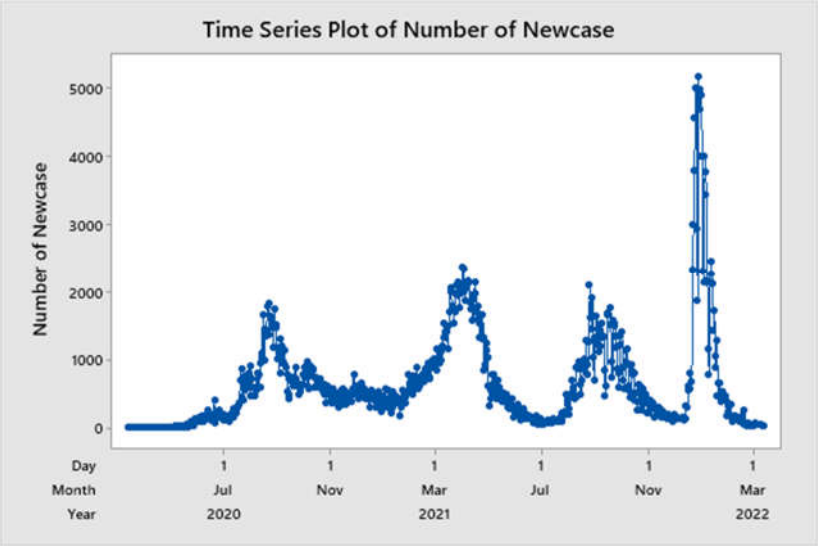


Figure 1: Time series plot for daily covid-19 new cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

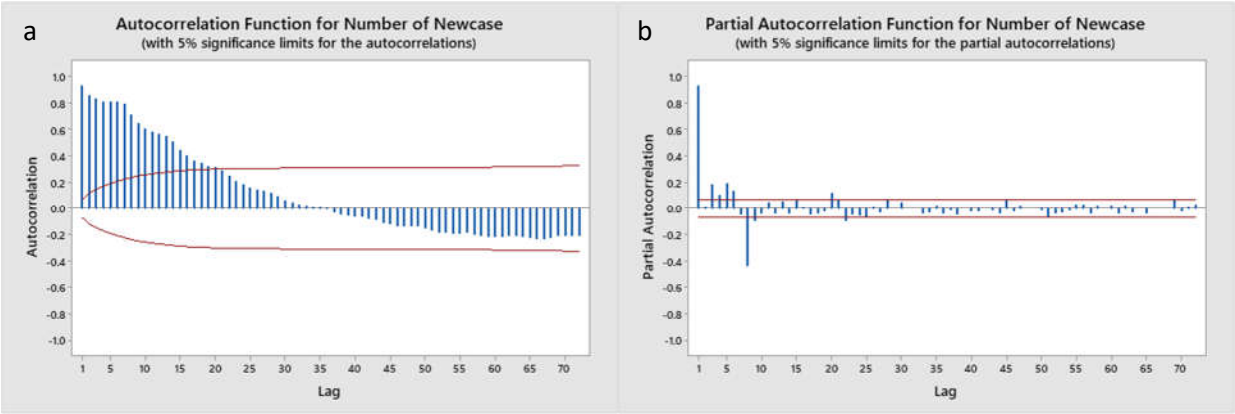


Figure 2: Autocorrelation (a) and Partial Autocorrelation (b) plot for daily covid-19 new cases report with 95% confidence interval in Ethiopia

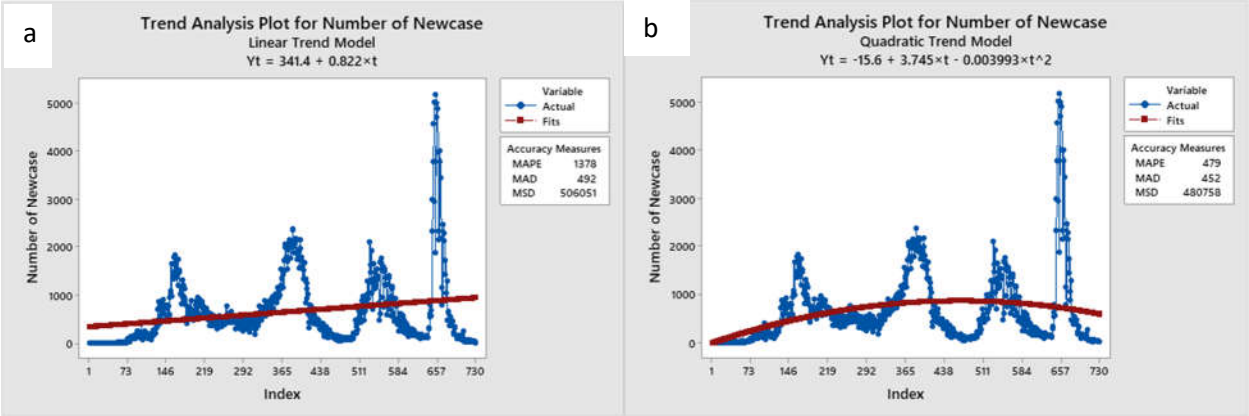


Figure 3: Linear (a) and Quadratic (b) trend plot for the daily covid-19 report from 13 March 2020 to 13 March 2022 in Ethiopia

3.2 Trend Analysis

In this article, the researchers employed linear and quadratic trend analysis. Based on measures of accuracy shown in Table 2 and Fig 3 (a) and (b), the quadratic trend is found to be best with the minimum value of MAPE, MAD, and MSD. From Fig.3b the quadratic trend model is the best-fitted overall trend for a daily case report of COVID-19 distribution in Ethiopia from 13 March 2020 to 13 March 2022.

Table 2: Measures of accuracy for trend analysis and Equation for daily COVID -19 cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

Model Type	Measures of Accuracy			Equation
	MAPE	MAD	MSD	
Linear	1378	492	506051	$y_t = 341.4 + 0.822t$
Quadratic	479	452	480758	$y_t = -15.6 + 3.745t - 0.003993t^2$

3.3 Stationary Test

The pattern of the time series plot in Figure 1 shows a systematic upward and downward change in the mean. This indicates that the series is non-stationary. However, by critical observations day by day, it is clear that there existed a sharp rise and fall in daily confirmed cases of COVID-19. Besides, from the autocorrelation function plot in Figure- 2 (a) and (b), the series is not stationary & the behavior of the series is clear. Therefore, from the time series plot (Figure-1), autocorrelation, and partial autocorrelation plot (Figure- 2), it can be observed that our series has an upward & downward fluctuation then, differencing is needed to make it stationary.

Table 3: Summary statistic for different stationary tests on the original daily new cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

Series	Types of test	P-value	Decision	Decision
Original	Augmented Dickey-Fuller Test	0.5179	Do not reject Ho	Non-stationary
	Phillips-Perron Unit Root Test	0.3885	Do not reject Ho	Non-stationary

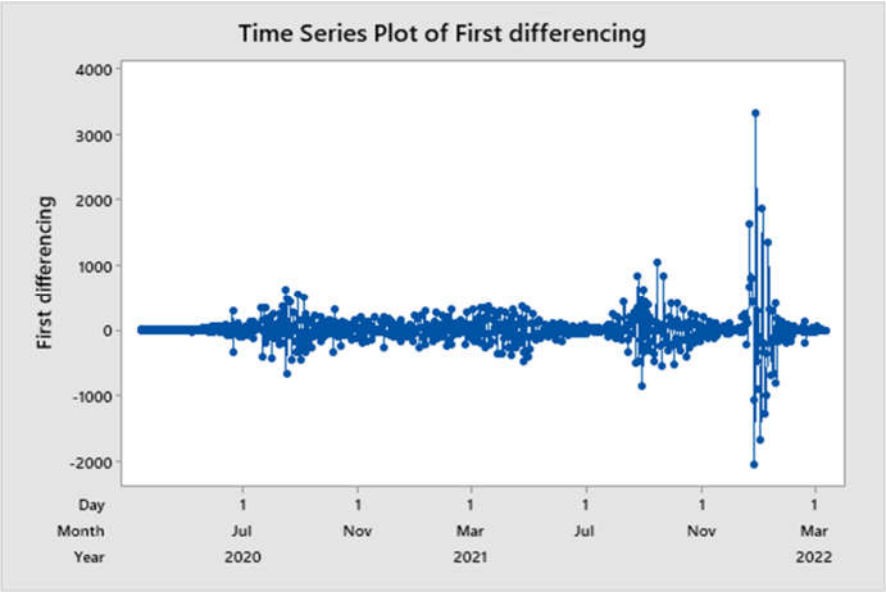


Figure 4: Time series plot after the first non-seasonal differencing of new covid-19 cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

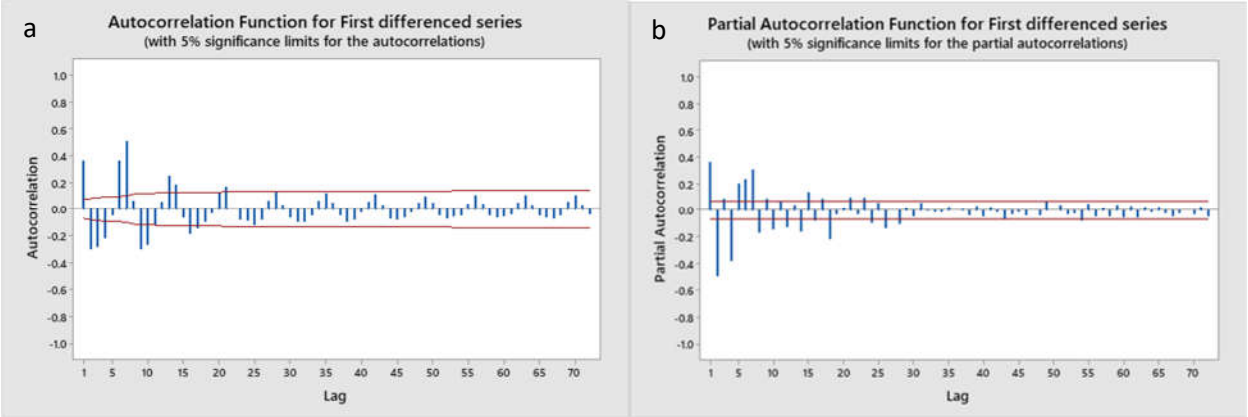


Figure 5: Autocorrelation (a) and Partial Autocorrelation (b) for the first differenced series with a 5 % significance limit for daily new cases from 13 march 2020 to 13 March 2022 in Ethiopia

Table 4: Summary statistic for different stationary tests after the first non-seasonal differencing of new daily Covid-19 cases from 13 March 2020 to 13 March 2022 in Ethiopia

Series type	Test type	P-value	Decision	Non-stationary/stationary
First non-seasonal differencing series	Augmented Dickey-Fuller Test	0.013	Reject Ho	Stationary
	Phillips-Perron Unit Root Test	0.021	Reject Ho	Stationary

Functions to estimate the number of differences required to make a given time series stationary was employed using the urca package in kpss unit root test, ndiffs (for non-seasonal differences), and nsdiffs (for seasonal differences). It suggested that the first differencing is enough for non-seasonal differencing & no need for seasonal differencing. The researchers also employed auto.arima function in forecast package in R software to get the best order of differencing to convert non-stationary data to stationary. The first differencing is enough to achieve stationarity and it gives us an initial model of ARIMA (4, 1, 3). After the first differencing of the original series, the data became stationary from Fig. 4 and Table 4

3.4 Box-Jenkins Models

ACF and PACF showed in Fig 5 (a) and (b) indicate a graph of sine function patterns, which would reveal some combination of AR(p) and MA(q) processes. From this, the researchers employed a comparison of different autoregressive integrated moving average models (ARIMA (p, q, q)) in the estimation stage. The auto.arima function in the forecast package of R software suggested that first differencing is enough to achieve stationarity and it gives us an initial model of ARIMA (4, 1, 3).

3.4.1 ARIMA (p, d, q) Model Comparison

Visual inspection of ACF, and PACF plots above shows; that there are no clear properties of autoregressive and moving average models that indicate the mixture of autoregressive and moving average models (ARMA) was better. So, based on different model selection criteria the best time series model after applying techniques of first differencing was selected. As can be seen from Table 5 ARIMA (4, 1, 3) model with the smallest value of ME, MAPE, RMSE, MAE, MASE, and AIC and the largest value of log-likelihood was the best.

Table 5: Different ARIMA models with different values of p and q with d=1 on daily new cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

ARIMA Types	ME	MAPE	RMSE	MAE	MASE	AIC	Log-likelihood
ARIMA(4,1,3)	0.0275	30.860	242.8989	127.7192	0.1822	10109.36	-5046.68
ARIMA(4,1,2)	0.0409	32.219	245.5861	129.6082	0.9457	10123.04	-5054.52
ARIMA(4,1,1)	0.0544	33.044	259.0882	131.9598	0.9628	10198.48	-5093.24
ARIMA(3,1,3)	0.0057	33.689	245.7657	130.3098	0.9508	10124.43	-5055.21
ARIMA(2,1,3)	0.0251	38.175	247.0686	125.9882	0.9193	10130.03	-5059.01
ARIMA(1,1,3)	0.0442	35.353	264.2849	134.8127	0.9837	10225.29	-5107.64
ARIMA(2,1,2)	0.0107	34.307	248.0218	128.765	0.9395	10133.65	-5061.83
ARIMA(1,1,1)	0.0442	38.167	268.6893	133.078	0.9710	10245.34	-5119.67
ARIMA(2,1,1)	0.0454	33.014	263.4958	134.6445	0.9824	10218.95	-5105.48
ARIMA(4,1,4)	0.0284	35.006	242.8803	127.6378	0.9313	10111.24	-5046.62
ARIMA(5,1,3)	0.0434	33.519	244.5772	129.7554	0.9468	10121.05	-5051.53
ARIMA(5,1,4)	0.0128	35.005	242.2946	127.269	0.9286	10109.75	-5044.88

3.4.2 Test of the Significance for the ARIMA (4, 1, 3) Coefficients

In Table 6, the ARIMA (4, 1, 3) shows AR (1), AR (3), AR (4), MA (1), MA (2), and MA (3) coefficient was found to be statistically significant. Thus, the corresponding parameters are significantly different from zero. Therefore, we incorporate these parameters in the final model to forecast daily COVID – 19 reports in Ethiopia. In the reverse AR (2) coefficient was found to be insignificant. Hence, there is not enough evidence that the parameters of AR (2) are significantly different from zero.

