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Ethnobotanical and nutrient survey of indigenous edible fruits, vegetables and mushrooms of Iringa District, Tanzania

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Abstract

A study on ethnobotany and nutrients survey of indigenous vegetables, fruits and mushrooms was conducted in March 2020 in Iringa Rural District of Tanzania. The objectives was to collect ethnobotany information of the edibles, analyse the level of nutrients and use the obtained information to create awareness in the community on how to use these edibles to improve its economy and health of the citizens. Questioners were used to obtain ethnobotanical information. Opportunistic collection of the edibles was done in March during the rainy season. One hundred edibles were collected for analysis and 80 respondents were interviewed. Data analysis was accomplished using one way ANOVA in the SPSS software (Version 14). Indigenous names and medicinal use of the edibles were reported. Utility and awareness of the community to the edibles was observed to be higher although not statistically significant. Three vegetable species were observed to be more nutritive and statistically significant than others in terms of Fe^{2+} and ß-carotene while all mushrooms collected were observed to be rich in Fe^{2+} and $PO3^{-4}$. Three fruit species, four vegetables species, and two mushrooms families were observed to be preferably eaten in the community. *Vitex mombasae* and *Agaricaceae* were the dominating population in the study area. However, the differences in the nutrient levels in the fruits and mushrooms were statistically not significant. Communities were gathered to receive feedback and create awareness on the importance and use of the edibles. The government is encouraged to be involved in the dissemination of this information to bolster the economy and improve the health of her people.

Keywords: Ethnobotany, Iringa, Edibles, Indigenous, Vegetables, Mushrooms.

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INTRODUCTION

Iringa region previously was among the rich regions in the production of indigenous edible fruits, vegetables and mushrooms in Tanzania (Azzali & Menenti, 2000). Acoording to Azzali & Menenti (2000), Iringa soil was very fertile and rich in organic matter in the 1960's up to the end of 1980's. Increase in human activities including the use of industrial fertilizers, bush cleaning for new settlement and new farming areas, firewood requirement and timber for commercial and domestic uses influenced climatic change and environmental degradation leading to infertile soil and reduced crop production from the beginning of 1990's (Azzali & Menenti, 2000).

The three edibles (mushroom, vegetable and fruits) are important to human health and life due to their nutritive characteristics as they contain cellulose, vitamins, proteins, oil, carotene and other minerals and can be extracted from the plants to determine their level (Tucker *et al*., 1985). The level of ethnobotanical knowledge of the community is the one which determine the level of production, consumption and protection (conservation) of the food plants in their places (Rampilla *et al*., 2020). The common knowledge to a particular community or people living together in a certain area, generated by their own experience as well as that of their ancestors is generally referred to as indigenous knowledge of that specific society (Ohiokpehai, 2003).

Naturally growing vegetables indigenous to a particular locality or area serve as food and source of energy and nutrients in local communities (Grivetti & Ogle, 2000). They are used as edibles in rainy and drought seasons and in the treatment of various diseases in local communities. However, only few varieties from few families are still found naturally in Iringa in particular and Tanzania in general because of the extinction of others due to environmental degradation and climatic change (Azzali & Menenti, 2000).

The reduced number and scarcity of available edibles that naturally grow in most regions in Tanzania was one of the warning signals that necessitated the need to conduct this research. The frequent selling of indigenous vegetables along the streets of Iringa compared to other regions was a reason for deciding to conduct this research in Iringa in other to understand the variations in these edibles and better understand their nutritive values in the community. Understanding the variation in these edibles will help us to understand the dominating species and family, their nutritive value and their medicinal use in the communities (Msuya *et al*., 2008). Apart from maize production in Iringa especially in previous years, locally growing (indigenous) mushrooms in Iringa rural district have been the sources of foods and nutrient supplements to many people in the region despite the decline of nutrient in the soil of the region (Ogundele *et al*., 2014; Azzali & Menenti, 2000). Iringa rural district is among the few areas in Tanzania which are rich in more than five (5) edible mushroom species growing naturally and can be sold in markets, offices, bus stands and streets of the district seasonally from October through May every year (Venturella *et al*., 2015).

