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Community-based methods of using goldenberry (*Physalis peruviana* L.) for managing *Salmonella typhi*

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Abstract

Physalis peruviana has been used for the treatment of bacterial, fungal, protozoan, and viral infections. The purpose of this study was to establish knowledge, attitudes, and practices regarding the ethnobotanical value of goldenberry plants in the treatment of infections. The study was conducted between April and June 2021 in five villages in the Mbeya Rural District, Tanzania. Through focused group discussion and structured questionnaires, the information was collected from 15 traditional healers and 93 household members. All data was analyzed using the Statistical Package for the Social Sciences (SPSS). The overall survey revealed that the leaves of the plant are used for typhoid fever treatment. The methods for plant preparation include boiling of leaves (33.3% and 29.8% for traditional healers and household members, respectively) and soaking of ground leaves in cold or hot water (66.7% and 70.2% for traditional healers and household members, respectively). Therefore, among the two methods, soaking leaves in water is preferable compared to boiling because it works better in terms of disease treatment. According to key informants, the differences in efficacy between the two methods could be due to the loss of some phytochemical compounds during boiling, which might be effective against the disease-causing agent. The differences in efficacy provide access for further research, especially in finding out which compounds might be effective against the disease might be present in *Physalis peruviana* leaves.

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Introduction

Typhoid fever is an acute, life-threatening, and febrile illness to human and poultry (Mulu *et al*., 2021; Shakya *et al*., 2019). The disease is spread through food and water contaminated by animal and human feces (Gomes, 2022). The associated risk factors for the disease are poor hygiene and poor sanitation mainly in low- and middle-income countries compared to the developed countries (Ingle *et al*., 2020; Muresu *et al*., 2020; Yemata *et al*., 2021). Therefore, typhoid fever continues to be a major health problem especially in developing countries (Saxena *et al*., 2021).Globally more than 21 million incidence cases of typhoid fever and 220,000 typhoid-related deaths occur per year (Arunkumar *et al*., 2022; Muresu *et al*., 2020).

Typhoid fever is treated using antibiotics however the bacterium causing agent has developed resistance to multiple drugs through different mechanisms (Browne *et al*., 2020; Butt *et al*., 2021; Wasfy *et al*., 2002). This has given birth to newer and more powerful strains, such as Multi-Drug Resistant (MDR) and extensively drug resistant (XDR) *Salmonella typhi* strains (Batool *et al*., 2021). Resistance to antibiotics leads to the overuse of drugs, which results in high costs of treatment, poor treatment prognosis, and deaths. Therefore, due to the resistance of bacterium causing agent, it is necessary to have alternative management, such as medicinal plants. About two-thirds of the world population in developing countries rely on plant-based traditional medicines and herbal drugs for primary healthcare requirements (Ahmad *et al*., 2017). Overdependence on medicinal plants would be caused by the unaffordability of synthetic medicines and also due to many people having the belief that medicinal plants are safe. Therefore, medicinal plants have become an important alternative therapeutic agent among different communities worldwide since they contain valuable bioactive phytochemical compounds (Kumar *et al*., 2021; Mondal, 2021). *Physalis* species are among of medicinal plants used because they contain different enriched bioactive phytochemicals (Chhikara *et al*., 2021; Mondal, 2021). *P. peruviana* is among of *Physalis* species under the family Solanaceae (Elhassaneen *et al*., 2016). The plant is a perennial and widely grown throughout the world. The plant has been reported to have medicinal values such as antioxidant, anti-bacterial, and anti-inflammatory; elimination of intestinal parasites, analgesic, diuretic, and antiseptic (Chhikara *et al*., 2021; Kamau *et al*., 2020; Lean-teik *et al*., 2005; Roger *et al*., 2015). In Tanzania like other countries, different plants have been used in communities for the treatment of various infections (Kitula, 2007; Moshi *et al*., 2012; Msuya & Kideghesho, 2009). Mbeya is one of the regions in Tanzania where the use of medicinal plants has been reported in different communities (Msuya & Kideghesho, 2009).Among the plants, the *Physalis peruviana* has been used in communities for the treatment of typhoid fever and other diseases.Users have reported positive results regarding the efficacy of herbal drugs against disease-causing agents. For the preparation of herbal drugs, two methods, which include boiling and soaking of ground parts of the plant in water, are used. However, the preparation methods, amount used, and efficacy of the methods used are not internationally documented. In order to optimize the use of the goldenberry plant, there is a need for proper documentation of the indigenous knowledge that will attract different researchers to scientifically validate and further explore the plant in the development of drugs. Thus, this study aimed to optimize community-based methods of using goldenberry for managing *Salmonella typhi*.