Table 6: ARIMA (4, 1, 3) model for new daily COVID – 19 cases reported from 13 March 2020 to 13 March 2022 in Ethiopia

Type	Coef	SE of	T	P-value
AR (1)	0.2147	0.0608	3.531	0.000
AR (2)	0.0738	0.0589	1.253	0.289
AR (3)	-0.6687	0.0503	13.294	0.000
AR (4)	- 0.1879	0.0447	4.204	0.000
MA (1)	-0.4004	0.0523	7.656	0.000
MA (2)	-0.2997	0.0560	5.352	0.000
MA (3)	0.7407	0.0438	16.911	0.000
MSE	59653			

P-value< 0.05 significant

3.4.3 Diagnostic Checking

The box-pierce statistics gives an insignificant p-value = 0.1965 (p-value greater than significant level of alpha =0.05, Chi-squared value = 1.6681) which revealed that the residuals are uncorrelated. Because the first difference that applies before shows the constant mean, constant variance, and the residuals are white noise. Visual inspection in the top left corner of the normal probability plot in Figure 6 shows it is approximately a straight line this revealed that the residuals are normally distributed. The graph in the top right corner of residual versus fitted values has no obvious pattern this indicated that the residuals have constant variance.

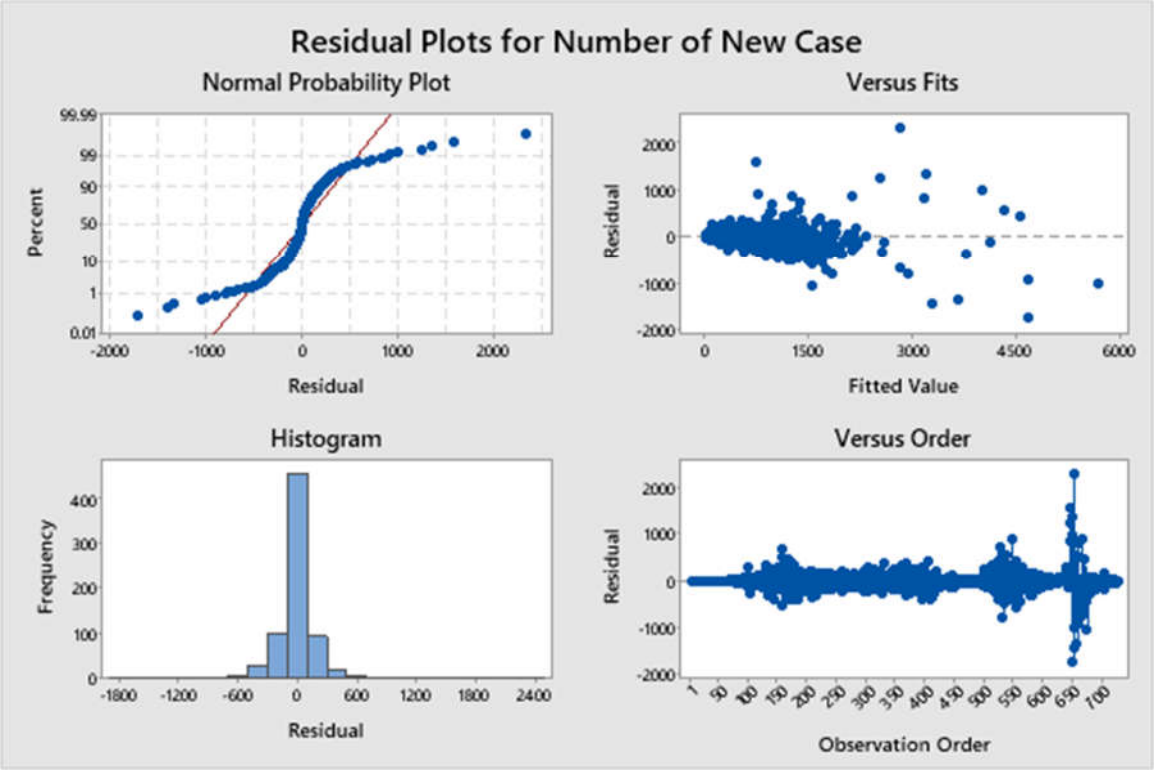


Figure 6: Normal probability (top left corner), residual vs fitted value (top right corner), histogram of residuals (lower-left corner), and residual vs order (lower right corner) plots of residual of coronavirus in Ethiopia between March 13, 2020, and march 13, 2022 in Ethiopia

3.4.4 Forecasting of New Daily COVID -19 Report

Using the selected model forecast was made for the coming 60 days. As shown in Figure 7 the number of daily COVID -19 incidences is forecasted in Ethiopia. If special emphasis is not

given, the 95 % forecasting values for the next 60 days shows there will be an increment of new report between 314 and 14,165.

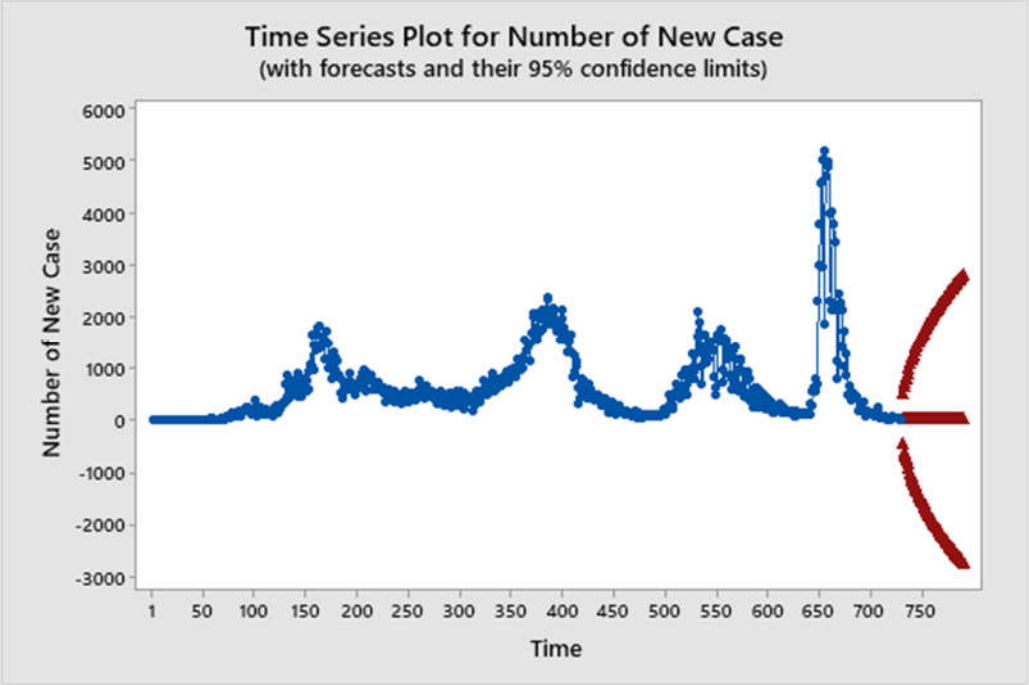


Figure 7: Forecasting graph for the coming 60 days in Ethiopia

4. CONCLUSION

The study data in the indicated period shows the highest records were recorded in December 2021 and January 2022 but the daily report of new cases decreases in February and March 2022. The maximum number of new cases was reported on December 28, 2021, with 5185. A total of 469,184 newly confirmed COVID-19 cases were reported from 13 March to 13 March 2022. Trend analysis and different ARIMA models were employed and Quadratic trend analysis and ARIMA (4, 1, 3) were finally confirmed as the optimal model. The ARIMA model was also used to identify the COVID-19 trend and showed an up-and-down pattern daily in the number of confirmed cases. Based on the next 60-day forecasted values of a 95% confidence interval between 314 and 14,165 new confirmed cases of COVID-19 will expect. This up-and-down behavior in the number of cases in Ethiopia needs more attention must have been paid to the control of COVID-19. Although the Minister of Health of Ethiopia and other concerned bodies of the government implements a mechanism to control the pandemic, it may affect the health, economic, political, and social activities of the country. The study suggested that different

stringency and control mechanisms should be implemented to control the contagious behavior in the seasons that indicate increment of the pandemic to curb its negative effect on economic, educational, social, and political issues of the nation.

ABBREVIATIONS

ACF, autocorrelation function; ADF, augmented Dickey-Fuller test; AIC, Ackakie information criteria; AR, autoregressive; ARIMA, autoregressive integrated moving average; CDC, communicable disease control; COVID-19, coronavirus disease 2019; EPHI, Ethiopia Public Health Institute; **MA,** Moving Average; **MAD, Mean Absolute Difference;** MAE, mean absolute error; MAPE, Mean Absolute Percentage Error; ME, Mean Error; MASE, Mean Absolute Squared Error; MoH, Minister of Health; **MSD,** Mean Squared Deviation**;** MSE, mean squared error; PACF, partial autocorrelation function; PP, Phillips-Perron; RMSE, root mean squared error; SPSS, statistical package for Social Science; WHO, World Health Organization.

Declarations

Ethics approval and consent to participate
Not applicable
Consent for publication
Not applicable
Availability of data and materials
The data used in this study are available from Ethiopia public health institute, https://www.ephi.gov.et/ and Ministry of Health, https://www.moh.gov.et/ facebook pages upon reasonable request.
Competing interests
The authors declared that there was no competing interest.
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Honeybees (*Apis mellifera* L.) Beyond Honey production: Pollination

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Abstract

Honeybees (Apis mellifera L.*) play a crucial ecological role as pollinators of many flowering plants and are the source of multi-billion dollars in several parts of the world. Pollination by honeybees take place in almost all major ecosystems of the world except in areas with extremely cold (Alpine/Afroalpine) and extremely hot (Desert*) weather. *Even though it is hard to estimate the overall value of honeybee pollination in crop production, several authors estimated it more than $1.6-$40 billion a year in United States of America alone. Surprisingly, this could be the annual budget of more than 5-10 least developed Countries. In Africa, bee pollination is sometimes estimated to be 100 times the value of the honey harvest, depending on the type of crop. Unfortunately, pollinators in general and honeybees in particular have extremely declined these days. Thus, every country has to incorporate policies to help conserve the pollinators maintaining pollination system healthy and productive. Creating awareness about the importance of honeybee apart from honey production especially to farmers could have a crucial value in maintaining honeybee diversity in particular and pollinators in general*.

Keywords: Conservation, Ecosystem service, Honeybee, pollination value, Pollinators

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INTRODUCTION

Plants have a wide array of both economic and ecological importance as source of food,

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medicine, cosmetics, construction, pulp, microhabitat, oxygen source, carbon dioxide sequestration etc. Obviously, almost all flowering plants depend on pollinators in one or the other way. The pollinators include insects, birds, mammals, wind and others. Exclusive to self-pollinating plants, over 90% of the flowering plants are pollinated by animals, especially insects (Buchman and Nabhan, 1996; Kevan and Viana, 2003). Without pollinators human beings lose food and other plant products (Buchman and Nabhan, 1996; Kearns et al., 1998). Pollinators are vital to agriculture because crops, fruits, vegetables fodders etc are their output (CSPNA, 2007). According to FAO (2008) out of some one hundred crops worldwide, seventy one of them are bee pollinated. These insect pollinators, however, are declining in several countries (Kevan and Viana, 2003; Newstrom-Lloyd, 2013).

Honeybees (*A. mellifera*) play a crucial ecological role as pollinators of many flowering plants and are the source of multi-billion dollars in several parts of the world (Saas, 2011; Suwannapong et al., 2012). Moreover, these are highly rated pollinators of agricultural and horticultural crops in different parts of the world. This could be due to their important attributes they owe like body parts modified to effect pollination and number of individuals in a colony (Abrol, 2012). Thus, the objective of this article is to review the importance of honeybees in pollination.

Importance of honeybees in the ecosystem

I grew up in a community [Tigray, Ethiopia] in which honey production is a common practice. All the farmers in the community know flowering plants are very important for honeybees and honey production. Nonetheless, the majority don't have any idea about the importance of honeybees for their crops. If you ask the majority of people about the importance of honeybees, the answer is expected; it is production of honey. For instance, a survey in in Gojam, Ethiopia revealed that nearly 80% of the farmers participated in the survey are not aware of pollination services and pollinators (Misganaw *et al*., 2017). A report in Ghana also showed nearly 90% of the farmers are not aware of the pollination service of honeybees (Kasina *et al*., 2007). However, honey rates low in comparison to the pollination services that honeybees provide to the living world.

Plant-pollination interactions are one of the prestigious interactions which strongly

influence ecological relationships, ecosystem conservation and stability, genetic variation in the plant communities, floral diversity, specialization and evolution (co-evolution/co-adaptation) (FAO, 2009). According to Kasina (2007), honeybees use plants apart from food; bees require plants for other purposes such as nest material, hiding, mating or just as resting sites. The productivity of terrestrial plants and animals is linked to pollination (Kevan and Viana, 2003). Beyond its direct economic value, pollination by honeybees is crucial in maintaining ecosystem functioning (CSPNA, 2007). Even though honeybees are the most important and highly adapted pollinators in the ecosystem Kevan and Viana (2003), it is very difficult to estimate their value of pollination in wild plants (Allen-Wardell et al, 1998) because pollination researches in wild plants are very scanty. The existence of flowering plants is certainly important for the existence of honeybees and vice versa.

Pollination

Pollination has been categorized as a supporting service, i.e. a service that contributes to human welfare by maintaining or enhancing other services by Millennium Ecosystem Assessment (2003) and as a regulation service (De Groot et al., 2002; Hein et al., 2006). Pollination by honeybees take place in almost all major ecosystems of the world except in the areas with extremely cold (alpine/afroalpine) and extremely hot (Desert) weather. In these areas other pollinators like bats and birds could be the most influential pollinators. Lack of honeybees for pollination can mean a loss for the farmer of maybe 75 percent of the crop (FAO, 2009). Furthermore, a research by Breeze et al. (2012) in UK reported that replacing honeybee services with hand pollination would cost £1.8 billion per year. In Ethiopia, the economic value of pollination was assessed for the years 2003-2013. Even though the assessment was holistic, the mean economic value of pollination was estimated to be about US$81.3 million for this period (Mulatu, 2019).

Plant taxonomic groups pollinate by *A. mellifera*

Several researchers (Listabarth, 2001; Smith, 2002; Dick et al., 2003; Klein et al., 2003; Rader et al., 2009; Mensah and Kudom, 2011; Suwannapong et al., 2012; Pérez-Balam et al., 2012; Negussie et al., 2013; Chiari et al., 2013; Bernhardt et al., 2013; Archer et al., 2014; Kumsa and Tadele, 2014; Karanja et al., 2014) revealed that honeybees visits several varieties

of flowers. Some of the wide arrays of plants pollinated by *A. mellifera* are listed in table 1. Moreover, Kemper (----) reported more than 150 home garden flowering plants pollinated by honeybees.