Mushroom is the fleshy spore-producing body of any of various basidiomycetous fungi; they basically consist of a cap (pileus) at the end of the stem arising from the underground mycelium. Some species among them are edible mushrooms (Venturella *et al*., 2015). The parent organism of mushrooms which is known as mycelium lies beneath the soil and can cover as much as 1,500 acres. Most of the mushrooms have a stalk which is also called a stem and a cap which is disc shaped. Below the caps of edible mushrooms, there are series of closely spaced slits known as gills in which pores can be found (Ogundele *et al*., 2014). Mushrooms differ largely in shapes and colour and some of edible and non-edible mushrooms do not conform to stalk and cap structure present in majority of mushrooms.

Despite that more than five (5) edible mushroom, vegetable and fruit species grow naturally in Iringa rural district, there were not enough information as to what extent the community was aware of the nutritional importance, medicinal use, names, habitants, and other associated information. This lack of information informed the need to conduct this ethnobotanical and nutrients analysis study.

The general objective of this research, therefore, was to survey and obtain information on ethnobotany of the three edibles and ascertain the nutrient levels of the two indigenous edible (vegetables and

mushrooms) so as to use the obtained results in creating awareness in the community on the use and importance of the edibles so as to improve its economy and health of her citizens.

This objective was accomplished by three specific objectives including the conduct of an ethnobotanical survey on the three indigenous edibles (fruits, vegetables and mushrooms) in Iringa rural district, extraction and analyses of nutrients level from the two indigenous edibles (vegetables and mushrooms) and finally on the need to creat awareness on the use and importance of the three edibles for improving health and economy by using results of the study.

Hypothesis

The hypotheses below were tested to guide the specific objective of the current research.

Null hypothesis I: The community is not aware of the use, names, medicinal use and importance of the edible fruits, vegetables and mushrooms in their environment.

Alternative hypothesis I: At least one of the names, medicinal use and importance of the edible fruits, vegetables and mushrooms is well understood in the community.

Null hypothesis II: All the two edibles (vegetables and mushrooms) are not evenly nutritive in the community

Alternative hypothesis II: At least one of the edibles (vegetables or mushrooms) is more nutritive than the other.

MATERIAL AND METHODS

Study area

Since the opportunistic sampling design was planned to be used due to scattering of the villages in the rural district (Magingo, 2001), four villages from Iringa rural district were randomly selected for collection of ethnobotany information and sampling of fruits, vegetables and mushrooms for nutrients level analysis (Figure 1). Idodi village (7° 46' 36.4404"S, 35° 12' 7.02"E) is located 76.4 km from Iringa towm, Kiwere village (7° 38' 37.608"S, 35° 36' 9.5112"E) is located 20.6 km from Iringa town, Nduli village (7° 40' 58.602"S, 35° 44' 50.7228"E) is located 20.2 km from Iringa town and Ilula village (7° 40' 51.0456"S, 36° 2' 16.8216"E) is located 46.1 km from Iringa town (*Institute of Resource Assesment, University of Dar Es Salaam - Google Scholar*, n.d.). The four villages are located in the same region, district, vegetation characteristics, soil and weather conditions (Virmani, 1988) under the region which was recently reported to decline its soil fertility (Washa, 2020).

Data collection

Sampling and sample size

Sampling of indigenous (vegetables, fruits, and mushrooms) was done within the study area during rainy season in March 2020. Samples were taken wherever available and not in specific areas (opportunistic) (Magingo, 2001). About 25 respondents were involved in each of the villages and 20 samples were collected for each of the fruits, vegetables, and mushrooms. Standard procedures as previously described were used to sample and package the edibles and store in places where they can stay longer before they decompose (Leakey *et al.,* 1990).