Materials and methods

Location of the study

The study was carried in five villages (Swaya, Utengule Usongwe, Mapinduzi, Iwindi, and Horongo) located in five wards (Swaya, Utengule Usongwe, Nsalala, Iwindi, and Igale) found in Mbeya Rural District, Tanzania (figure 1). Mbeya rural District is located between Latitude 7 ° and 9 ° Southern Equatorial and longitudes 33 ° and 35 ° the Eastern Prime. Mbeya Rural District lies within Mbeya Mountain ranges at an altitude between 1600 and 2400 meters above sea level.

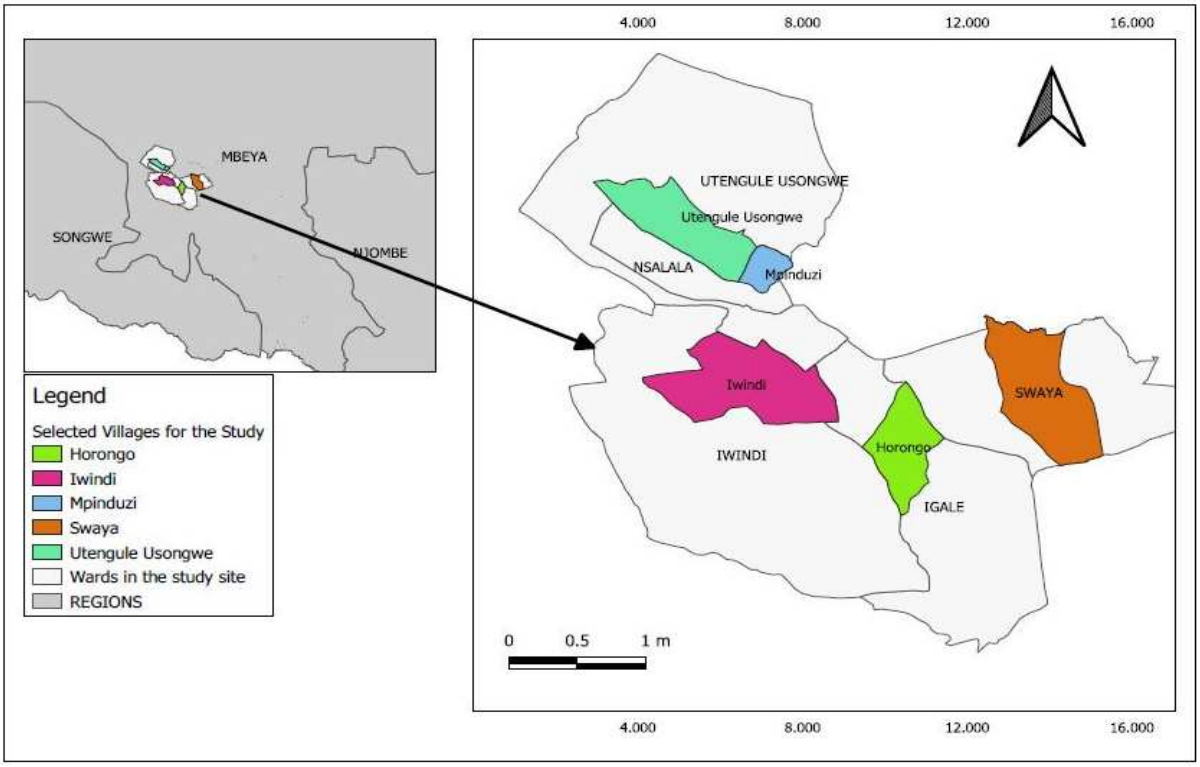

Fig. 1. Location of study sites in Mbeya, Tanzania.

The average rainfall for the district is 1200mm and the annual temperature of 25°C. The average minimum and maximum temperature range between 11°C and 28° C respectively.