Table 1: List of some plant species visited and pollinated by *A. mellifera*

Species name	**Family name**	**Reference**
***Acacia negrii* Pic.-Serm.	Fabaceae	Adal *et al*. (2015)
***Acanthus sennii* Chiov.	Acanthaceae	Adal *et al*. (2015)
***Aloe pulcherrima* Gilbert & Sebsebe	Aloaceae	Adal *et al*. (2015)
***Inula confertiflora* A. Rich	Asteraceae	Adal *et al*. (2015)
***Laggera tomentosa* (Sch. Bip. ex A. Rich.) Oliv.& Heirn	Asteraceae	Adal *et al*. (2015)
***Lobelia rhynchopetalum* Hemsl.	Lobelliaceae	Adal *et al*. (2015)
Acacia brevispica Harms.	Fabaceae	Jenberie *et al*. (2014)
Adenocalymma bracteatum (Cham.) DC.	Bignoniaceae	Almeida-Soares *et al. (*2010)
Balanite aegyptica (L.) Del.	Balatinaceae	Jenberie *et al*. (2014)
Bidens biternata Merr. & Sher	Asteraceae	Suwannapong *et al*. (2012)
Borassus aetheopum Mart.	Arecaceae	Dukku (2013)
Brassica carinata A. Br.	Brassicaceae	Bareke *et al*. (2014)
Cocos nucifera L.	Arecaceae	Suwannapong *et al*. (2012)
Coffea Arabica L.	Rubiaceae	Klein et al. (2003) Kumsa and Takele (2014); Karanja et al. (2014)
Combretum glutinosum Perr. ex DC.	Combretaceae	Dukku (2013)
Croton macrostachys Del.	Euphorbiaceae	Kumsa and Takele (2014)
Cucumis sativus Linn.	Cucurbitaceae	Suwannapong *et al*. (2012)
Euclea shimperi Murr.	Ebenaceae	Jenberie *et al*. (2014)
Fagophyrum esculentum Moench	Polygonaceae	Bareke *et al*. (2014)
Gossypium hirsutum L.	Malvaceae	Dounia and Fohouo (2013)
Guizotia abyssinica L.F.	Asteraceae	Bareke *et al*. (2014)

Hypoestes trifolia Forssk.	Acanthaceae	Jenberie *et al*. (2014)
Jatropha curcas L.	Euphorbiaceae	Negussie *et al*., (2013)
Malus domestica Borkh.	Rosaceae	Hein (2009)
Ocimum basillicum L	Lamiaceae	Suwannapong *et al*. (2012)
Persea Americana L.	Luaraceae	Pérez-Balam *et al*. (2012)
Phoenix dactylifera L.	Arecaceae	Dukku (2013)
Scheffleria abyssinica Hochst. ex A. Rich.	Araliaceae	Kumsa and Takele (2014)
Sisyrinchium palmifolium L.	Iridaceae	Silva *et al*. (2013)
Tamarindus indica L.	Fabaceae	Dukku (2013)
Vaccinium ashei Reade	Ericaceae	Dedej and Delaplane, (2003)
Vernonia amygadalina Del.	Asteraceae	Kumsa and Takele (2014)
Vicia faba L.	Fabaceae	Smith (2002)

***** Endemic to Ethiopia

The value of honeybee pollination

As a result of cross pollination by honeybees, somatic reproductive and adaptive heterosis or hybrid effects occur in plant progeny (Abrol, 2012). Even though it is hard to estimate the overall value of honeybee pollination in crop production, several authors (Robinson et al., 1989; Southwick and Southwick, 1992; Johnson, 2010; Saas, 2011) estimated it more than $1.6-$40 billion a year in U.S. Surprisingly, this could be the annual budget of more than 5-10 least developed countries. Thus, conserving pollinators in general and honeybees in particular could be very crucial to maintain ecosystem functioning and boost the livelihood of the world. Several crops are pollinated by bees, including apples, berries, cantaloupes, cucumbers, alfalfa, and almonds. In Australia Gill (1991) estimated the total value of $156million while Winston and Scott (1984) put the total value for Canada at C$1.2 billion. In a country like Denmark, about 3,000 tonnes of honey is harvested every year. It has a value of 60 million DKK or about €7.6 million. However, the value of oilseeds, fruits and berries produced by the pollination of bees is estimated to be between 1,600 and 3,000 million DKK, equivalent to €200 and €400 million (FAO, 2009). NZ$5 billion of the New Zealand GDP is directly attributed to honeybee pollination (Newstrom-Lloyd, 2013). In

Africa, bee pollination is sometimes estimated to be 100 times the value of the honey harvest, depending on the type of crop (Abrol, 2012).

Coffee (*Coffea arabica*) accounts for 4-5% of Ethiopian GDP and 60% of export earnings. It provides a livelihood to 25% of its population (Tafesse, 1996). In the absence of pollinators yield of *C. arabica* reduces by 36%. Klein et al. (2003) and Reddy et al. (1988) reported that the fruit set of honeybee pollinated *C. arabica* increased by 12.3% and 17% respectively. than the self-pollinated. The average farmers of coffee could lose 40 euro per year if pollinators are ignored (FAO, 2006). If we lost this much income from one species it needs not a special talent to imagine how devastating this could be considering the flowering plants which are more than 300, 000.

Conservation of *A. mellifera* to boost productivity

Even though the value of honeybees in pollination is conspicuous, their population and diversity is severely declining in all continents except Antarctica (Kearns et al., 1998; UNEP, 2010; Breeze et al., 2012; Newstrom-Lloyd, 2013; Vanbergen and the Insect Pollinators Initiative, 2013). The number of commercial US bee colonies, for example, nose dived from 5.9 million in the late 1940s to 4.3 million in 1985, and 2.7 million in 1995 (Devillers, 2002). In UK (Breeze et al., 2012) the number of managed honeybee colonies is dropped by 53% between 1985 and 2005 (Potts et al., 2010) and wild honeybees are thought be nearly extinct throughout the British Isles (Carreck, 2008). In North America the number of managed colonies dropped from 5.9 million in 1947 to 2.4 million 2005 (CSPNA, 2007). Researches in the status of honeybee population are still scanty in several countries.

Certainly, the major threats to biodiversity are also threats to honeybees and other pollinators too. Habitat fragmentation, deforestation, invasive species, agricultural practices and others are some of the major threats to pollinators and pollination system. However, there are reports from different countries on the specific threats for honeybees. According to Kearns et al. (1998), Abrol (2012), Vanbergen and the Insect Pollinators Initiative (2013) application of pesticides and herbicides is one of the reasons for the decline of honeybees. Herbicides influence honeybee decline by reducing the nectar content of flowers. In some instances, the effect of herbicides is severe than that of pesticides (Kearns et al., 1998). Somewhere else in the world mites are severely affecting honeybee population (Kearns et al.,

1998; CSPNA, 2007; UNEP, 2010; Suwannapong et al., 2011). Furthermore, honeybee Colony Collapse Disorder is has been reported as a threat to honeybees (Johnson, 2010; UNEP 2010). Introduction of non-native pollinators, for example wasps and bumblebees, could be potentially harmful for the honeybees (Kearns and Inouye, 1997; Kearns et al., 1998).

Conclusion and recommendation

Honeybees (*A. mellifera*) have high positive impact if they are conserved but severe impact if lost on flowering plants for their pollination. Several flowering plants of different taxonomic groups depend on honeybees and, other pollinators of course, to be productive. However, due to several factors honeybee population is declining. Thus, conserving plants should be more important in conserving honeybees. Furthermore, countries should better incorporate policies to conserve pollinators and pollinator habitat in consideration of vital pollination systems. Public education about the importance of honeybee apart from honey production, especially to the farmers and honeybee breeders of developing countries, could have a crucial value in maintaining honeybee diversity. Moreover, the introduction of non-native pollinators should be taken at a great care. National laws which ban harmful practices like application of pesticides and herbicides which could have a potential impact on honeybees and other pollinators should be ratified and implemented.

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Prevalence, associated factor and economic importance of major Metacystode in slaughtered cattle at Jimma Municipal Abattoir, Southwestern Oromia, Ethiopia

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ABSTRACT

A cross-sectional study was conducted to assess the prevalence and associated factor of major metacestode in slaughtered cattle and its economic importance at Jimma municipal abattoir from October 2019 to June 2020. Out of 384 bovine examined at Jimma municipal abattoir 197 (51.3%) at 95% CI of: 46.29-56.29) cattle were found positive for Metacestode, of which 191 (49.74%, 95% CI: 44.74-54.75) and 9 (2.34%, 95%CI: 1.22-4.45) were positive for Hydatid cyst and Cysticercous bovis, respectively. The highest prevalence of metacestode were found in Asendabo (66.67%) followed by Bilida (58.44%) and Agaro (57.89%) and lowest in Sarbo (43.94%) and Kefa (40%). The highest prevalence of hydatid cysts was observed in lung (58.64%), and liver (23.04%). While the highest prevalence of cysticercus bovis was detected in heart (33.33%). Furthermore, out of 190 hydatid cyst identified, the proportion of small, medium, large and mixed cyst were 13.16%, 7.89%, 4.21% and 74.74%, respectively. The prevalence of metacestode infection showed a significant difference ($p < 0.05$) between sex, age, and body conditions of the animals. A total of 528,155.32 ETB annual financial losses were calculated during the study period. In conclusion, the present study has revealed the presence of metacestode which have significant impact on the health and production of the cattle in the study area. Therefore, Control of the parasite directed both in the intermediate and definitive host should be carried out.

Keywords: Cattle, Factor, Jimma municipal abattoir, Metacestode, Prevalence

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INTRODUCTION

Background of the Study

Cestodes of the family Taeniidae infect dogs and humans as the definitive host and are transmitted to a wide range of intermediate host species where they cause Hydatidosis, and Cysticercosis, respectively. Among the parasitic diseases metacestode of *Taenia saginata* and *Echinococcus granulosus* are the most important ones because they have economic as well as public health significance (4,5). Metacestode of *taeniasis* and *echinococcosis* prevalence are considered to be higher in developing countries because of poor sanitation, traditional cattle husbandry systems and inadequate meat inspection facilities (6)

Bovine cysticercosis, is an infection of cattle with metacestode of the human tapeworm *Taenia saginata* (8,9). Even though, clinical infection of Bovine with is not significant but it is more important on its public health impact and regarding to high economic losses due to the condemnation of heavily infected carcasses and (10). In Africa, there are an estimated 12 million carriers with a 30% incidence in some African stockmen (11). In Ethiopia, the prevalence of *bovine cysticercosis* reported ranges from the lower prevalence of 1.7% in Central Ethiopia (12) to higher prevalence of 26.25% in Hawassa (5). It is believed that the cultural habit of eating raw meat in the form of “Kourt”-meat cubes and “Kitfo”-minced meat in Ethiopia, has favored the spread of this disease (13–15).

Cystic *echinococcosis* (*CE*) is another frequently encountered metacestode in developing countries. Infested carnivores eliminate eggs with their feces. Intermediate hosts (cattle, shoat and camels) become infested with the eggs on account of having fed on contaminated pastures (16). The disease is characterized by the formation of large fluid field cyst in the internal organs of the intermediate host(17). Adult worms have been reported to be found in small intestines of dogs and wild carnivores like the wolf and fox (18). It is extensive distribution with a broad range of host worldwide, and highly endemic in the continent of southern America, Africa, Asia and Australia (19). In Ethiopia, Hydatidosis is known and documented since the 1970s and it is one of the major causes of organ condemnation in most abattoirs and slaughter houses and leads to huge economic losses (20), and prevalence of 51% in cattle with area specific occurrences of 44% in Arsi, 30% in Borana, 85% in Jimma and 67% in Mi'eso were reported by (21).

Multiple factors seem responsible for the observed fluctuations. It may be associated to the poor hygienic conditions that prevail in different regions, illegal slaughtering of animals, lack of proper disposal of infected carcass, and the alarming high number of stray dogs. Remains of animal that die due to any disease become food of such free roaming dogs. Such remains may contain fertile hydatid cysts, thus infecting stray dogs. These dogs become a major cause of dissemination of infected eggs on pasture. Most herder were ignorant of the fact that these dogs shed infective stages (eggs) of Echinococcus in the field (22). Having almost no knowledge about mode of transmission of disease, majority of villagers offer raw visceral organs to dogs. These organs may carry infective stage of parasite (23).

Economic losses associated with Hydatidosis were estimated at various levels in different locations of Ethiopia. Annual losses of 19,847,704.00 ETB in Addis Ababa Abattoirs Enterprise (24), 1,791,625.89 ETB at the Hawassa (25), 473,173.75 ETB at Debre Markos (26), 52,828 ETB at Adama (27) and 930,918.52 ETB at Mekelle (28) were reported due to CE and bovine cysticercosis. Moreover, annual economic losses of 1,841,311.00 ETB (73,652.44 USD) consisting of 1,831,890.00 ETB due to C. bovis from organ condemnation were estimated (29) in Ethiopia.

The rest 9,421 ETB annual economic loss were due to cirrhosis, fasciolosis and other factors. Globally, *cystic echinococcosis* was estimated to cause livestock associated annual economic losses of at least US$141,605,195 (30). Despite it has a significant economic impact due to organ contamination by the case of metacestode; there is no study conducted yet on the determination of prevalence, associated factor and economic loss by major metacestode in cattle slaughtered at Jimma municipal abattoir. Therefore, the aim of this research is to assess the prevalence and associated factors of major metacestode in cattle and its economic importance at Jimma municipal abattoir from October 2019 to June 2020.

MATERIALS AND METHODS

Description of study area

The study was conducted at Jimma town which is located about 352km south west of Addis Ababa. It has a latitude and longitude of $7^0$40'N $36^0$50'E/ 7.667^0N 36.833^0E. The area received a bimodal rain fall with an average annual rain fall of 1530mm. The long rainy season occur during the

months of June to September while the short rainy season occurs during the months of March to May. The climatic condition of the town is "Weinadega" and the town is located at an altitude of 1915 MASL. The annual maximum and minimum temperature ranges from 24-30◦c and 7-14◦c respectively. According to the statistical data obtained (34) Jimma districts has a livestock population of 2,016,823 cattle.

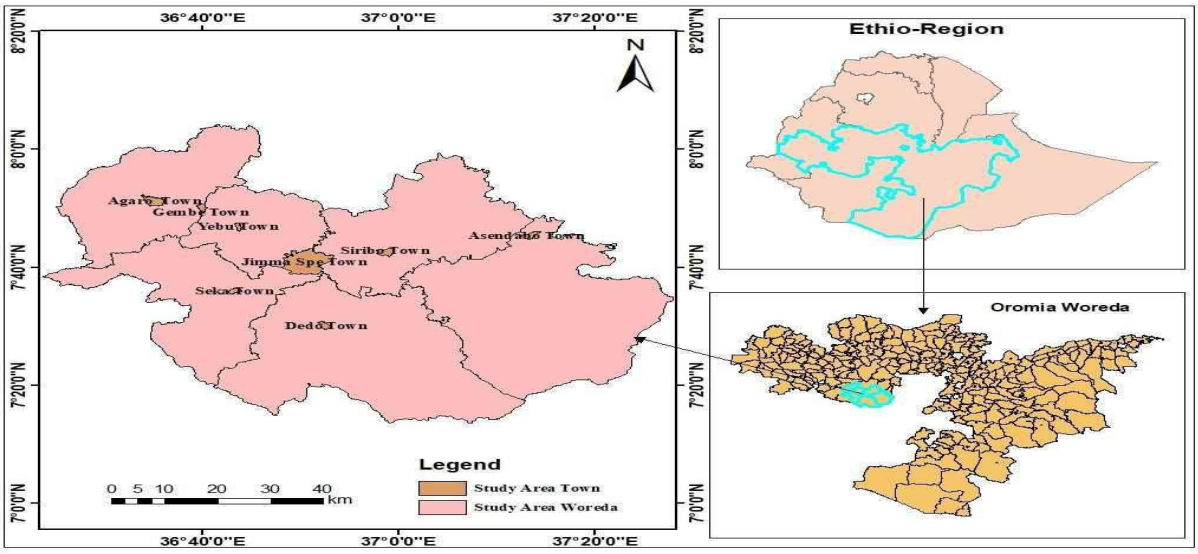


Figure 1: Map of study area for bovine metacestode

Study Population.