Nutrient extraction and analysis

Nutrient extraction and analysis from the edibles (mushrooms and vegetables) were done according to standard methods as per AOAC (1999). Chemistry laboratories from Mkwawa University College of Education (MUCE) and UDSM main campus were used. The extracts containing nutrients were obtained from mushrooms and vegetables by using selective solvents through standard procedural methods such as chromatography, Soxhlet, maceration, infusion, percolation, decoction, digestion, microwave assisted extraction, ultrasound assisted extraction, accelerated solvent extraction and supercritical fluid extraction (Gupta *et al*., 2012). Minerals were determined using inductively coupled plasma-atomic emission spectroscopy (ICP-AES),

Ethnobotanical information collection and analysis

Collection of ethnobotany information from the three edibles was done according to standards as per Rampilla *et al*., (2020) Botanical information can be collected from selected areas by various methods but the most common includes semi-structured interview

with the community where questioners were used, inventory interview, participatory workshops and vegetation sampling (Rampilla *et al.*, 2020). The frequency of the community mentioning the fruit, vegetable or mushroom for use or medicinal use was tabled for analysis.

Questions for respondents on fruits:

1. What names (local) of edible fruits grow naturally in your environment? (ethnobotany).
2. What fruit do you eat many times in a day or in a week? (utility).
3. Give reasons as to why you eat fruits (Awareness).

Questions for respondents on Vegetables:

1. What are the names of vegetables found in your environment?
2. Is there any known medical use from any of the vegetables you have mentioned?
3. Do they grow everywhere? If not, which vegetable(s) grow in what place (vegetation)?

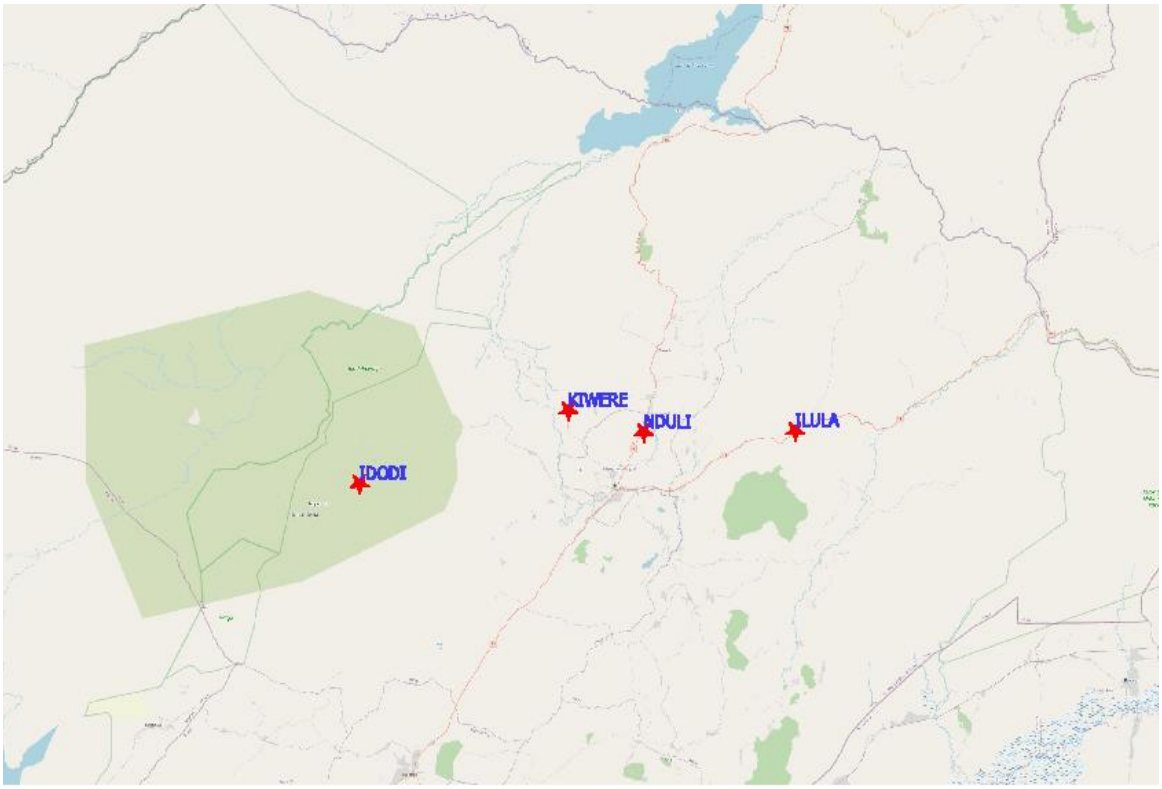

Figure 1: Sampling areas of the present research.