Data collection

The data was collected between April and June 2021 in five villages found in Mbeya rural district. A total of 108 key informants, including 15 traditional healers and 93 household members, were interviewed. A structured questionnaire was used in collecting the data; therefore, both the traditional healers and household members were accessed using the same questions. For the collection of information, traditional healers were interviewed through focus group discussion while household members were visited one after another in their home place.

Study design

A cross-sectional survey was carried in selected villages from Mbeya Rural District. Both selected wards and villages were sampled randomly.

The selected villages are surrounded by forests that harbor a variety of medicinal plants. Also, the communities in the study areas depend on medicinal plants as their source of primary health care.

Study population

The study population involved traditional healers and household family members. The selected household family members are those who are familiar with the *Physalis peruviana* and how the herbal drug is prepared and used for the treatment of typhoid fever.

Sample size estimation

A method described by Angelsen (2014) was used to select 108 participants, involving 15 traditional healers and 93 household family members. Since there are 60 registered traditional healers in Mbeya Rural District and 15–30 known household members in each village, therefore, based on the Angelsen (2014) method, 25 percent of key informants were sampled to represent the whole population in the district.

Sampling techniques

The key informants were selected using snowball sampling techniques. Traditional healers were identified by the district's traditional healer

chairman, and household family members were identified by village leaders. All key informants were first demonstrated the purpose of conducting the research, followed by signing the consent, and then conducting focus group discussion and filling in questionnaires for traditional healers and household members, respectively.

Statistical analysis

The questionnaire data were entered in Microsoft excel 2019, filtered, and cleaned ready for analysis. Analysis was done using Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistics, as well as frequency tables, were used to summarize the obtained data. Also, chi-square was determined using Pearson whereby $p<0.05$ was considered significant.

Results and discussion

Results

Demographic information's for household members and traditional healers

Out of 108 key informants interviewed, 93(86.1%) were household members and 15(13.9%) traditional healers. From 93 household members ;48(52%) were males and 45 (48%) females, the majority were above 50 years (52.5%) followed by 41-50 years (21.7%) then 31-40 years (18.5%), and 18-30 years (6.3%). For marital status, 97.8% of household members were married, and 2.2% single. About education level; 73.2% attended primary school, 13.96% didn't attend school, 7.5% attended secondary school and 5.4% attended tertiary education. Also, among 15 traditional healers, 10 (66.7%) were male and 5(33.3%) were female, 53.3% were above 50 years followed by 41-50 years (40%) and 31-40 years (6.7%). All 15(100%) were married, about education level; 66.7% attended primary school, and 33.3% didn't attend school as summarized in table 1. Also, the chi-square tests indicate that there was an association between the characteristics of household members throughout the wards as shown in table 2.

Awareness on Physalis peruviana

From the collected results, 100% of both traditional healers and household members responded knows the plant. This implies that the community where the study was conducted is familiar with the plant in terms of its use.

Table 1. Demographic information for both household members and traditional healers representing Mbeya rural district.

Variable	Category	HH member's n (%)	TH n (%)
Gender	Male	48(52)	10 (66.7)
	Female	45(48)	5(33.3)
Age	<18	0 (0)	0 (0)
	18-30	6 (6.3)	0 (0)
	31-40	17(18.5)	1(6.7)
	41-50	21(21.7)	6 (40)
	>50	49 (52.5)	8 (53.3)
Marital status	Single	2(2.2)	0(0)
	Married	90(97.8)	15(100)
	Divorced	0(0)	0(0)
Education level	Primary school	68(73.2)	10(66.7)
	Secondary school	7(7.5)	0(0)
	Tertiary	5(5.4)	0(0)
	Didn't attend school	13(13.96)	5(33.3)

Other diseases apart from typhoid fever treated by Physalis peruviana

According to the survey different diseases as shown in figure 2 were mentioned by key informants as shown;(36.6% of household members responded that they don't know, 17.2% of household members, and 26.7% of traditional healers mentioned peptic ulcers, 2.2% of household members mentioned typhoid in chicken, 11.8% of household members and 20% traditional healers mentioned urinary tract infection, 6.5% of household members and 13.3% traditional healers mentioned malaria, 2.2% household members

mentioned intestinal worms,9.7% of household members and 33.3% of traditional healers mentioned stomach ache,4.3% of household members mentioned fever,1.1% of household members mentioned hemorrhoids, 8.6% of household members mentioned GI diseases.