The study animal were all cattle comes from different districts of Jimma zone to Jimma municipal abattoir for slaughtering purpose. Those are 384 cattle of two breed (47 cross and 337 local breed). Both sexes (58 females and 326 male), body condition score was made (35) and recorded as poor, medium and good. The age of the animal was estimated by looking to the dentition pattern of the animals (36). Based on this, study animals were classified as < 5 year and >5 year. Animal origins were categorized into Jimma, Agaro, Blida, Dedo, Asendabo, Serbo, Seka, Kefa and from Unknown districts.

Study Designs.

A cross sectional study was carried out to assess the prevalence, determinants, and economic significance of major metacestode of cattle slaughtered cattle at Jimma municipal abattoir from October 2019 to June 2020.

Sampling method and Sample Size Determination.

Simple random sampling technique was employed to select the study animal. The total number of cattle required for the study was calculated based on the formula given by (37). By rule of thumb where there is no information for an area, it is possible to take 50% prevalence. In this study 50% prevalence with 5% desired level of precision and 95% of confidence interval are used to calculate the sample size using the following formula.

$$N=\frac{1.96^2 \times Pexp\ (1-Pexp)}{d^2}$$

Where N= Sample size

Pexp= expected prevalence

d= desired absolute precision

Then by taking Pexp=50% and d=5%

$$N = 1.96^2 \times 0.5(1-0.5)/0.05^2$$

N=384

Abattoir Based survey

During meat inspection, carcasses and their respective organs were carefully examined in accordance to the procedures of the Ethiopian Ministry of Agriculture Meat Inspection Regulation (1972) for the detection of T. *saginata cysticercosis* and *hydatidosis*.

During ante-mortem inspection, each of the study animals was given an identification number (with a paint mark on their body). Origin, breed, age, sex and body condition scoring of the study animals were also recorded accordingly.

During meat inspection of each organ of an animal was strictly and separately examined to avoid mixing up of organs. All cattle slaughtered on visiting days of the abattoir were examined at Jimma University school of veterinary medicine. Postmortem examination was conducted thorough visual inspection, palpation and systemic incision of each visceral predilection sites such as heart, tongue, masseter muscle, diaphragm, neck muscle, thigh muscle, spleen, liver and lung were being inspected carefully for the presence of metacyst of *Taeniasis* and *Hydatidosis* (47).

The infected organs from positive animal were collected; the total number cyst was counted per infected organ and recorded. The size of the diameter of hydatid cyst, was measured and classified as large (>10cm), medium (5 - 10cm) and small (Diameter<5cm) (26).

Assessment of Direct Financial Loss due to organ condemnation

Losses due to infected organs and tissue condemnation were calculated by considering information on the recent market price of the condemned organs and tissues (22) at butcher shops and customer interview in Jimma town. Direct losses were calculated on the basis of the condemned organs and tissues (38). Average market prices of the lungs, liver, spleen, kidneys, heart, tongue and a kilogram of beef were found to be 20, 60, 10, 15, 30, 20 and 240 Ethiopian Birr (ETB), respectively. The economic loss due to condemnation both totally and partially was estimated by the weight of each organ per (kg) and its current price in Jimma town. Financial losses were then computed mathematically by adapting the formula of Ogunrinade and Ogunrinade (1980) as follows:

$$EL = n\ Srx * Coy * Roz$$

Where:

EL = estimated annual economic loss due to organs condemnation from domestic market

n Srx = annual cattle slaughter rate of the abattoir

Coy = average cost of each cattle liver/ lung/ heart /kidney

Roz = condemnation rate of cattle liver /lung/ kidney/ heart

Data Management and Analysis

The data has been entered and managed in Microsoft Excel. All the data analysis has done by Stata software version 14. The prevalence of metacyst was analyzed using percentages. Accordingly, after chi square testing for Bernoulli assumptions both bi-variable and multi variable analysis were performed to determine the occurrence of metacestode by explanatory variables. Variable with P value less than 0.3 in the Bi variable was fitted for multi-variable analysis. The result of Bi-variable analysis was presented as Crude odds ratio (COR) with 95% CI and to identify the predictors of metacestode among slaughtered cattle on the Jimma municipal abattoir, adjusted odds ratio (AOR) with 95% CI was computed and a P-value <0.05 was used as a measure of statistical significance.

RESULTS

Frequency distribution of variable

A total of 384 bovines were sampled in the Jimma municipal abattoir. Among these 77 (20.05%), are originated from Bilida, and 66 (17.19%) from Sarbo. In this study nearly two-third 235 (61.20%) of the cattle sampled for investigation were found in the age of >=5 (adult). Regarding the breed of cattle, the majority 337 (87.76%) of cattle sampled were local breed. in terms of sex the majority 326 (84.90%) of cattle were male in sex. Regarding body condition of the animal around 190 (49.48%) of the sampled cattle had good body condition (Table 1).

Table 1: frequency table of Variable on Metacestode

Variable	Category	Frequency	Percentage (%)
Origin	Seka	28	7.29
	Agaro	38	9.90
	Asendabo	30	7.81
	Bilida	77	20.05
	Dedo	45	11.72
	Jimma	42	10.94
	Kefa	10	2.60
	Sarbo	66	17.19
	Unknown	48	12.50
Breed	Local	337	87.76
	Cross	47	12.24
Sex	Male	326	84.90
	Female	58	15.10
Body Condition	Good	190	49.48
	Medium	117	30.47
	Poor	77	20.05
Age	<5	149	38.80
	>=5	235	61.20
Pus formation	Negative	325	84.64
	Positive	59	15.36
Level of condemnations	Pass	185	48.18
	Partially	74	19.27
	Totally	125	32.55
Total		**384**	**100%**

Prevalence

Out of 384 bovine examined 197 (51.3%, 95%CI: 46.29-56.29) were found positive for Metacestode of which 191 (49.74%, 95CI: 44.74-54.75) and 9 (2.34%, 95%CI: 1.22-4.45) were positive for Hydatid cyst and Cysticercous bovis, respectively. (Table 2).

Table 2: The prevalence of Metacestode among cattle slaughtered at Jimma abattoir

	Category	Frequency	Percent (%)	CI
Metacestode	Negative	187	48.70	43.71 53.72
	Positive	197	51.30	46.29 56.29
Hydatid Cyst	Negative	193	50.26	45.25 55.26
	Positive	191	49.74	44.74 54.75
C. Bovis	Negative	375	97.66	95.55 98.78
	Positive	9	2.34	1.22 4.45
Total		**384**	**100%**	

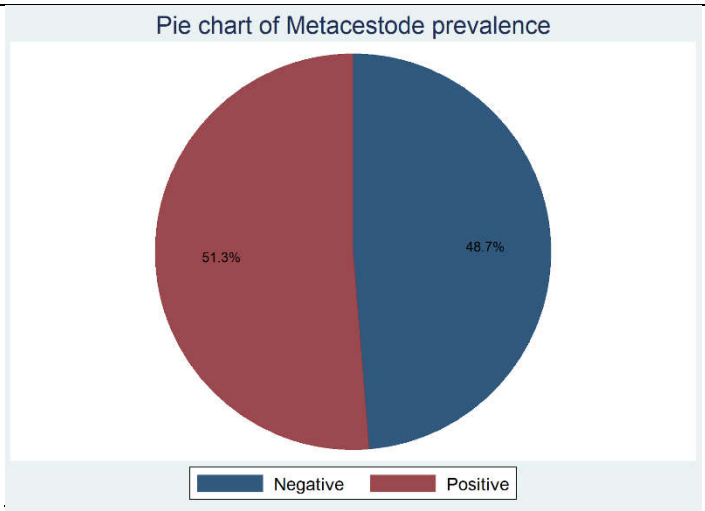


Figure 2: Prevalence of metacestode in the study area

In this study there were variation on the prevalence of metacestode among cattle found in Jimma zone of Ethiopia. Regarding area prevalence, the highest prevalence of metacestode were found in Asendabo (66.67%) followed by Bilida (58.44%) and Agaro (57.89%) and lowest in Sarbo (43.94%) and Kefa (40%) (Figure 2).

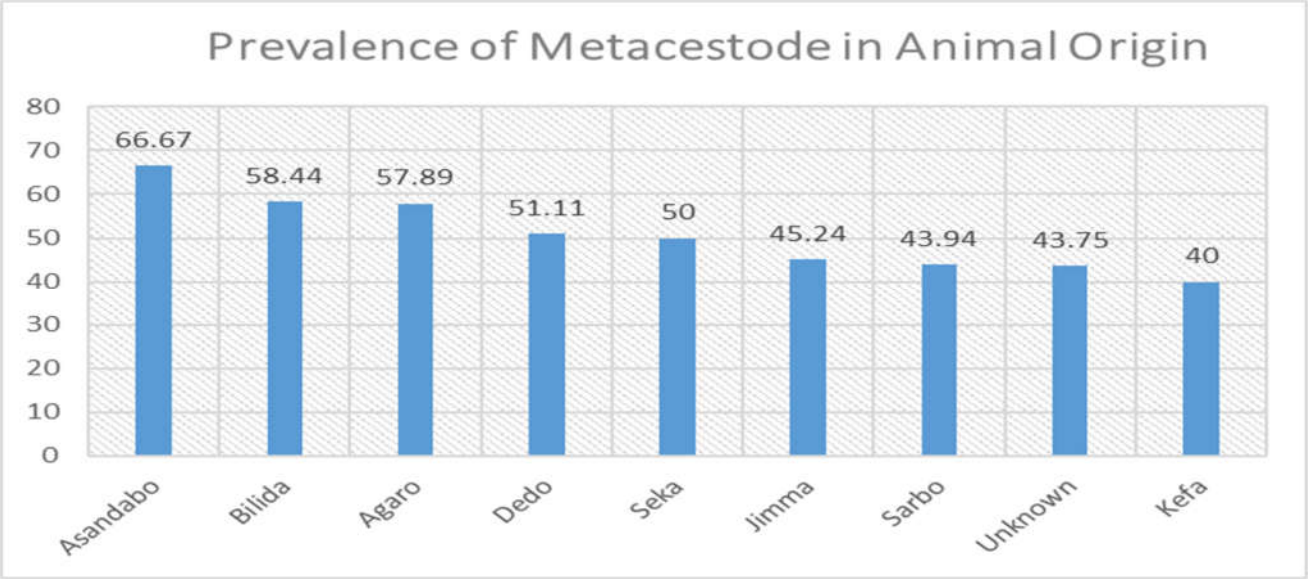


Figure 3: Prevalence of metacestode among the origin of animal

Associated risk factors

The present study used multivariable logistic regression model for the analysis of risk factors that affect the occurrence of metacestode on the study area. All of the variables that were found significant at p-value <0.3 were included into multivariable logistic regression model for further analysis to control confounding.

On the multivariable logistic regression analysis association of potential risk factors for the occurrence of metacestode were depicted on table 4. Accordingly, there was a significant association (P< 0.05) in the prevalence of metacestode between sex, age, body condition, (table 4).

Logistic regression analysis of the potential risk factors revealed presence of significant difference in the prevalence of Metacestode between sex, body condition and age of animals (*P* <0.05). In line with this female (OR=2.41, 95%CI=1.27-4.60), poor body condition (OR=3.61,95% CI=1.96-6.63), medium body condition (OR=2.46, 95% CI=1.49-4.05), and age ≥ 5 (OR=2.87, 95%CI=1.82-4.52) had higher odds to acquire Metacestode infestation than males, good body condition and age <5 years of animals respectively. Conversely, statistically insignificant association (P>0.05) was observed for ages, breed and origin of the animals

Table 3: Bi-variable logistic regression analysis of risk factors for bovine Metacestode among cattle slaughtered in Jimma municipal abattoir

Risk factor	Category	Presence of Metacestode		COR	95%CI		P-value
		-Ve	+Ve				
Origin	Seka	14	14	1	1		
	Agaro	16	22	1.38	0.52	3.67	0.525
	Asendabo	10	20	2.00	0.69	5.78	0.200
	Bilida	32	45	1.41	0.59	3.35	0.442
	Dedo	22	23	1.05	0.41	2.69	0.926
	Jimma	23	19	0.83	0.32	2.15	0.696
	Kefa	6	4	0.67	0.15	2.89	0.588
	Sarbo	37	29	0.78	0.32	1.90	0.590
	Unknown	27	21	0.78	0.31	1.98	0.598
Breed	Local	162	175	1	1		
	Cross	25	22	0.82	0.44	1.50	0.511
Sex	Male	168	158	1	1		
	Female	19	39	2.18	1.21	3.94	0.009
BCs	Good	115	75	1	1		
	Medium	48	69	2.20	1.38	3.53	0.000
	Poor	24	53	3.39	1.93	5.95	0.000
Age	<5	94	55	1	1		
	⩾ 5	93	142	2.61	1.71	3.98	0.000
Total		**187**	**197**				

COR: Crude Odds Ratio, CI: Confidence Interval, 1: Reference

Table 4: Multivariable logistic regression analysis of risk factors for bovine Metacestode

Risk factor	Category	Presence of Metacestode		AOR	95%CI		P-value
		-Ve	+Ve				
Origin	Seka	14	14	1	1		

	Agaro	16	22	1.19	0.40	3.47	0.757
	Asendabo	10	20	1.90	0.61	5.96	0.271
	Bilida	32	45	1.30	0.50	3.38	0.586
	Dedo	22	23	0.92	0.33	2.57	0.870
	Jimma	23	19	0.63	0.22	1.80	0.388
	Kefa	6	4	0.58	0.12	2.90	0.511
	Sarbo	37	29	0.66	0.25	1.75	0.407
	Unknown	27	21	0.65	0.23	1.82	0.315
Sex	Male	168	158	1	1		
	Female	19	39	2.41	1.27	4.60	0.008**
BCs	Good	115	75	1	1		
	Medium	48	69	2.46	1.49	4.05	0.000**
	Poor	24	53	3.61	1.96	6.63	0.000**
Age	<5	94	55	1	1		
	⩾ 5	93	142	2.87	1.82	4.52	0.000**
Total		**187**	**197**				

AOR: Adjusted odds ratio, CI: Confidence interval, 1: Reference *Significance at P<0.05, **Significance at P<0.01

Distribution of Metacestode among the organ of animal

The present study showed that the highest prevalence of hydatid cysts was observed in the lung (58.64%), and liver (23.04%). While in case of cysticercus bovis the highest prevalence was detected in heart (33.33%) (Table 5)

Table 5: Distribution of hydatid cysts & C. bovis in different organs of positive cattle

Organ	Number of H. cyst	Percent (%)	Number of C. bovis	Percent (%)
Lung	112	58.64	0	0.00
Liver	44	23.04	0	0.00
Heart	6	3.14	3	33.33
Kidney	0	0.00	0	0.00

Neck-Muscle	0	0.00	2	22.22
Tongue	0	0.00	1	11.11
Masseter Muscle	0	0.00	2	22.22
Spleen	8	4.19	0	0.00
Diaphragm	0	0.00	1	11.11
Liver and lung	21	10.99	0	0.00
Total	**191**	**100**	**9**	**100**

Size of Hydatid Cyst

On this study out of 190 hydatid cyst identified during study period, the proportion of small, medium, large and mixed cyst were 13.16%, 7.89%, 4.21% and 74.74%, respectively. From the hydatid cyst found on lung majority 79 (70.54%) had mixed size and 14 (12.50%) had small and medium size respectively. Regarding the cyst found on liver 36 (83.72%) had mixed size (Table 6).