Source: IRA-Udsm,2000

Questions for respondents on Mushrooms

1. Mention any local names of mushrooms you know from your environments
2. Give colours or any feature(s) of the mushroom you have mentioned
3. Give name of the mushroom you preferably eat frequently than the others

Data analysis

Data analysis was accomplished according to (Zar, 2010), using Statistical Packages for Social Sciences (SPSS version 14) software. Descriptive statistics were first performed to observe the characteristics of the study variables. The characteristics of the study variables were presented by using frequency tables. Since the study had only one dependent variable with two to three

independent categories, the one factor Analysis of Variance (ANOVA) was suitable for use in observing the presence of significant effect among the categories. The effects of groups were considered significant if the P-value were less than 5%, otherwise the null hypothesis was not rejected. The data were recorded in the period of rainfall in March 2020 when indigenous fruits, vegetable and mushrooms are cheaply available in the forest.

RESULTS

Ethnobotanical information collected for fruits, vegetables and mushrooms were summarized in Tables 1, 2, 4 and 5 below showing the local names, utility level of the edibles in the community, medicinal uses of the edibles, dominating population of the edibles, frequently eaten species and level of awareness of the community to the edibles. However, differences between utility and awareness of the community on fruits, differences between mentioning the medicinal use and names of the vegetables and the mushroom families which were observed to be most frequently eaten in the community were statistically not significant (P=0.418347, P= 0.27641 and P>0.05 respectively) from Tables 1, 4 and 5 respectively. Nutrients extracted from vegetables and mushrooms but also their nutrient levels obtained were summarized in Tables 3 and 6 below. Differences in the three (3) nutrients levels from vegetables. (Fe^{2+}, Zn^{2+} and ß-carotene) were found to be higher and statistically significant (P=3.704892, P= 0.050727) as indicated from Table 3. However, nutrient levels in Fe^{2+} and PO^{3-4} from the six (6) mushrooms were observed to be higher than others but not statistically significant (P>0.05) as indicated from Table 6.

DISCUSSION

Fruits: In Table 1, descriptive observations indicated that utility and awareness of the community on fruit species as *Adansoma digitata, Vitex mombasae, Vitex doniana* and *Tamarinds indica* was very higher but not statistically significant where P=0.418347. A total of 9 local names of indigenous fruits were obtained and documented in A – I of Table 1. More than 100 respondents attempted to mention several fruits they know from their environment, their importance, use and local names as listed in ethnobotany section. It was experienced from respondents that most of local names are correlated to colour, use or habitat in which the fruit grow. Most of the respondents were found to have enough knowledge on their fruits and environment. This finding is supported by Rampilla *et al*., (2020) who stated that, the level of ethnobotanical knowledge in the community is the one which determine the level of production, consumption and protection (conservation) of the food plants in their places. Ethnobotany survey in this regard was successful rejecting the null hypothesis I. Nutrient extraction and analysis in this study was not conducted on fruits due to insufficient funds.

Vegetables: In Table 2, descriptive observation indicated that local names and medicinal use of 14 indigenous vegetables were obtained and documented. Descriptive observation on Table 3 indicated that, extraction of minerals in 6 indigenous vegetables (*Spider flower, Jute mallow, African eggplant, Nightshade, Amaranth* and *Moringa*) identified 3 minerals (Fe^{2+}, Zn^{2+} and ß-carotene) which their differences were statistically significant between vegetables (P= 0.050727, hence rejecting the null hypothesis, meaning that at least these 6 vegetables were more nutritive than others.