Table 2. Characteristics of household members in selected wards.

Varibles	Wards						
	Swaya	U/usongwe	Nsalala	Iwindi	Igale	Overall	Chi-square
Gender	%	%	%	%	%	%	
							$\square^2$=12.39
Males	47.4	42.1	58.8	47.4	63.1	51.8	p=0.014
Females	52.6	57.9	41.2	52.6	36.9	48.2	
Age							
18-30	10.5	10.5	0	10.5	0	6.3	$\square^2$=124.36
31-40	36.8	5.3	29.4	15.8	5.3	18.5	p<0.001
41-50	21.0	21.0	29.4	31.6	5.3	21.7	
>50	32.6	63.2	35.3	42.1	89.5	52.5	
Marital status							
Single	0	5.3	5.9	0	0	2.2	$\square^2$=14.37
Married	100	94.7	94.1	100	100	97.8	p=0.006
Education level							
Primary school	73.7	68.4	76.5	68.4	78.9	73.2	
Secondary school	0	15.8	5.9	10.5	5.3	7.5	$\square^2$=41.99
Tertiary	5.3	5.3	5.9	10.5	0	5.4	p<0.001
Didn't attend school	21.1	10.6	11.8	10.5	15.8	13.96	

Part of plant used for the treatment of typhoid fever

From the survey, 100% of both household members and traditional healers reported leaf as part of plant used for the treatment of typhoid fever as shown in figure 3.

Methods used for drug preparation

From the survey results (figure 4), two methods were mentioned which include; Boiling (33.3% of traditional healers and 29.8% household members); Soaking goldenberry part in water (66.7% for traditional healers and 70.2% for household members).

Mode of drug administration

As the survey data indicates, 100% of both traditional healers and selected household members responded that the oral route is the only method used for herbal drug administration (figure 5).

Dissolving time of fresh and powdered part of Physalis peruviana

According to respondent's different times are used in dissolving the *Physalis peruviana* part in water as indicated hereunder;(less than a day, 67.7% for household members and 60% for traditional healers; one day, 17.2% for household members and 20% for traditional healers; more than one day, 15.1% for household members and 20% for traditional healers); How often does the herbal drug apply per day?

In case of dose prescription, the respondents came with the following information's; (once per day, 18.3% for household members, and 20% for traditional healers; twice per day, 60.2% for household members and 26.7% for traditional healers; thrice per day, 21.5% for household members and 46.7% for traditional healers).

Measurements in preparing herbal drugs

For preparation of herbal drug different views were given by respondents as indicated hereunder;(100% of traditional healers and 58.4% of household members use measurements while 41.6% of household members do not use measurements).

There was a strong relationship in terms of knowledge, attitude, and practice among household members regarding the use of plants in treating typhoid fever in selected wards ($\square^2$=20.759, df=4, $p = 1.678 \times 10^{-11}$) (table 3).

Table 3. Knowledge, attitude, and practice of household members in selected wards regarding the use of *Physalis peruviana* in the treatment of typhoid fever.

Variable	Wards						
	Swaya	U/usongwe	Nsalala	Iwindi	Igale	overall	Chi-square
	%	%	%	%	%	%	
Herbal preparation							
Boiling	31.6	42.1	17.6	36.8	21.1	29.8	χ^2=20.759
Soaking	68.4	57.9	82.4	63.2	78.9	70.2	p<0.001
Measurements							
Yes	47.4	52.6	76.5	78.9	36.8	58.4	χ^2=56.368
No	52.6	47.4	23.5	21.1	63.2	41.6	p<0.001
Repetition of dose							
Yes	63.2	73.7	88.2	47.4	68.4	68.2	χ^2=40.928
No	36.8	26.3	11.8	52.6	31.6	31.8	p<0.001
Age of plant							
Semi-mature	63.2	42.1	76.5	47.4	94.7	64.8	χ^2=81.151
Mature	36.8	57.9	23.5	52.6	5.3	35.2	p<0.001

Amount of plant used in preparing herbal drug

Since measurements play a great role in medicine preparation, the following were the results collected from respondents (43% of household members use approximation and while 57% for household members and 100% for traditional healers use measurements).