Table 6:- The size of hydatid cyst in the respective organ inspected at Jimma municipal abattoir

Organ	Small cyst	Medium Cyst	Large Cyst	Mixed Cyst	Total
Lung	14	14	5	79	**112**
Liver	4	1	2	36	**43**
Heart	5	0	0	1	**6**
Spleen	2	0	0	6	**8**
Liver and lung	0	0	1	20	**21**
Total	**25**	**15**	**8**	**142**	**190**

Financial loss assessment

The direct financial loss was analysed based on the information obtained during post-mortem examination and interview. Accordingly, the annual loss due to organ condemnation was calculated to be **528,155.32 ETB** (Table 7)

Table 7: Financial loss assessment among organ condemned at Jimma municipal abattoir during study period

Organ inspected	No of organ condemned	Percent involvement of organ	Average unit price
Lung	112	29.16%	20
liver	44	11.46%	60
heart	6	1.56%	30
tongue	1	0.26%	20
spleen	8	2.1%	10
Total	**171**	**44.54%**	**140**

EL = n Srx * Coy * Roz

EL= 8470X44.54X140

= 528,155.32 ET

DISCUSSION

Both metacestode of the Taeniosis and echinococcosis are downgrading and responsible for lowering the quantity and quality of animal commodities. Out of 384 bovine examined 197 (51.3%, 95CI: 46.29-56.29) were found positive for Metacestode. Among this the overall prevalence of cysticercosis in cattle slaughtered at Jimma Municipal abattoir was 2.34%, which is comparable to the prevalence of 2.0 % from Bedelle municipality abattoir (39), 2.6% around Batu (40), and 1.7% from Shashemene (12). Conversely, the current finding lower than previous findings conducted in Southern Ethiopia 26.25% (41) and also in Hawassa municipal abattoir (22.9%) (42) and in Northwestern Ethiopia (18.49%) (43). But this study is relatively higher than study conducted in Croatia (0.11%) (44) and South Africa (0.2%) (45). This could be due to better application of public health extension education (developing the habit of using a toilet) and meat inspection techniques.

Variations in the values of prevalence for the bovine hydatid cyst from different parts of globe have been reported. In this study from the overall prevalence of metacestode in Jimma municipal abattoir, the Hydatid accounts 48.96%. This result similar with the study conducted in Debre Markos (48.9%) (26) and Shashemane (50.1%) (12). Conversely, this result was relatively lower than study conducted in Jimma (85%) (21) and slightly higher than study conducted in Bishoftu (42.86%) (46) and in Jimma(31.44%) (28). However, the current prevalence of hydatid cyst in contrary with the study conducted in northern India (5.39%) (47) and (2.76%) in Hail province of

Saudi Arabia (48). This variation on the prevalence of metacestode could be due to differences in management system, topography, de-worming practices and climatic condition that favors the survival of infective stage of the parasite.

Regarding determinants of metacestode in Jimma municipal abattoir, regression analysis identified several factors that affect the occurrence of metacestode. Sex, age and body condition of animal were among factors significantly associated with the occurrence of metacestode in cattle in and around Jimma town.

In this study, statistical analysis has revealed that; there is a significant relation ($P<0.05$) between sex of animals and occurrence of metacestode. Accordingly, being female 2.41 (95% CI=1.27-4.60) times more likely acquire the disease as compared to male. This finding is consistent with previous study done in Ethiopia by (49). This might be due to differences in exposure to infection as a result of the variation in stocking density (sex ratio). One more reason to elevated prevalence value observed in cows might be due to their longer captivity for breeding that increase the chances for higher prevalence and intensity to the parasitic infections (50). Certain factors can break down the immunity to parasitic diseases in female animals like various stages in the reproductive cycle, lactation and gestation. However, this result is contradicted by (43,51).

This study identified that body condition of animal was strongly associated with the occurrence of metacestode in Jimma municipal abattoir. According to this study animal that had poor body condition 3.61 (95%CI=1.96-6.63), and medium body condition 2.46 (95%CI=1.49-4.05) more likely attain metacestode as compared to animal that had good body condition. This finding is in line with the study conducted in Ethiopia (52). This might be due to in moderate to severe infections, the parasite may cause retarded performance and growth, reduced quality and yield of meat and milk as well as live weight loss (38).

There were statistically significant association ($P<0.05$) between occurrence of metacestode and age of the animal. Found on the age of >5 years of age increase the odds of attaining metacestode infestation as compared to the animal that are found on the age of <5 years of age. This finding agrees with studies conducted on different part of Ethiopia (25,53). The possible explanation could be the age increase; the risk of developing disease is also increases

In the present study, direct financial loss was estimated to be **528,155.32 ETB** were lost due to the effect of the diseases during the study period on the peculiar organs examined. Affected organs were condemned accordingly as per the degree of infestation. Variations in the amount of economic lost in different abattoirs probably due to the differences in the prevalence of diseases, rejection rate of organs, slaughtering capacity of the abattoirs, local market price of organs and management of animals.

CONCLUSION

The present study has shown that metacestode is a major cause of organ condemnation at Jimma municipal abattoir with having the overall prevalence 51.3%, from this hydatid cyst and Cysticercus bovis accounts 49% and 2.3% respectively. Most risk factors such as sex, age, body condition of animal have significant relationship ($p< 0.05$) with the presence of parasitic infestation. Accordingly, being female, having poor and medium body condition and also found on the age of >5 years are factors that affect the occurrence of metacestode in the study area. **528,155.32 ETB** were lost due condemnation of organ infested by this parasite this year. This high prevalence of metacestode in the study area indicates the disease has a great economic importance and requires a great control and preventive issue. So to minimize the wide spread prevalence of this parasitic problem in the study area Prohibition of back yard and road side slaughter activities, and construction of fenced abattoirs in towns and villages controlled by properly trained meat inspector should be conducted.

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Assessment of Medicinal Plants Used to Treat Human Diseases in Mille District, Afar Regional State, North-eastern Ethiopia

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ABSTRACT

Ethnobotanical study of medicinal plants was conducted in Mille district, Afar regional state, Ethiopia. The aim of the study was to assess medicinal plants used to heal human diseases by traditional healers. Among twelve (12) Kebelles of the district four (4) Kebelles were selected purposefully. The data were collected using semi-structure interview and focused group discussion. Thirty (30) informants were selected purposively by the help of district administration and elders. A total of 21 plants species were documented. Most claimed plants are trees (52.6%), leaf part was also widely used (41.6%) than others. The frequently used route of administration is oral which accounts 62.5%. Aloe was the most important plant species to treat different human disease and the species was ranked first. The traditional knowledge transfer mechanism for generations is very important experience. As per the informants, wild growing medicinal plants are the most efficacious. Further exploration of traditional knowledge and conservation of dry wood forest is vital.

Keywords: Ethnobotany, Medicinal plants, traditional healer, Mille, Afar

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INTRODUCTION

Peoples have been utilizing plants for basic preventive and curative health care for long time. In most developing countries common use of medicinal plants to maintain good health, has been widely observed (UNESCO, 1996) and the concern and knowledge varies from region

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to region, and from community to community (Fekadu Fullas, 2010). Currently more than 800 (eight hundred) species of plants are used in traditional health care system to treat nearly 300 (three hundred) mental, physical and other disorders. In Africa, traditional medicine is the oldest therapeutic system and the practices are varied forms and holistic. The traditional healers typically diagnose and treat psychological basic of illness before prescribing medicines (Van Wyk., 1999).

In Ethiopia about 800 plants are used in traditional health to treat nearly 300 disorders. The wide spread use of traditional medicine could be attributed to cultural acceptability efficiency against certain types of disease, physical acceptability and economic affordability. Ethiopian traditional medicinal system is characterized by variation and shaped by ecological diversities, socio-cultural background as well as historical development. The existence of traditional medical pluralism in the country, either the knowledge from herbalists was passed secretively from one generation to the next through world of mouths or their descendants the medico-spiritual man scripts (Asfaw Debela et al, 1999).

Nearly 80% of the Ethiopian population is still dependent on traditional medicine, which largely involves the use of plants (Tesfaye Hailemariam, et al, 2009; Mirutse Giday et al, 2003). However, little effort has so far been made to documented medicinal plant and associated knowledge despite ongoing deforestation, environmental degradation and accumulation in the country (Mirutse Giday et al, 2003). In Afar region, people have also traditional practices which they put in to effect for generation to take care of themselves (AWAO, 2009) and it have important contribution in the primary health care system of local communities (Sibhatu Gebrehiwot et al, 2019), but enormous knowledge is still being lost before it is recognized and properly documented. Thus, the objective of the study was to document traditional medicinal practices and plants used.

MATERIALS AND METHODS

Description of the study area

Mille is one of 39 districts of the Afar region of Ethiopia which located in the administration Awsi rasu of Afar region. There are 12 kebelles in Mille district both in rural and urban areas. Mille bordered on the west by Chifra, on south Yangudi district, on east Logia and north Teru. Mille district far from the country capital city of Addis Ababa around 480 km.

The average temperature of the district is 23^0c - 44^0c throughout the year in the district. The climatic condition of the district is characterized by arid and semi-arid with low and short

rain fall pattern. The rain fall is bi-modal throughout the year with mean annual rain fall ranges bellow 200 mm. This indicates the district is highly prone area to concurrent drought. Based on the statistics report, Mille district has estimated total population of 92,778 out of this 50, 996 are males and 41, 782 are females (CSA, 2008).

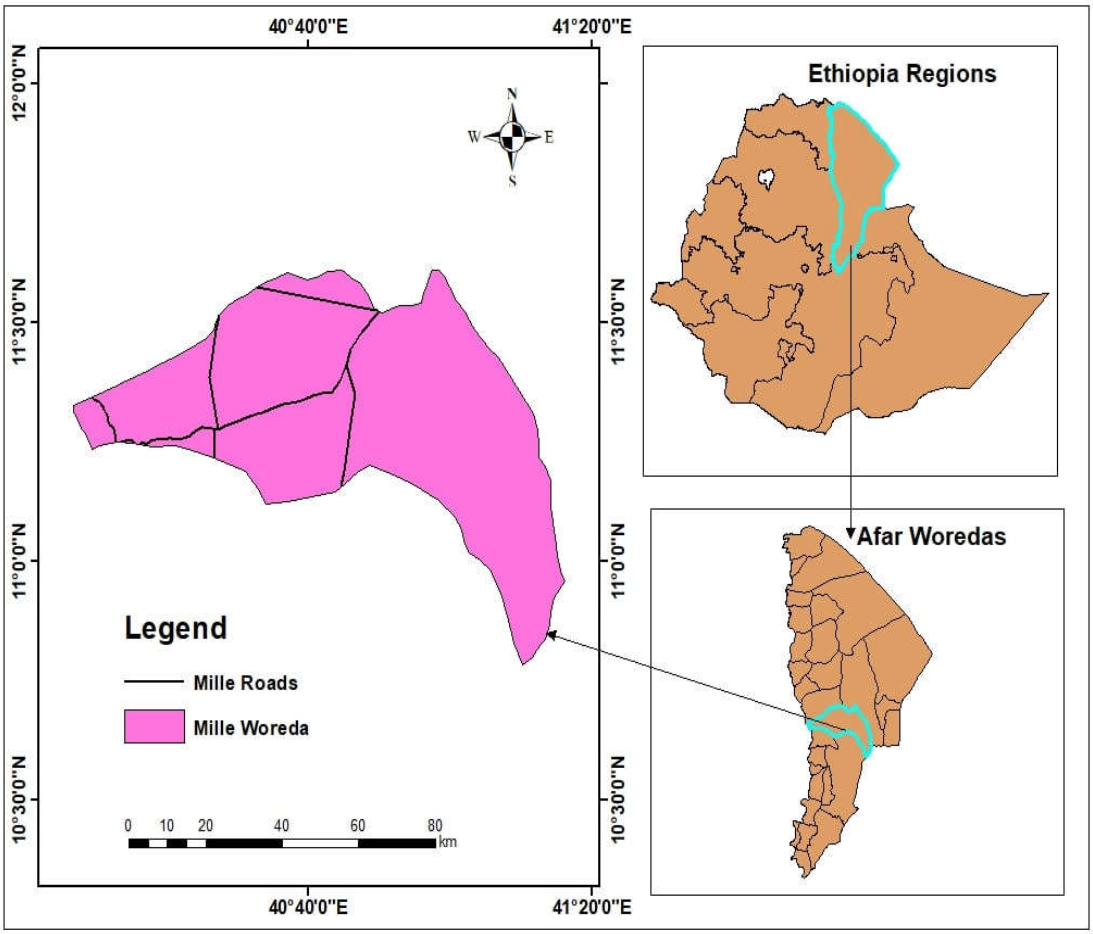


Fig. 1: Map of the study area

Survey and site selection

Primarily, permission was obtained from Mille administration. Following this, survey and site selection were accomplished. A total of 4 kebelles located at varying distance from the main center namely 01 kebelle, Harsis, Bekedar and Hantimegatan were selected.

Selection of informants

Informants age of 18 and above were involved in the study. The identification was employed with the help of Mille administration. Finally, 30 informants were selected in which 90 % male and 10 % female.