Table 1: Responses from respondents on indigenous fruits

S/N	Species name	Utility	Awareness of community on fruits
A	*Syzygium cordatum*	31	22
B	*Acokanthera schimpen*	37	34
C	*Azanza gackeana*	52	42
D	*Trema orientalis*	11	9
E	*Vitex doniana*	69	56
F	*Vitex mombasae*	70	60
G	*Strychnos spinosa*	50	40
H	*Adansoma digitata*	72	60
I	*Tamarindus indica*	67	59

Table 2: Vegetables found in Iringa community

S/N	Family name	Medicinal use reported by community
1	Capparaceae	Its juice is used to treat flu (Influenza). Rich in Fe^{2+} and Zn^{2+} which helps to increase blood supply in the body
2	Solanaceae	Leaves of Solanaceae are used to treat stomach problems Members of Solanaceae are used to treat chest pain and problems associated with the respiratory systems Solanaceae are also eaten to remove protection from witch doctors The solution of the root extracts is used to treat stomach problems
3	Amaranthaceae	Members of the family are poisonous during certain seasons. Rich in Fe^{2+} and Zn^{2+} which help to increase blood supply in the body. Rich in carotene which is used to treat eye problems. Good source of vitamin C Leaves are used to treat stomach problems
4	Tilaceae	Good source of vitamin C. Rich in Fe^{2+} and Zn^{2+} which help to increase blood supply in the body. Rich in carotene which is used to treat eye problems.
5	Moringaceae	Provide vitamin C, used to add Fe^{2+} and Zn^{2+} for increasing blood in the body, they add carotene which are used to treat eye

Table 3: Iron, zinc and ß-carotene contents in *Spider flower, Jute mallow, African eggplant, Nightshade, Amaranth and Moringa* (mg/100 g)

S/N	Vegetable	Fe	Zn	ß-carotene
1	*Spider flower*	7.52	2.00	2.50
2	*Jute mallow*	11.20	1.71	3.56
3	*African eggplant*	2.00	0.10	0.03
4	*Nightshade*	9.00	0.30	3.10
5	*Amaranth*	35.05	0.50	3.60
6	*Moringa*	1.90	1.02	2.50

Table 4: Frequency of mentioning a vegetable in each question used in investigation out of 100 respondents

Question	*Spider flower*	*Jute mallow*	*African eggplant*	*Night shade*	*Amaranth*	*Moringa*
1. What names of vegetable which are found in your environment?	67	52	51	70	68	66
2.There any known medical use from any of the vegetables you have mentioned?	12	9	23	17	52	45
3.Do they grow everywhere? If not, which vegetable grow in what place (vegetation)?	10	8	2	15	20	21

Table 5: Responses of the respondents to the questions of mushrooms

Family name	Number of respondents Frequently eat
Agaricaceae	72
Agaricaceae	43
Agaricaceae	31
Amanitaceae	52
Amanitaceae	47
Agaricaceae	11
Agaricaceae	6
Coprinaceae	8
Coprinaceae	0
Agaricaceae	0
Agaricaceae	4
Agaricaceae	13

Table 6: Mushrooms and their nutrient contents

Mushroom	Nutrient contents in (mg/100 g)							
Family/local names	Fe	Zn	ß-carotene	K^{+}	Ca^{2+}	$P03^{-4}$	Mg^{2+}	Na^{+}
Agaricaceae (Wimenda)	15.0	0.8	2.7	8.1	3.7	14.2	0.03	0.5
Agaricaceae (Wisimba)	17.7	3.2	0.4	5.5	3.7	11.0	0.03	0.01
Amanitaceae (Wikulwe)	30.1	0.8	2.2	3.6	1.9	8.7	0.1	0.04
Agaricaceae (Wisogola)	27.0	1.1	3.3	7.0	2.4	12.0	0.01	0.2
Agaricaceae (Unyafiguru)	28.3	0.3	4.1	6.8	2.2	15.3	0.03	0.07
Amanitaceae (Wilelema)	32.4	1.3	3.8	5.7	2.3	13.4	0.11	0.62