Amount of water used for preparing herbal drug

Preparation of herbal drug is accompanied by water estimation, the indicated are information collected from key informants (approximated, 43% of household members use approximation while 57% of household members and 100% for traditional healers use measurements).

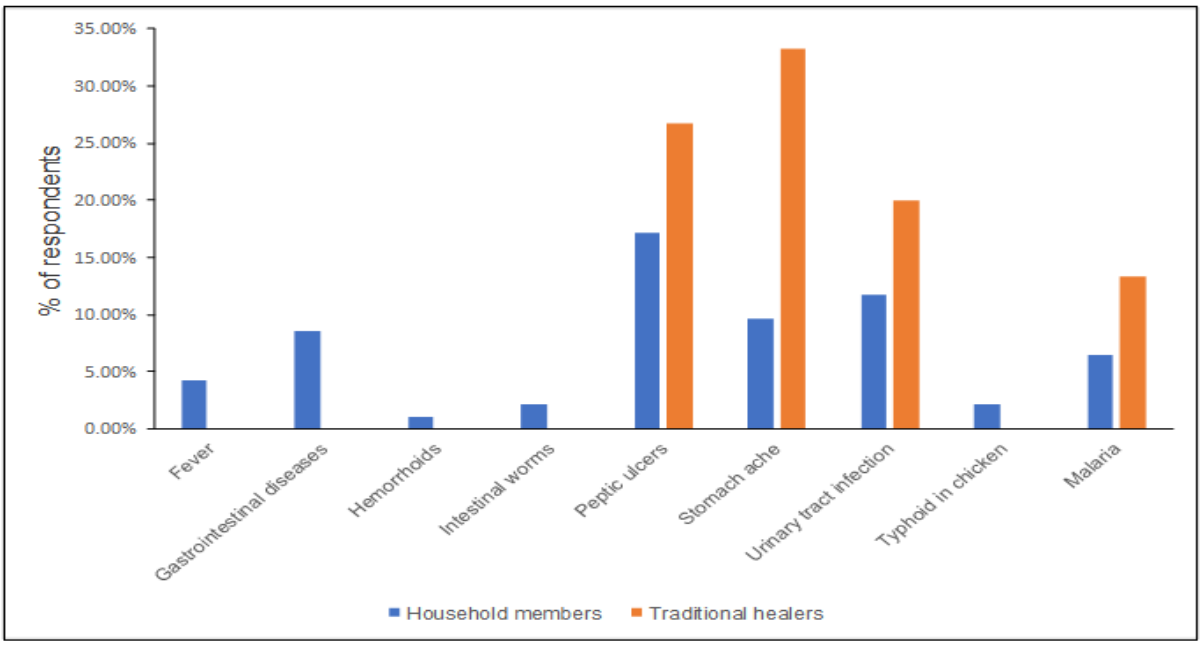

Fig. 2. Other diseases treated by the *Physalis peruviana*.

Herbal drug dose duration

The prepared herbal drugs are being used differently in communities the survey revealed the following information from the key informants;(less than a week, 53.8% for household members and 40% for traditional healers; one week, 40.9% for household members and 40% for traditional healers; more than a week, 5.4% for household members and 20% for traditional healers).