Data collection techniques and data type

Both primary and secondary data are used. The secondary data was collected from published and unpublished material and documented. Primary data was collected using semi-structured interview, focus group discussion. The interview was list of question prepare in English and translate to local language (Afar af).The traditional healers were asked to provide information on plant used against any kind of illness in human and particular plant type and part used, method of preparation and routes of administration. The age range of the informants was between 18-80 and both male and female were participated. Interview was conducted with 30 informants in Afar af language. Focus group discussion was employed with 5 key informants whom selected based on their knowledge and use of medicinal plant. The fidelity level and ranking of each claimed medicinal plant was accomplished based on these informants.

Data analysis

The data were transferred in to Microsoft excel and summarized. Preference ranking Matrix ranking was employed to rank up medicinal plant with various ethnobotanical roles. The fidelity level also been employed to rate the comparative curative capacity of the plant and it was calculated by applying the following formula.

$$\mathbf{FL = [SF/TF] * 100}$$

Where: SF refers to frequency of citation for specific aliment.TF – refers to total number of citation of that species.

Relative importance (RI) of the medicinal plants was calculated.

$$\mathbf{RI = NBS + NPP}$$

Where: RI = relative importance, NBS = number of body systems and NPP = number of pharmacological properties. NBS is obtained by dividing the number of properties (reported specific ailments) attributed to a species divided by the total number of properties attributed to the most versatile species. NPP is the number of body system treated by a given species divided by the total number of body systems treated by the most versatile species. Species with RI value of 2.0 (the highest possible value) are the ones with the highest diversity of medicinal application.

RESULTS

Medicinal plants reported

A total of 21 medicinal plants of different growth habit used to treat human ailments were documented (Table 1, appendix I) of these 52.4% of trees, 38.1% tree, 4.75% climber and 4.75% of herbs. Most of the claimed plants are trees.

Table 1. Medicinal plants growth habits

S. No.	Growth habit	Frequency	Percentage
1	Tree	11	52.4%
2	Shrub	9	38.1%
3	Climber	1	4.75
4	Herb	1	4.75%
	Total	21	100%

Plant parts commonly used to treat human health problems include- leave, root, steam and all plant parts (Table 2). The preparation of traditional healers used plant leaves (41.6%), root (33.4%), steam (8.4%) and all plants parts (16.6%) to prepare medicines. The leaf part of the plants was frequently used part. There are some plants in which two plant parts used for medicine preparation and this why the total is 24.

Table 2. Parts of plant used to prepare the medicine

S. No	Parts of plant	Frequency	Percentage
1	Leaf	10	41.6%
2	Root	8	33.4%
3	Stem	2	8.4%
4	All plant part	4	16.6%
Total		24	100

Mode of preparation

Traditional medicinal plants was prepared in various ways by different traditional knowledgeable local healers in the area were vary as the type of disease.

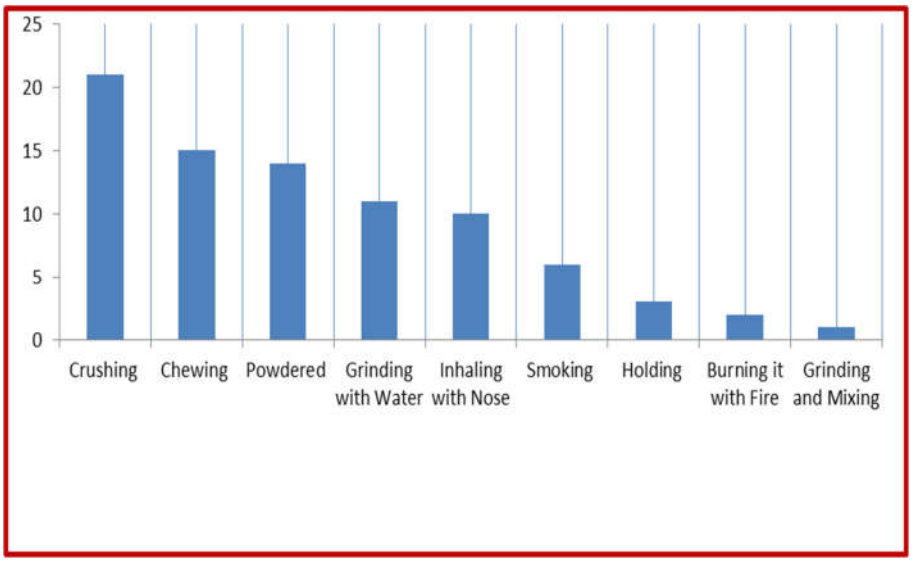


Fig. 2: Mode of Preparation

Fidelity level

Table 3. Fidelity level of the medicinal plants

S.No.	Medicinal plant species	Number of diseases	Rank
1	*Moringa oleifera*	4	2nd
2	*Aloe* spp.	5	1st
3	*Senna alexandrina*	3	3rd
4	*Balanites rotundifolia*	2	4th
5	*Acacia nubica*	2	4th

In the above table-3 result of fidelity level for five medicinal plants to treat human illness shoes that *Aloe* species. high number of treating was ranked 1st and *Acacia nubica* with low number treating was list as last/4th rank.

Route of administration

Table 4. Route of administration of the medicinal plants

S.No.	Routes	Frequency	Percentage
1	Oral	15	62.5%
2	Dermal (skin)	4	16.67%
3	Nasal (inhaling in nose)	4	16.67%
4	Other	1	4.16%
	Total	24	100%

Traditional knowledge transfer

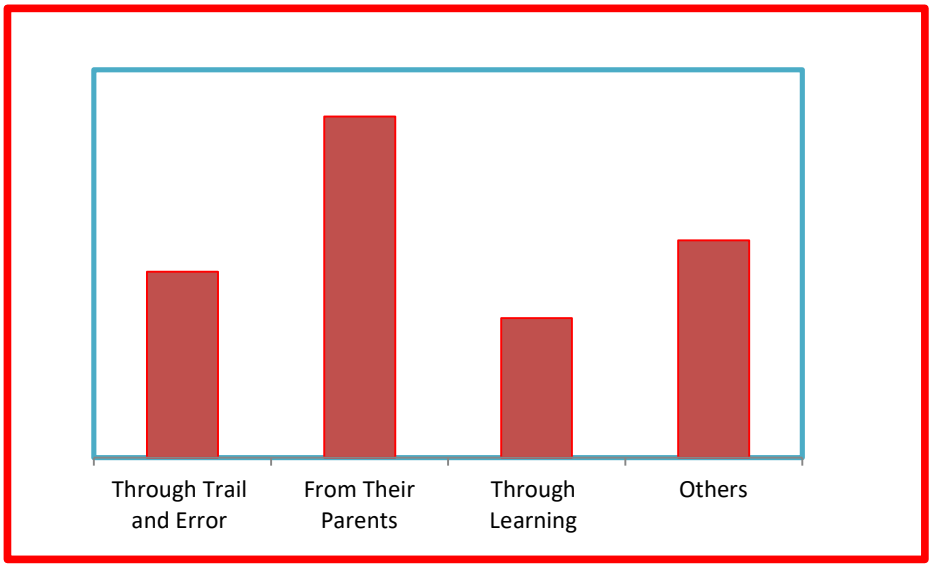


Fig.3. Traditional knowledge transfer

Dosage measuring instruments

The local healers used traditional devices to measured dosage and amount of medicines. The dosage measured by the local healers mostly used by local materials using in different age restriction. The dose was measured in various ways using coffee and tea cup for drink for children and for oldest by water cup and powdered material are measured by hand and spoon.

DISCUSSION

The current study identified 21 medicinal plants that have been used by the local people of Mille district, Afar, Ethiopia. The growth habits of medicinal plants are shrubs and trees. The fresh plant part were claimed the most curable. The leaf and root are widely used parts respectively (Kflay Gebrehiwot and Mohammed Shumbahri, 2015). Previous studies employed in different parts of Ethiopia showed leaf is widely and frequently used plant part (Mirutse Giday et al, 2003). This is in line with the current study and this phenomenon may decrease the destruction of medicinal plants (e.g. tree and shrub). The fidelity level reveals that crushing and chewing were the most frequently used methods of preparation. The highest rank or fidelity level (FL) was given to 5 (five) medicinal plants based on their highest level of value. Accordingly, *Aloe* (Uurayta) shows with highest medicinal value in terms of number of diseases treated (Trotter and Logan, (1986). The knowledge transfer of traditional knowledge from generation to generation in the study area is paramount important to

document the knowledge and further for pharmacological production. The most common indigenous knowledge transfer mechanism of this study revealed that, they obtained from their parents and higher numbers of medicinal plants were reported by informants among 25-30 age groups. This result confirmed that the traditional knowledge declined from elder to younger age group and this is in line with Mirutse Giday et al, (2003), in which 90 % of the elder above 40 year possessed with enough knowledge in medicinal plants. The dosage handling mechanisms of the healer is very impressive. The dosage could vary in relation to type of alignment, client and it ranges from a droplet up to liters but taking highest dose can be toxic (Giday and Teklehaymanot, 2013).

CONCLUSION

The ethnobotanical study of medicinal plants in Mille district was aimed to help local people to take care of their health problems. The wisdom of local community in using plants for medication is continuing from generation to generation. The leaf part was widely used. Thus, they are equipped with how to use without affecting the plant survival. This has to be recognized and documented in proper manner and applies it for different purposes. Finally the investigator recommended the following;

- The knowledge of traditional medicine is not fully explored. Thus further study is required.
- Studying current status of claimed plants is important for further intervention.
- The connection of professional health expert and traditional healer is important for efficacy and clinical trial studies.
- Establishing institutions for indigenous knowledge collection, research and utilization.

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Appendix I. Medicinal plant species composition

Local name	Scientific name	Family name	Growth habit	Plant part	Disease treated	Preparation	Route of application	Dose
Olayto	*Aerva javanica* (Burm.f.) Juss ex Schullt	*Amaranthaceae*	Shrub	All part	Snake disease and wound	Chewing, hold	Oral	Small amount of the plant parts
Uureyta	*Aloe* species	*Aloaceae*	Shrub	Root	Vomiting, Diarrhea, Eye, Fever Abdominal pain	Crushing and mix with water for a few minute then drink	Oral	One coffee cup
Ayrowagit	*Senna italica Mill.*	*Fabaceae*	Tree	Root Leave Leave	Abdominal pain Headache Wound	Chewing and mix water and drink Crushing and mix with water and inhaling in nose Powdered and put in wound	Oral	One cup of coffee
Halbona	*Euphorbia actinoclada Carter*	*Euphorbiaceae*	Climber	Root	Influenza Malaria	Chewing	Oral	One a cup of coffee
Shiferaw	*Moringa oleifera*		Tree	Leave	Influenza Fever Hyper tension	Grinding and mix with boil water then drink	Oral	One a cup of coffee
Gini kusra	Ziziphus mucronata	*Rhamnaceae*	Tree	Root	Headache, skin infection Goiter	Grinding and mix with water then drink	Oral	One a cup of coffee
Bunaytu	*Coffea arabica*	*Rubiaceae*	Tree	Leave	Abdominal pain	Crushing and mix with water then boil and drink	Oral	Tea cup
Leeh amo hara	*Kanahia laniflora* (Forssk.) R.Br.	*Ascepiadaceae*	Shrub	Root	Headache	Mix with water inhale in nose	Nasal	
Kusra	*Ziziphus spinachristi*	*Rhamnaceae*	Tree	Leave	Skin infection	Powdered and smear in skin	Dermal	
Dat hara	*Prosopis juliflora*	*Fabaceae*	Tree	Leave	Wound, Inflammation	Powdered and put in wound then mix with water and drink	Oral	One a cup of coffee
Saaganto	*Tamarix aphylla* (L.) Karst	*Tamaricaceae*	Shrub	Leave	Abdomen pain and Tuberculosis	Chewing of leave	Oral	
Uddayto	*Balanities ejeptica*	*Balanitaceae*	Tree	Leave	Wound,	Crushed leave in water both a	Other	

					Inflammation	few hours and wash as shower		
Galaqto	*Calotropis procerra* (Ait) f.	*Ascelepiadacea*	Shrub	Root	Cough, Common cold, Head ache	Crushed the roots and mix with water for few minutes then drinks	Oral	
Alayto	*Balanites rotundifolia* (van Tieghem) Blatter	*Balanitaceae*	Shrub	Leave	Abdomen pain Malaria	Powdering and mix with water and tea then drink	Oral	One a cup of coffee
Uddayto	*Balanites aegyptiaca* (L.) Del.	*Balanitaceae*	Tree	Roots	Diarrhea	Crushing and mix with water and shaking then drink	Oral	
Dammaho			Tree	Roots	Abdominal pain	The powdered root and mix with honey is eaten	Oral	One spoon
Uddayto	*Acacia nubica*	*Fabaceae*	Shrubs	All part, Root	Children disease, Dental diseases	Boiling whole parts and decanted the solution to drink and washing body	Oral	
Adaylu	*Jatropha glauca*	*Euphorbiaceae*	Shrub	Steam	Mental problem	Burning in fire and in haling its smoke nasally	Nasal	
Hantiululus	*Solanum coagulans* Forssk.	*Solanaceae*	Herb	All part	Skin infection	Powdered and paint	Dermal	
Auriba'la	*Solanum somalense*	*Solanaceae*	Shrubs	Root	Mental problem	Burning in fire and inhaling its smoke.	Nasal	
Elcayto	*Boswellia neglecta*	*Burseraceae*	Small tree	Gum	Evil eye	Burning it inhaling its smoke	Nasal and oral	
Datbarbare	*Schinus mole* L.	*Anacardiaceae*	Tree	All part	Dental diseases, Cough and lung diseases	Brushing teeth by the stem, boiling the leaf and fruit inhaling nasally	Oral and nasal	The amount is not limited

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Wild Edible plants study in a Dryland Ecosystem of Ethiopia

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ABSTRACT

The study was conducted in districts surrounding to Hirmi dryland, Northwestern Zone of Tigray region, to study the wild edible plant species (WEPs) type, use, threats, and conservation practices as well as associated community knowledge in the study areas. Six kebeles near Hirmi dryland were chosen to collect the necessary information, with 60 general informants and six key informants recruited. Data were collected through a semi-structured questionnaire, key informant interview, group discussion, and field walk. The collected data were analysed via descriptive statistics, preference ranking, and direct matrix ranking using their respective statistical and computer packages such as ANOVA and t-tests in SPS. A total of 41 wild edible plant species that belong to 35 genera and 28 families were recorded. The family Moraceae was represented by the highest number of species. Riverside was a good source (39%) of wild edible plants. 63% of the plants were eaten their fruit raw while it becomes riped. The informants identified Diospyros mespiliformis, Syzygium guineense, Vangueria madagascariensis, Ximenia americana, and Ziziphus spina-christi as the most abundant, diversified, and year-round wild food plants, accounting for more than 65% of WEP marketability. Deforestation, browsing, expansion of agriculture, over-harvesting, and timber production were the major threats to the wild edible plants. The community utilizes homegardening, awareness raising, selective fencing, and ecological restoration to combat these challenges. There was a significant difference (P 0.05) in the mean number of wild edible plants reported by informants of various ages, marital status, educational status, and experiences. There was no substantial difference between males and women, religion, or districts. Local peoples have indigenous knowledge and expertise in using and conserving wild edible pants, which necessitates participation in the government's sustainable forest management approach.