Ethnobotany

Descriptive observations indicated a total of 12 species of indigenous vegetables which were mentioned in the community (Table 2). Local names of 12 indigenous vegetables were obtained from the community and documented (*Spider flower* = Mgagani, *Jute mallow* =,Mlenda, *African eggplant* = Mnafu, *nightshade* = Mnafu, *Amaranth* = Mchicha poli, *Moringa* = Mlenda poli, *Java plum* = Zambarau/Mivenge, *Arrow poison* = Mgola, *Azanza gackeana* = Mitowo, *Trema orientalis* = Mikole, *Vitex domana* = Mifudu, *Adansoma digitata* = ubuyu, *Tamarindus indica* = ukwaju, *Strychnos spinosa* = Minyewa). Local names obtained for indigenous fruits were as follows: *Syzygium cordatum* (Miyenge/Zambarau), *Acokanthera schimpen* (Mgola/Mchunga), *Azanza gackeana* (Mitowo), *Trema orientalis* (Mkole/Mpesi), *Vitex doniana* (Mifudu/Mfulu), *Strychnos spinosa* (Mnyewa/Mtonga), *Adansoma digitata* (Mbuyu/ubuyu) and *Tamarindus indica* (Ukwaju). Local names of indigenous mushrooms obtained from respondents include: *Agaricaceae* (Wisogola), *Agaricaceae* (Wimenda), *Agaricaceae* (Wisimba), *Amanitaceae* (Wikulwe), *Amanitaceae* (Wilelema), *Agaricaceae* (Nyakapulikilo), *Agaricaceae* (Nyausako), *Coprinaceae* (Wilufu), *Coprinaceae* (Nyalunga), *Agaricaceae* (Wigwingwi), *Agaricaceae* (Wilulwi) and *Agaricaceae* (Unyafiguru). As an indication of a successful ethnobotany survey of indigenous vegetable, 14 local names and 14 medicinal uses were mentioned by more than 100 respondents but also extraction and identification of nutrients from vegetable was done. Again level of understanding their foods in these communities was found to be higher as also supported by Rampilla *et al* (2020). Ethnobotany survey in this regard was successfully carried out, meaning that to a certain level, the utility, names, medicinal use and importance of the edibles was known in the community thus allowing the chance for improving the awareness using the obtained information. In this regard, the three specific objectives as well as the main objective was fulfilled as the research intended to do.

Mushrooms

Descriptive observation in Table 5 indicated that, a total of 12 local names of indigenous mushrooms were obtained from the community and documented. *Agaricaceae* and *Amanithaceae* mushroom families were observed to be the most frequently eaten in the community but not statistically significant (P>0.05). Descriptive observation in Table 6 indicated that minerals like Fe^{2+}, Zn^{2+}, ß-carotene, Mg^{2+}, K^{+}, Ca^{2+}. Na^{+} and $P03^{-4}$ were identified from the 6 indigenous mushrooms. Fe2+ and $PO3^{-4}$ were observed to be at high level in the 6 mushrooms than other minerals. However, differences in nutrient level between the mushrooms were statistically not significant (P>0.05). Most of the 6 indigenous mushrooms were repeatdly and continously mentioned by every rrespondent implying that the community was konwledgerble and aware of the type, names, uses and habitats of these mushrooms. The community also was aware of the poisonous species *Coprinaceae* (Wilufu). That was a knowledgable community as stated by (Grivetti & Ogle, 2000) but was necessary for the researcher to use these results to improve awareness as it was done. Generally, mushrooms were found to be more nutritive than vegetables and fruits due to higher number of nutrient types identified in mushrooms. These findings lead to rejection of null hypothesis I, meaning that at least some of the mushroom species were either nutritive than others or frequently eaten than others. Many researchers including Moonmoon *et al* (2011) have made similar observations.

Sensitization (awareness improvement) to the community.

A positive response of respondents made the sensitization gathering in each village to be easy and successful. Gatherings of not less than 50 respondents in each village in different days and time were conducted in July 2020 to give feedback on nutrition level, medicinal use, utility, availability, and the importance of including these edibles in their daily meal. The community agreed to conserve, utilise and improve the availability of the edibles in their environments. The researcher believes that this will improve their health as well as the economy when the available edibles are commercialised.

CONCLUSION AND RECOMENDATIONS

It is reflected in both descriptive and statistical Tables (1-6) that, actively and positively participating, and mentioning of local names, uses and habitants of various indigenous edibles was an indication that respondents (community members) were ready to support the study, and this was why it succeeded. The investigation also succeeded in identifying the preferred eaten species in the community and the dominating populations among the three edibles. The investigation was also able to sensitize the community on the edibles and remind the government of the importance of empowering the researchers and other stakeholders in sensitising the community. Government can do more yearly by providing the needed resources required to sensitize the community. This will improve the economy and health of the community members. Communities in Iringa as well as Tanzania need to understand that fruits, vegetables and mushrooms are not only sweat and palatable but also very important in improving health and economy when commercialised.