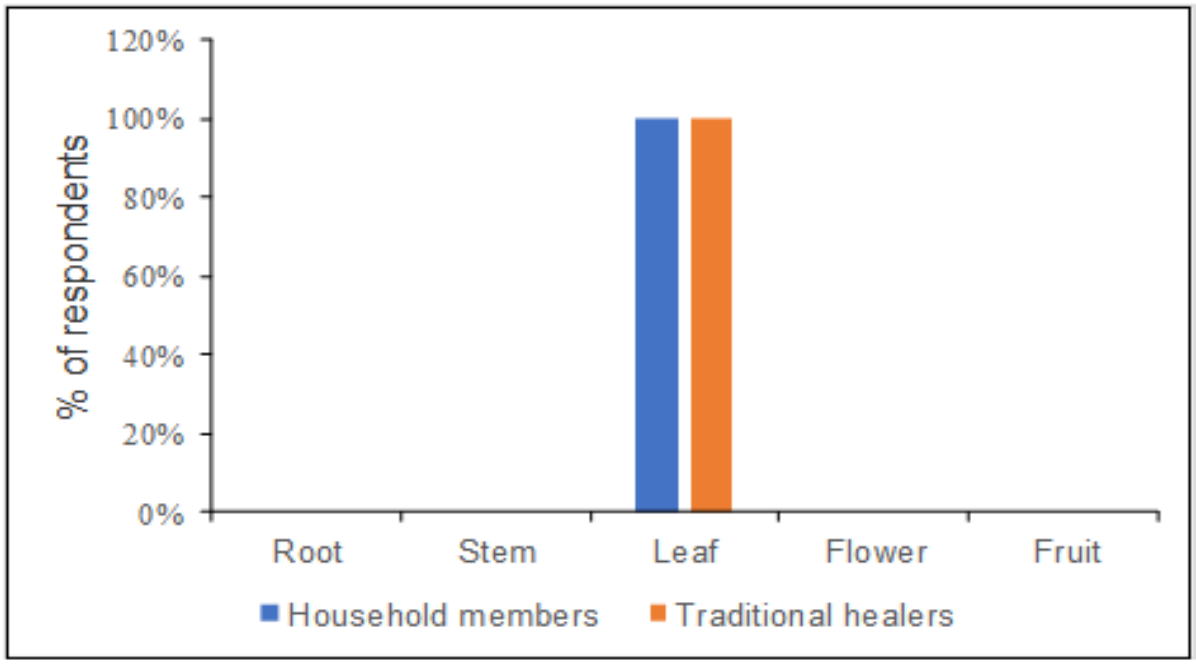

Fig. 3. Part of a plant used in the preparation of herbal medicine.

Repetition of the dose if not recovered

Whether there is repetition or not of herbal drug dose when unrecovered the respondents provided the following information (100% of traditional healers and 68.2% of household members responded there is repetition while 31.8% of house hold members responded no repetition of dose). The chi-square signifies high association in different wards among the selected key informants in terms of their knowledge, attitude, and practice of how typhoid fever is treated using the plant ($\square^2$=40.928, df=4, p= 2.781× 10 $^{-08}$) (table 3).

Fig. 4. Methods used for herbal drug preparation.

Side effects associated with the herbal drug

From the survey data concerning side effects associated with herbal drugs prepared from *Physalis peruviana*; the results from respondents came with different views as indicated here under; (90.3% of household members and 100% of traditional healers responded no side effects, while 9.7% of household members responded that they don't know).

Reason for selecting herbal drug prepared from Physalis peruviana in treating typhoid fever

For someone to choose *Physalis peruviana* for managing typhoid fever here are the results presented by respondents;(80.7% of household members and 100% of traditional healers mentioned due to efficiency,10.8% of household members mentioned due to availability and 8.6% of household members mentioned that due to cost of synthetic medicine).

Any diagnostic test undertaken before taking herbal drug

According to survey data whether someone undergoes a diagnostic test or not here are the information's provided by respondents: (53.8% of household members and 53.3% of traditional healers responded no, while 46.2% of household members and 46.7% of traditional healers responded yes).

What age of Physalis peruviana is used to make herbal drug

For the case of age of the plant, the following information's were provided by respondents;(64.8% of household members and 60% of traditional healers mentioned semi-mature plant while 35.2% of household members and 40% of traditional healers mentioned mature plant as indicated in figure 6. The chi-square test reveals a strong association between household members in selected wards and the plant used for herbal drug preparation and thus typhoid fever management ($\square^2$=81.151, df=4, p= 9.932 × 10^{-17}) (table 3).