Keywords: Conservation, Ecological services, Hirmi, Indigenous knowledge, Wild edible plant

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1. INTRODUCTION

Wild edible plants are important components of natural vegetation that play an important role in guaranteeing food and livelihood security for countless families and communities worldwide (Lulekal et al., 2011). They play an important role in food security in arid and semi-arid regions (Assefa and Abebe, 2011). Traditional communities around the world have amassed a wealth of wild edible plant knowledge through extensive interactions with the natural environment (Cotton, 1996).

Indigenous knowledge about the functionality of food plants in Ethiopia has a very long history. Habitually the use of functional food plants is still widespread, acceptable, and popular in Ethiopia (Deribe et al., 2006). The knowledge, perception, use and management practice of edible plants in Ethiopia is being lost at an accelerated rate and disappearing with changes in lifestyle, occupational patterns of household members, and the death of knowledgeable persons (Garí, 2003). The other reason for the loss of indigenous knowledge and forest degradation is human interference such as an expansion of agricultural land, grazing, firewood and drought (FAO, 2010). Documenting the uses of plants as a supplemental value and source of food is noteworthy to understand the threats to the survival of the entire forest in general and wild edible plants in particular, with their means of management knowledge.

The forest around the study area is currently becoming scant and reduced because of various reasons, such as human intervention. A community in the study districts has day to day interaction with Hirmi forest. There is no doubt that, peoples in the study area has knowledge of the use and management practices of those edible plant species. However, it is obvious to occur a gap in the knowledge of sustainable utilization, conservation status, ecosystem services and socio-economical contribution of wild edible plants among the local community. In addition, collecting and documenting the Ethnobotanical uses of wild edible plants, conservation practices, and diverse uses of these plants by communities in the remote part of the country is inadequate (Soromessa et al. 2004; Lulekal et al., 2011). Hence the present study was conducted in a northern dryland landmass of the country, where no recorded document was there on this regard. Therefore, this study was conducted to meet the following the following objectives to: (a) document wild edible plant species, (b) determine the most popular wild edibe plants used, (c) assess the indigenous knowledge and utilization practices of wild edible plants by different social

groups, (d) evaluate the stastus and threats of wild edible plants species and (e) assess conservation practices of wild edible plants by the local community.

2. MATERIALS AND METHODS

2.1. Description of the study area

The present study was conducted in districts that surround to Hirmi forest (Fig. 1). The forest is surrounded by three districts of the north-western zone of Tigray namely; Asegde-Tsimbla, Tahitay-Koraro, and Medebay-Zana. It is situated at a latitude of 13º49'–14º04' N and a longitude of 38º14' –38º25'E, along the altitude ranges from 900-2200 meters above sea level (Girmay et al., 2020).

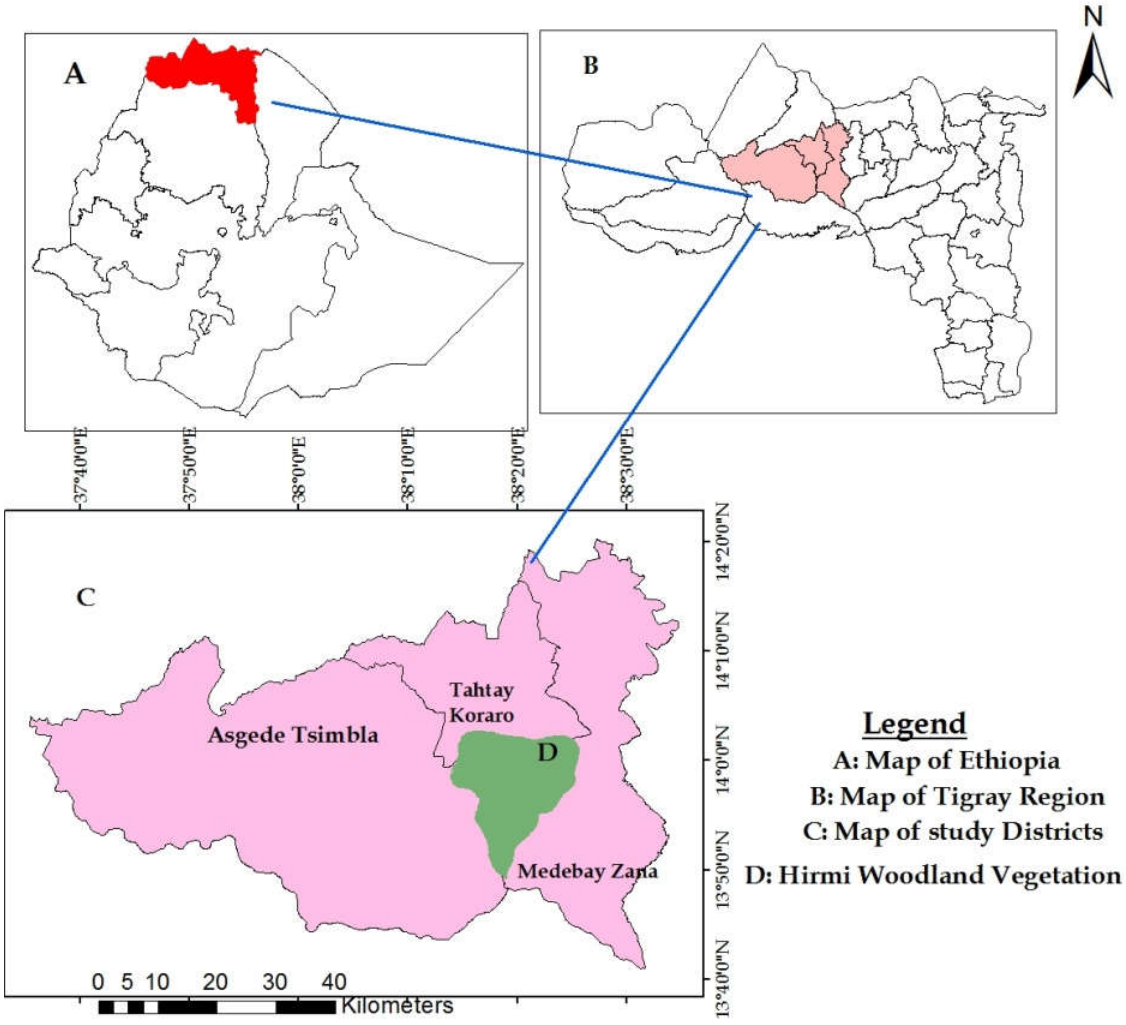


Figure 1: map of the study area(three districts)

2.2. Agro-ecology and climate

Hirmi vegetation is a dryland type landmass in northern Ethiopia, featuring Dry-evergreen mountain forests, Acacia-Commiphora, and Combretum-Terminalia woodland forest types. The study area has two climatic zones: lowlands (from 800-1500 masl) and intermediate altitudes (from 1501-2300 masl), with temperatures ranging from 14 to 35 degrees Celsius. The annual rainfall is between 720 and 1400 mm. Between June and/or up to mid-September, the research area has a high rainfall distribution (Girmay et al., 2020).

2.3. Socioeconemy, demography and land use type of the study area

Based on the 2015 national census conducted in the 3 woredas (in the 12 kebeles) where Hirmi forest falls, the total population of the area is 74,283 out of these 37,851 are males and 36,432 females (CSA, 2015). All (100%) of the local community in the study area are Tigrigna speakers. 98.02% of the study population are orthodox followers and the rest are Muslims.

2.4. Methods of data collection

A reconnaissance survey was carried out prior to collecting ethnobotanical and environmental data. The survey sought information/data on the area's agroecology, the status of wild edible plant species, and indigenous knowledge of local people in using plants for various reasons. Local leaders and certain informants were contacted during the survey, and the research site/Kebele/ was chosen.

The vegetation fell in three districts and twelve kebeles. Six kebele were chosen on purpose, with the Kebele closest to the forest being given precedence during the reconnaissance study. There were 4,868 householders in these kebeles, with a total population of 34,080. A stratified random sample was used to pick 60 general informants from the six kebeles of the three research Woredas (with age group above 18 years and by taking sex ratio into account). Purposive sampling was used to pick six key informants with good knowledge of wild edible plant consumption and management, as proposed by the local leader and locals in the study region (Alexiades, 1996; Addis et al., 2013).

Data were collected between September and October of 2020 using the Alexiades (1996) and Cunningham (1996) technique (2001). As a result, semi-structured interviews, guided field trips, and group discussions were used to collect indigenous knowledge about wild edible plants from the local people. All of the interviews were conducted using a checklist of questions developed in English and translated into Tigrigna, the local language of the residents. Following that,

interviews and conversations with informants and important informants were conducted. The debate focused on issues concerning wild food plants.

An interview is the basis of most ethnobotanical data collection methods (Addis et al., 2013). In this study, the ethnobotanical data of wild edible plants were collected using semi-structured interviews from randomly and purposively selected informants consists of knowledgeable elders, and youth of both sexes in the study area. It was an important tool for the collection of both qualitative and quantitative data on using and conservation of wild edible plans in the districts. Field observation and group discussion was made during the study about the status, acceptance, conservation and usage of wild edible plants by the local peoples. In each kebele, a small group discussion on the aforementioned topics was held with locals in general and important informants in particular. During the guided field visit with key informants, physical visits, walking chats, and photography of various wild edible plants were conducted. On-site, detailed notes on the manner of collection, landforms, significant risks, habits, and habitat were taken.

2.5. Methods of data analysis

The descriptive data analysis method was employed to summarize the information associated with wild edible plants obtained from the informants using an Excel spreadsheet. t-test and one-way ANOVA at a 95% confidence level was used to test the distribution of indigenous knowledge on wild edible plants among the informants. In addition, preference ranking was used to order wild edible plants based on their importance value across a community. The most important in the set is given the highest number, decreasing in number as the members of the set decrease in importance. Preference ranking was computed by taking six key informants to assess the degree of importance of those wild edible plants highly cited by the informants used as food at a particular time (Martin, 1995). Direct matrix ranking is also another method used to order wild edible plants by considering several attributes/uses for seven most frequently cited species by the informants. To recognize the wild edible plant species with multipurpose uses, values from 1–7 were given: the highest score has a high multipurpose value whereas the least score indicates species with a relatively small value.

3. RESULT AND DISCUSSION

3.1. Wild edible plant species in the study area

Wild edible plant specie has a significant role in filling the food insufficiency and insecurity gap in Ethiopia for a long time (Lulekal et al., 2011). The present study demonstrates the community that surrounding Hirmi forest has good knowledge and practice in using of plant and plant products as wild food. The study area is endowed with different wild edible plants which serve the local communities as food sources and for other purposes. It was recorded that 41 species belong to 35 genera and 28 families (Table 1). The families of Acanthaceae, Brassicaceae, Ebenaceae, Fabaceae, Rhamnaceae, Rutaceae, and Verbenaceae have the highest numeral of genera. In another regard, the plant family Moraceae was represented by the highest number (four) of species. The taxa *Ficus* species was the most common edible and diverse wild edible plant in the study area, showing the similarity with the study edible elsewhere by Hegazy *et al*. (2013). The wild edible plants found in the present study area have also been reported in different parts of the country by different investigators such as (Addis et al., 2013; Giday and Teklehaymanot, 2010).

3.2. Habit and distribution of wild edible plants

Of the recorded wild edible plants in the study area, shrubs were the most dominant wild edible plants used by the inhabitants with a quantitative proportion of 44%. Similar studies reported by Kebu Balemie and Kebebew (2006) in Derashe and Kucha districts reveal shrubs accounted for the highest part of wild edible plants in contrast with the rest of plant habits. This is because dry land agroecology is mostly endowed with shrubs and different bushs that adopt such type of landmass. Next to shrubs, trees cover 37% of the WEP's habit. A study conducted by Assefa and Abebe (2011) in South Omo agrees, trees and shrubs were the main sources of wild food in Benna Tsemay districts.

Table 1: list of wild edible plant species in the study destricts

Scientific name	**Family**	**Local name**	**Habit**	**Parts used**	**Mode of consumption**
Acacia abyssinica Hochst. Ex Benth.	Fabaceae	Chea	T	Gum	Raw
Acacia seyal Del.	Fabaceae	Keyihchea	T	Gum	Raw
Balanites aegyptiaca (L.) Del.	Balanitaceae	Mekie	T	Fruit	Ripe
Brassica carinata A. Br	Brassicaceae	Hamli Adri	H	AG	bioled/cocked

Carissa edulis (Forssk.) Vahl	Apocynaceae	Agam	S	Fruit	Raw
Citrus aurantiifolia (Christm.) Swingle	Rutaceae	Lemin	S	F	Raw
Cordia africana Lam.	Boraginaceae	Awhi	T	F	Raw
Cucurbita pepo L.	Cucurbitaceae	Duba	H	F	Via Cocking
Datura stramonium L.	Solanaceae	Mezerba'e	H	pollen nectar	Sucking Sucking
Dioscorea schimperiana Kunth	Dioscoreaceae		Cl	Root	Raw
Diospyros mespiliformis Hochst. ex A. DC	Ebenaceae	Aye	T	F	Raw
Euclea racemosa Murr.	Ebenaceae	Kuleo	S	F	Raw
Ficus hochstetteri A. Rich.	Moraceae	Tsekente	T	F	Raw
Ficus palmata Forssk. (Miq.)	Moraceae	Beleskola	S	F	Raw
Ficus sycomorus L.	Moraceae	Sagla	T	F	Raw
Ficus vasta Forssk	Moraceae	Daero	T	F	Raw
Flueggea virosa (Willd.) Voigt.	Euphorbiaceae	Harmazo	S	F	Raw
Hypoestes forskaolii (Vahl) R.Sch.	Acanthaceae		H	pollen nectar	Raw
Grewia ferruginea Hochst. exA. Rich.	Tiliaceae	Tsimkuya	S	F	Raw
Justicia schimperiana (Hochst. ex Nees) T. Anders.	Acanthaceae	Simieza	S	pollen nectar	Via Sucking
Lantana camara L.	Verbenaceae	Alalimo	S	F	Raw
Lepidium sativum L.	Brassicaceae	Shinfa'e	H	F	Crushed with other
Lippia adoensis Hochst. ex Walp.	Verbenaceae	Keskese	S	L	leaves with other
Mimusops kummel A. DC.	Sapotaceae	Kumel	T	F	Raw
Moringa oleifera Lam.	Moringaceae	Moringa	T	L	Via cocking
Opuntia ficus-indica (L.) Miller	Cactaceae	Beles	S	F	Raw
Phoenix reclinata Jacq.	Arecaceae	Siye	T	F	Raw
Rhamnus prinoides L'Herit.	Rhamnaceae	Gesho	S	L	Drink crushed leaf
Rhus retinorrhoea Oliv.	Anacardiaceae	Tetaelo	S	F	Raw drink
Rumex abyssinicus Jacq.	Polygonaceae	Mokmoko	H	Root	Drink with water
Rumex nervosus Vahl.	Polygonaceae	Mchicho	S	Young twing	eaten in raw
Ruta chalepensis L.	Rutaceae	Chena-Adam	H	L	leave with sauce
Sterculia setigera Del.	Sterculiaceae	Darle	T	Bark	Bioled/Raw
Syzygium guineense (Wild.)DC.	Myrtaceae	Liham	T	F	Raw
Tamarindus indica L.	Fabaceae	Humer	T	F	Raw
Terminalia catappa L.	Combretaceae	Wawa	T	F	Raw
Vangueria madagascariensis Gmel.	Rubiaceae	Guramayle	S	F	Raw
Woodfordia uniflora (A. Rich) Koehne.	Lythraceae	Lekemeja	S	pollen nectar	Sucking
Ximenia americana L.	Olacaceae	Mileo	S	F	Ripe
Ziziphus mucronata Willd.	Rhamnaceae	Abetere	S	F	Ripe
Ziziphus spina-christi L.	Rhamnaceae	Gaba	S	F	Ripe

Key: part of usd; F= fruit S= shrub L= leaf……..T= tree H= herb Cl= climber

3.3. Plant parts used and mode of consumption WEPs

The majority (63%) of the recorded wild edible plants in the study districts had their fruit eaten. Other parts included 11% for leaves, 10% for pollen nectar, and 5% for root and gum. As a result, the fruit was considered an important element of the wild food plant by the people in the study area. This was consistent with the findings of research by Asfaw and Tadesse (2001), Giday and Teklehaymanot (2010), and Addis et al (2013).

