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The role of *Teff* crop in Ethiopian life: consumption and contribution to rural livelihoods

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Abstract

Teff (*Eragrostis tef*) is believed to be the smallest grain in the world. It is the most important crop in Ethiopia in terms of production and consumption. Smallholder farmers produce *Teff*, and it is the main source of income for farmers in comparison to other cereal crops. *Teff* is the daily staple food for over 50 million Ethiopians. There is a need for information on agricultural consumption, disaggregated at district level, to support evidence-based decision-making at local level. The objective of this paper is to understand the consumption of *Teff* among rural smallholder producers at district level and assess the position of *Teff* among cereals in the lives of Ethiopian rural farmers. The study employed a multistage sampling technique to select the top *Teff* producing regions, districts, and *kebeles* (small administrative units) and collected primary data through focus group discussions (FGDs), key informants, and questionnaire respondents. The survey collected qualitative and quantitative data from 357 households. FGD, key informant interview (KII) participants and survey respondents were drawn from the same areas where the survey was conducted. The quantitative and qualitative data were subjected to statistical and content analysis respectively. The study findings revealed that on average households consume 26.92% of their *Teff* production per year. Moreover, there is a shift in the consumption of *Teff* which might be due to improved standards of living among the farmers, a health-conscious community, and improved income from *Teff* sales. Although *Teff* is a staple grain in Ethiopia, there is a statistically significant variation in *Teff* consumption among districts.

Keywords Cereal, Ethiopia, Smallholder farmers, *Teff* consumption

Introduction

Teff, botanically known as *Eragrostis tef*, is believed to be the smallest grain in the world (Gebremariam and Zarnkow 2014). Physically, *Teff* is the smallest grain, which is 1.0 mm in length and 0.60 mm in width and is consumed as a whole grain (Habte et al. 2022). *Teff*

originated and was domesticated in Ethiopia between 4000 and 1000 BC (Simoons 1965). It is a staple that has been consumed for thousands of years (Mottaleb and Rahut 2018).

Teff, cultivated in Ethiopia and Eritrea, is used in preparing a pancake-like meal called *Injera*. The crop is used as forage or hay for livestock (Awulachew 2020). In recent years it has been grown in India, Australia, Canada, United States, and South Africa (Alemneh et al. 2022). *Teff* can be cultivated in any range of climatic condition as it is resistant to drought and waterlogging, and it is also a low-risk crop. *Teff* can resist many biotic and abiotic stresses (Sridhara et al. 2021; Lee 2018). It is a traditional crop that grows well under various conditions

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in Ethiopia, yet little known elsewhere (Gelaw and Qureshi 2020). A warm-season annual cereal, *Teff*, is one of the underutilized crops with potential to contribute to food security and crop diversification (Lee 2018). *Teff* can adapt to varied environment factors and can play an important role in eradicating hunger, malnutrition, and poverty (Gelaw and Qureshi 2020).

Teff, Ethiopia's indigenous staple food, is a source of income and nutrition security in Ethiopia (Tadele and Hibistu 2012). *Teff* is nutritious and is part of Ethiopia's cultural heritage and national identity (Tadele and Hibistu 2012). *Teff* is the most important crop in Ethiopia in terms of production and consumption. It is produced by smallholder farmers and is the main source of income for farmers compared to other cereal crops (Fufa and Behute 2011). *Teff* is a daily staple food consumed by over 50 million Ethiopians (Vandercaesteel and Beyene 2018). Urban consumption is about 61 kg per year while in rural areas it is 20 kg per capita per year. The Food and Agriculture Organisation (FAO) reports that *Teff* contributes about 600 kcal per day in urban areas and 200 kcal per day in rural areas (FAO, 2015). This shows the high consumption rate of *Teff* crops among urban dwellers.