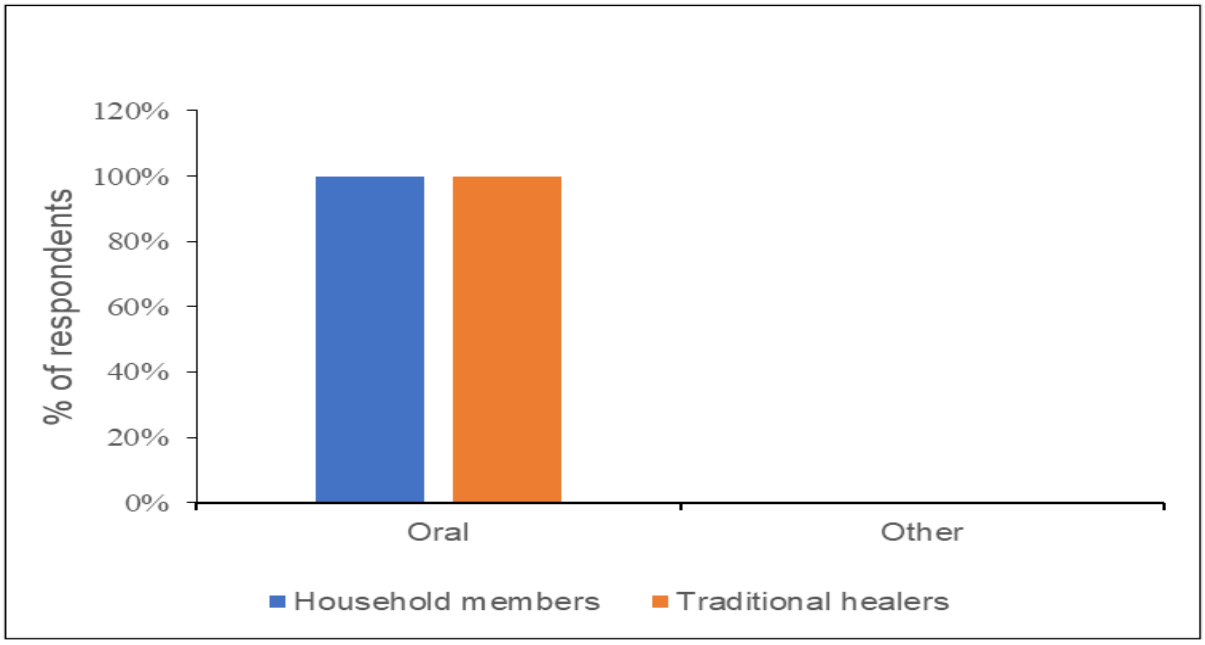

Fig. 5. Mode of herbal drug administration.

Characteristics of household members in selected wards as well as the knowledge, attitude, and practice on household members in selected wards regarding the use of *Physalis peruviana* in the treatment of typhoid fever are indicated in table 2 and table 3 respectively.

Discussion

As survey results indicate, gender had been considered in this study therefore the information's concerning the use of *Physalis peruviana* in treating typhoid fever could have some reality. Also, the majority of respondents are married therefore this have some impacts on medicinal use as there might be sharing of knowledge on the use of medicinal plants among the family members (Mag *et al.*, 2019). Other results in this part involve education level as shown, majority of respondents attended primary school and few of them attended tertiary education. According to Botucatu (2022) education and medicinal use have some correlation since majority who attended tertiary education had full knowledge

on synthetic medicine compared to herbal drugs.

From the survey data; *Physalis peruviana* is well known by the society including diseases treated with the same plant hence this could be due to the knowledge being shared within the community about medicinal plants and different diseases treated using those plants and trees (Buwa, 2019). So far other awareness on the particular plants could be because of the community living in the area where there is abandon of forest with plenty of different species of medicinal plants and trees. Also, the community living around the forest had been using medicinal plants as primary health care (Voeks & Leony, 2004). Since many countries worldwide including Tanzania depends on medicinal plants as the primary health care the current survey results conducted in the Mbeya Rural District indicates that apart of *Physalis peruviana* being used for the treatment of typhoid fever is also used for the treatment of other diseases. Among those diseases includes; peptic ulcers, stomach ache, gastrointestinal diseases, typhoid in chicken, fever, malaria, etc.

According to survey data, the leaf of the *Physalis peruviana* is the only part used for the treatment of typhoid fever similar to other studies conducted in other places (Fokunang *et al*., 2017; Kamau *et al*., 2020). The *Physalis peruviana* has been widely used as a medicinal plant due to its possession of bioactive compounds that have good medicinal properties (Mondal, 2021).