As previously stated, the fruit is the most significant component of the WEPs by the people. As a result, the most common mode of consumption (58%) indicates that wild items were consumed in uncooked form. Ripe fruit is simpler to consume and does not require any additional steps, making it superior to the other parts. This conclusion is consistent with prior research conducted in Southern Ethiopia (Assefa and Abebe, 2011), which found that 76.7% of WEPs were ingested raw or without further processing. Different Ethiopian researchers, including Wonidmu et al. (2006), Kebu Balemie & Fassil Kebebew, (2006), Teklehaymanot and Giday, have reported similar findings (2010).

3.4. Marketability and prefered season to collect WEPs

Only 30% of the WEPs have marketability value, the majority (70%) of species were used for local consumption. About 65% of the WEPs market was dominated by species such as *Diospyros mespiliformis*, *Syzygium guineense*, *Vangueria madagascariensis*, *Ximenia americana*, and *Ziziphus spina-christi*. This is due to these species being available all over the year and more diverse in the study area. A study conducted in a different part of Tigray on WEPs by Aregay et al. (2017) reports that plant species such as *Syzygium guineense*, *Balanites aegyptiaca, Ximenia americana*, and *Ziziphus spina-christi* were among the common wild edible plants both in local community and market which is more or less similar with the present findings. Alike this study, a few numbers of wild foods sold in the market were also reported by other studies made in Ethiopia **(**Asfaw, 1997; Balemie and Kibebew, 2006**;** Wondimu et al. 2006**).**

The wet season is the preferable season (55%) to collect WEPs followed by the dry season (27%) and all over the year (18%). This is because WEPs are more available in the rainy season than in the dry season. Similar studies were reported by Kebu Balemie and Fassil Kebebew (2006). Other findings reported by Aregay et al. (2017) showed, most of the fruits ripened at dry time (January to May) in contrast to the present study and almost all the vegetables ripened in the rainy season (June – August) i.e. similar to this study.

3.5. Other uses of WEPs

About 35% of the wild edible plant species are served only as wild food. The rest (65%) provides non-food ecological services such as medicinal value for human and livestock, fodder, fence, firewood, material culture, charcoal production, and other environmental services. Among the other use categories of wild edible plants, medicinal use has the highest score afterwards with material culture, firewood, and fence respectively (Fig. 2). A study conducted in the lower Omo river valley by Teklehaymanot and Giday (2010) divulges the highest other use categories of WEPs was medicinal value, i.e. comparable with the present findings. In line with this study, Berihun and Molla (2017) also reported that wild edible plants have different ecological services such as a fence, firewood, and material culture next to herbal medicine values.

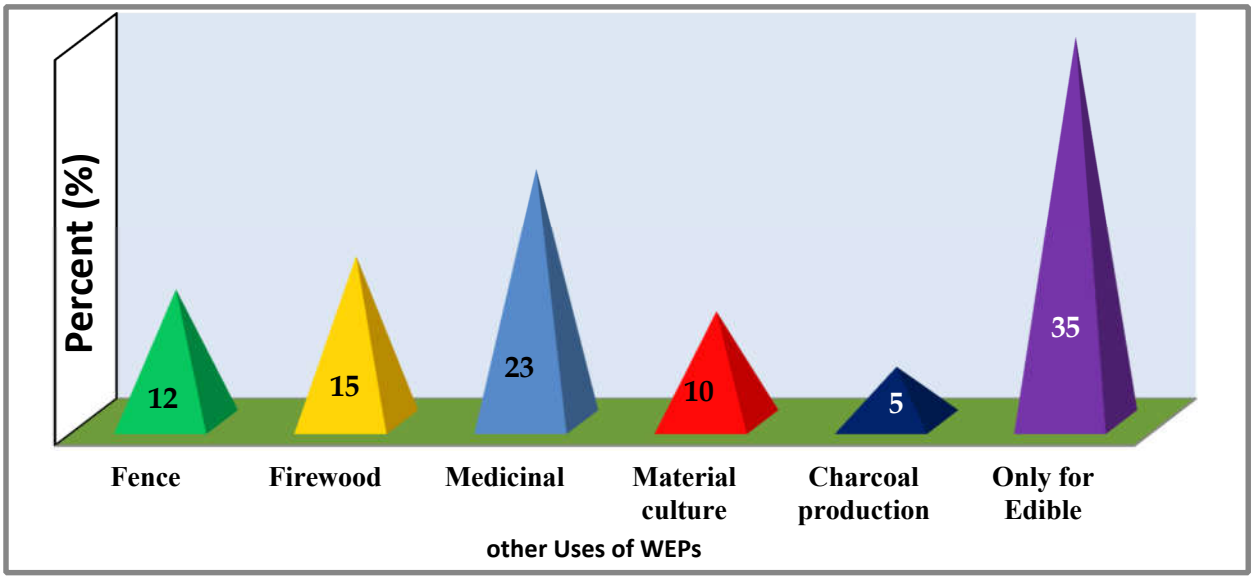


Figure 2: other uses of wild edible plant species

3.6. Threats and conservation of indigenous knowledge associated with wild edible plants

Overgrazing and deforestation were the major threats to wild edible plants which covers 23% each of the total threats followed by expansion of agriculture (17%), Over-harvesting (15%) fire, and timber production (7% each). This is because rapid human population and high demand for forest and forest products in the study area from time to time. Similar studies in other parts of the countries were reported by Giday et al. (2007); Regasa et al., 2014); Araya et al. (2015). It was investigated that, plant species such as *Phoenix reclinata, Balanites aegyptiaca, Sterculia setigera Mimusops kummel,* and *Woodfordia uniflora* are among the wild edible plants under

series threats and destruction status. The described above threats such as deforestation and agricultural expansion take a major role for this reason. Unless proper conservation way is committed to implementing in the study area, there will be a huge uncertainty to get foreign products and services for the inhabitants.

To conserve the wild foods plants in the study area inhabitants have used traditional practices such as growing in the home garden (27%), awareness rising (21%), and selective fencing (20%). Peoples around the study area has long experience and culture of plantation, terracing, water harvesting and ecological reclamation to conserve the wild edible plants and the entire forest in their surrounding. Community-based forest management, enclosure, reafforestation, afforestation activities, and supplying of alternative energy sources to the community will have a huge probability conserving of the wild edible plants as well as the entire frost.

3.7. Prefered and Multi-purpose of WEPs

Diospyros mespiliformis and *Ximenia americana* were the most preferable wild edible plants by the community in the study area followed by *Vangueria madagascariensis, Ziziphus spina-christi,* and *Syzygium guineense*, in descending order. This finding has more or less similar to a study conducted in different parts of Tigray reported by Aregay et al. (2017). Regarding the multiple use catagories of wild edible plant species, *Carissa edulis* was most popular followed by *Ziziphus spina-christ, Cordia Africana, Diospyros mespiliformis, Balanites aegyptiaca, Ximenia americana* and *Syzygium guineense* ranked 2nd, 3rd, 4th, 5th and 6th, respectively. among the other use categories of Wild edible plants, medicinal use has the highest score afterwards with material culture, firewood and fence respectively.

3.8. Distribution of indigenous knowledge on wild edible plants among the different social groups in the local community

For this study, a proportionate number of informants were recruited from each of the three districts. There were 34 (51.5%) males and 32 (48.5%) females among the total 66 informants chosen. In the study area, there was no significant difference in reporting of wild edible plants by gender (p-value 0. 869) (Table 2). This is comparable to the findings of Ashagre et al. (2016); (2017). There was also a significant difference between age groups (P-value 0.05). The older age group reported more wild edible plant species (56.1%). This demonstrates that the elderly have higher experience and understanding of wild edible plant species. A similar result was found in a study conducted by Wondimu et al. (2006), Regassa et al., (2014), and Ashagre (2017). In

contrast to the present study findings, there were more wild edible plants reported by youngsters than elders in Arsi-Ethiopian reported by Setalaphruk and Price (2007). This due to youngsters has high exposure in passing forests (far from their house residence) in keeping their cattle and goats.

Table 2. statistical test of significance on average number of wild edible plants among different informant groups in dstricts surrounding to hirmi forest

Parameters	Informant groups	N*(%)	Mean±SD	t - v alue	p–value
Sex	Male	34(51.5)	1.48± 0.50	23.95	0. 869
	Female	32(48.5)			
Age	18-30	26(39.4)	1.61± 0.49	26.5	0.000*
	>30	40(60.6)			
Marital status	Single	23(34.8)	1.65 ± 0.48	27.94	0.000*
	Married	43(65.2)			
Educational status	Literate	28(46.7)	1.52 ± 0.50	8.44	0.008*
	illiterate	38(53.3)			
Informants	General	60(90.9)	1.1 ± 0.29	30.59	0.032*
	Key	6(9.1)			
Religion	Orthodox	62(95.5)	1.05 ± 0.22	40.47	0.436
	Muslim	3(4.5)			
Destrict	Tahtay Koraro	21(31.8)	2.03 ± 0.82	20.06	0.229
	Medebay Zana	22(33.3)			
	Asgede Tsimbla	23(34.8)			

* = Significant difference ($p < 0.05$), ** t (0.05) (two tailed), N= Number of informants

Marital status was another factor of knowledge variation among informants. More wild edible plants were reported (65%) by married informants with a significance P-value of 0.00 (< 0.05). This is because married informants are elder and have long experience than the single informants. Illiterate people mentioned more (66.1%) wild edible plant species than the literate ones with a significance value of 0.008.

The number of wild edible plants reported by different informants varied significantly (P-value=0.032). Despite the fact that the key informats were fewer in number than the general informats, the key unformats mentioned 56.1% of the WEPs. In other words, key informants were shown to be more knowledgeable than the majority of the study's general informants. Ashagre made a similar discovery (2017). The districts were dominated by Christian Orthodox believers (>95%). According to the statistical study, there was no significant difference between the sampled Kebele and religion, with P-values of 0.229 and 0.436 (P-value>0.05).

Therefore, awareness raising, recording and transferring of typical knowledge of how to use and conserve wild food plants is a significant method in transferring and maintaining the ethnobotanical knowledge to the new generation for resolving food shortage at local and national levels both at present and future time.

4. Conclusion

The fundamental hypothesis of the study was the importance of Hirmi woodland vegetation as a source of wild food, the community's indigenous knowledge of conservation, and the utilization of wild edible foods in the study region. The aforementioned data and discussions support these and other hypotheses. The vegetation types in the research region include *Acacia* - *Commiphora* woodland, *Combretum* - *Terminalia* woodland, and Dry evergreen afromontane forest. The presence of distinct forest types in the research area resulted in the existence of a diverse range of wild edible plant species. These plants also provide multifunctional ecological services like medicine, fencing, firewood, and lumber production. Regarding ethnobotanical knowledge of wild edible plants by the informants, there was a significant difference between different age groups, educational status, marital status and between each informant. Elder people, illiterates, married and key informants have better knowledge. However, there was no significant knowledge difference among other social groups such as sex, religion, and districts. The community has no focus and understanding of sustainable conservation to the extent of utilization and consumption knowledge. 17% of the respondents said that they have no idea how to conserve and manage wild edible plants they use.

The finding of this study area shows that most wild edible plants consumed their fruit, which is the main reproductive part of the plants. This leads to the regeneration and sustainability of wild edible plant species under risk. Deforestation, browsing, expansion of agriculture, over-harvesting, drought, charcoal production, selective harvesting, and timber production was major challenges for the wild edible plants and entire forest in addition to communities deprived conservation mindset up. As a result, wild edible plant species such as *Balanites aegyptiaca, Sterculia setigera, Mimusops kummel,* and *Woodfordia uniflora* are under serious threaten and extinction status in the study area. Homegarden growing, awareness rising, selective fencing, general ecological reclamation were among the indigenous techniques used to conserve wild edible plants in the study districts.

4. Recommendations

Dryland is generally replenished by remnant vegetation and agricultural activity. The current investigation was conducted in dry terrain areas surrounding Hirmi woodland vegetation. The community is heavily reliant on the surrounding plant and plant products. Because of rapid human growth and agricultural expansion, the need for plants and their products is increasing, and vegetation coverage is expanding in both directions. The following proposals are presented in order to obtain various plant's ecological services on a long-term basis in the districts:

- Participatory forest management needs to be practised extensively and effectively in the study districts for the conservation of forests in general and wild edible plants in particular.
- Formal and informal education systems should be designed to create positive attitudes among the young by integrating tested and verified indigenous knowledge into the curricula about the traditional uses of plants in general and wild edible plants in particular.
- Stakeholders should be integrated with conducting relevant studies to conserve and sustainably use wild edible plants and fill the knowledge gap between generations through awareness rising and documentation.
- Decision makers and policy designers should involve traditional conservation practices such as *in-situ* conservation, homegarden and ecological restoration in their natural conservation program in line with appropriate scientific conservation techniques.

Ethical compliance and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data

The data used to support the findings of this study are included within the article.

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