Conflict of interest

The author has no conflict of interest to declare.

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REFERENCES

AOAC, I. (1999). *Association of Official Analytical Chemists, Official Methods of Analysis of AOAC International*. Gaithersburg, USA.

Azzali, S., & Menenti, M. (2000). Mapping vegetation-soil-climate complexes in southern Africa using temporal Fourier analysis of NOAA-AVHRR NDVI data. *International Journal of Remote Sensing*, ***21***(5), 973–996.

Grivetti, L. E., & Ogle, B. M. (2000). Value of traditional foods in meeting macro-and micronutrient needs: The wild plant connection. *Nutrition Research Reviews*, ***13***(1), 31–46.

Institute of resource Assesment, University of Dar es Salaam—Google Scholar.

(n.d.). Retrieved 9 March 2022, from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Institute+of+resource+Assesment%2C+University+of+dar+es+Salaam&btnG=

Leakey, R. R., Mesen, J. F. T., Tchoundjeu, Z., Longman, K. A., Dick, J. M., Newton, A., Matin, A., Grace, J., Munro, R. C., & Muthoka, P. N. (1990). Low-technology techniques for the vegetative propagation of tropical trees. *The Commonwealth Forestry Review*, 247–257.

Magingo, F. S. S. (2001). Propagation of two miombo woodland trees by leafy stem cuttings obtained from seedlings. *Agroforestry Systems*, ***51***(1), 49–55.

Moonmoon, M., Shelly, N. J., Khan, M. A., Uddin, M. N., Hossain, K., Tania, M., & Ahmed, S. (2011). Effects of different levels of wheat bran, rice bran and maize powder supplementation with saw dust on the production of shiitake mushroom (Lentinus edodes (Berk.) Singer). *Saudi Journal of Biological Sciences*, ***18***(4), 323–328.

Msuya, J. M., Mamiro, P., & Weinberger, K. (2008). Iron, zinc and β-carotene nutrient potential of non-cultivated indigenous vegetables in Tanzania. *International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development 806*, 217–222.

Ogundele, G. F., Abdulazeez, R. O., & Bamidele, O. P. (2014). Effect of pure and mixed substrate on oyster mushroom (Pleurotus ostreatus) cultivation. *J Exp Biol Agri Sci*, ***2*****,** 2S.

Ohiokpehai, O. (2003). Promoting the nutritional goodness of traditional food products. *Pakistan Journal of Nutrition*, ***2***(4), 267–270.

Rampilla, V., Khasim, S. M., & Thammasiri, K. (2020). Ethnobotanical Assessment of Medicinal Plants Used by Indigenous People Living Around the Sacred Groves of East Godavari District, Andhra Pradesh, India. In *Medicinal Plants: Biodiversity, Sustainable Utilization and Conservation* (pp. 143–194). Springer.

Tucker, C. J., Vanpraet, C. L., Sharman, M. J., & Van Ittersum, G. (1985). Satellite remote sensing of total herbaceous biomass production in the Senegalese Sahel: 1980–1984. *Remote Sensing of Environment*, ***17***(3), 233–249.

Venturella, G., Palazzolo, E., Saiano, F., & Gargano, M. L. (2015). Notes on a new productive strain of king oyster mushroom, Pleurotus eryngii (Higher basidiomycetes), a prized Italian culinary-medicinal mushroom. *International Journal of Medicinal Mushrooms*, ***17***(2).

Virmani, S. M. (1988). Agroclimatology of the Vertisols and vertic soil areas of Africa. *Management of Vertisols in Sub-Saharan Africa*.

Washa, W. B. (2020). Assessment on Potential of Cow Dung Manure in *Zea mays* Production at Kiwere Village in Iringa Rural District, Tanzania. *American Journal of Plant Sciences*, ***11***(11), 1751.

Zar, J. H. (2010). Biostatistical Analysis. 5rd. *Ed Hall P. New Jersey: Upper Saddle River*.