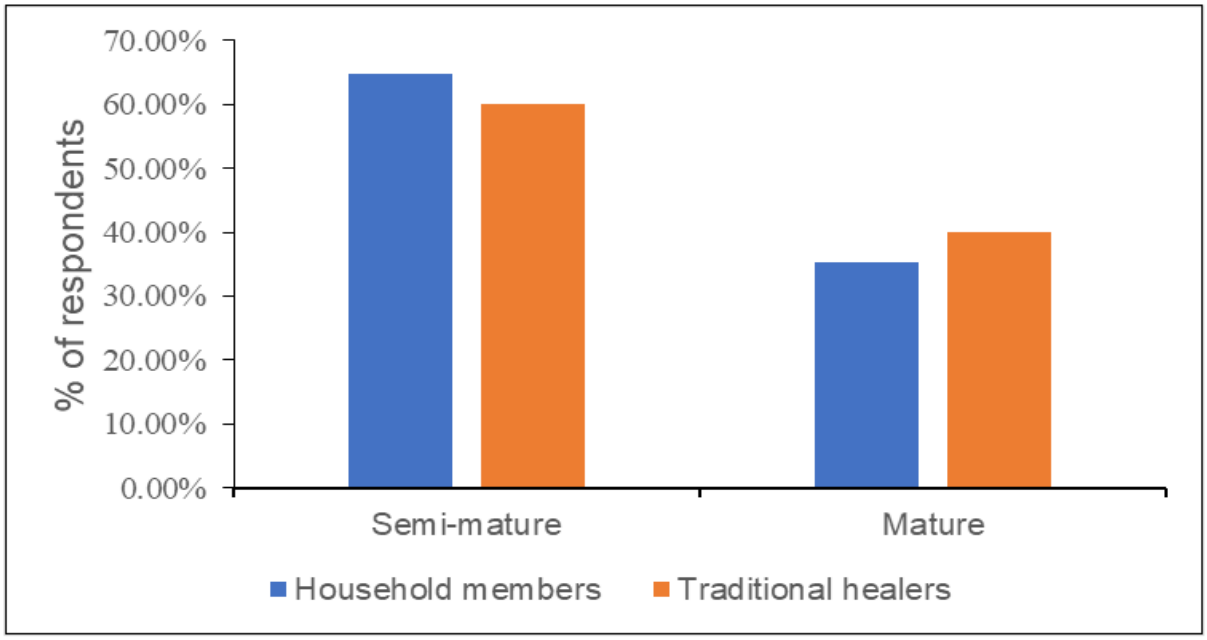

Fig. 6. The plant used in the preparation of herbal drugs.

Physalis peruviana like other medicinal plants are prepared using different methods namely; boiling of fresh leaves and soaking of powdered or ground fresh leaves in cold or hot water whereby soaking of plant part in water are mostly used compared to boiling. According to survey data most key informants reported that boiling is not preferred compared to soaking because it reduces the efficacy of herbal drugs hence making it less effective against the disease treated.For the treatment of typhoid fever as reported from the data both mature and semi-mature plants are used by the community. The results from the respondents show high frequency of individual using semi-mature plant compared to mature plant.

Conclusions

Medicinal plants play a great role to the communities found in rural areas since it is used as primary health care. Goldenberry plant as among of medicinal plants has shown different roles in disease treatments as survey data indicates. Since apart from typhoid fever being treated with the plant also other diseases were

found to be treated by the same plant, the diseases include; urinary tract infection, malaria, stomach ache, typhoid in chicken, gastrointestinal diseases, fever, peptic ulcers, intestinal worms, hemorrhoids, etc. The leaf of *Physalis peruviana* was pointed as a part used in treating typhoid fever and other diseases. Boiling and soaking of plant leaves are methods used for herbal drug preparation, however soaking being more preferable compared to boiling the reason being the efficacy. Thus, this opens a gap for further researches especially in identifying pure phytochemical compound(s) which could be more effective against the disease under study. Therefore, the documentation of this plant including methods for medicinal preparation, the diseases under study as well as other diseases pointed out by key informants will open another chapter to researchers for further studies. In addition, researchers should keep an emphasis on pharmacological and toxicological studies on this plant especially the leaves which are mostly used for disease treatments

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