Teff is high in nutritional value, and it is demanded by health-conscious consumers. It is believed to be made up of complex carbohydrates and slowly digestible starch (Lee 2018). *Teff* contains higher amount of several minerals than wheat, barley, or sorghum, and its straw is preferred by livestock to any other cereal straws (Gelaw and Qureshi 2020). It has a similar protein composition to cereals like wheat but it is superior in vital amino acid lysine contents. *Teff* is also high in fibre, minerals (particularly calcium and iron) and phytochemicals (polyphenols and phytates) (Sridhara et al. 2021). *Teff* flour is the main ingredient for *Injera*, a spongy pancake, the Ethiopian national dish. The demand for *Teff* has grown worldwide due to its gluten-free quality and high mineral content as an alternative to wheat [45; 47]. Important changes have occurred in the country's *Teff* value chain over the past decade, both in terms of production and consumption. Some analysts argue that *Teff* is a relatively unexplored cereal crop compared to others such as maize, wheat, sorghum, and barley (Fikadu, et al. 2019). Others note that *Teff* is one of the most important crops for farm income and food security in Ethiopia. Additionally, they argue that it is Ethiopia's second most important cash crop, after coffee, generating almost \$500 million in income per year for local farmers (Minten, et al. 2013). The local and global demand for *Teff* present new opportunities for smallholder agricultural producers (Mohammed, et al. 2009; Gideon 2016). *Teff* is likely to continue being a favourite crop among

Ethiopians and it is gaining popularity as a health food in the Western world. It is a gluten-free crop, making it suitable for patients with celiac disease – an allergy to gluten protein (Spaenij-Dekking and Kooy-Winkelaar 2005; Baye 2014; Cheng and Mayes 2017).

Recent studies have indicated that *Teff* is more preferred by farmers and consumers over many other common Eritrean and Ethiopian grain crops such as wheat due to its agronomic traits and uses. However, less is known about the crop by academic and scientific communities outside Eritrea and Ethiopia (Gebru et al. 2020). *Teff* is produced by male-headed rural households, who have access to relatively more land and more family labour (Mottaleb and Rahut 2018). In contrast to this reality, a higher proportion of *Teff* is consumed by urban households and those headed by older and educated heads.

Extensive research has been conducted on *Teff* marketing, determinants of smallholder farmers in market participation and *Teff* market supply (Habtewold and Challa 2017; Dalango and Mulugeta 2018; Gebremedhin and Hoekstra 2007; Belayneh and Tegegne 2019). Amentae explored the value chain and post-harvest losses of *Teff* in Ethiopia (Amentae 2016) and others analysed the incentives and disincentives for *Teff* production in Ethiopia (Demeke and Marcantonio 2013; Assefa 2015). Hyejin argued that the *Teff* value chain in Ethiopia utilised traditional production methods and that the *Teff* market was constrained by the government's export ban (Hyejin 2018). Dijkstra and Polman (2008) and Cheng and Mayes (2017) focused on the nutritional value and food security elements of *Teff*.

Smallholder farmers produce *Teff*, and it is the main source of income for farmers compared to other cereal crops (Fufa and Behute 2011). Supporting such arguments, Habtewold, et al. (2017) reported that 82.27% of farmers used *Teff* as their source of income in addition to home consumption. Previous studies noted that less expensive grains such as maize and sorghum dominated consumption in rural areas (FAO, 2015). Berhane, et al. argued that rural households and the urban poor considered *Teff* a luxury food, while maize and wheat were viewed as necessary food grains (Berhane, et al. 2011). Although preferred over other grains, *Teff* is mostly consumed by wealthier urban residents than by rural households (Berhane, et al. 2011). Minten, et al. (2013), also noted that changes occurred in the country in the *Teff* value chain in production and consumption of *Teff*.

The foregoing review suggests that previous studies focused on the *Teff* value chain, market participation of farmers, *Teff* market supply, post-harvest losses, nutritional security and health aspects *Teff* crops.

However, few studies assessed the consumption levels of *Teff* and its contribution to the livelihood of farmers. This is the knowledge gap that our paper attempts to address. Little is known about *Teff* consumption levels in rural areas from different regions. In this paper, we seek to fill the knowledge gap on *Teff* crop consumption, its contribution to livelihood and its position in relation to the consumption of other cereals in rural Ethiopia.

Understanding food consumption is crucial in sustainability studies. This paper adopted the definition of consumption by Bannock and Baxter (2011) which states that it is the utilisation of resources to satisfy present needs and desires. Consumption is a fundamental concept in economics and other social sciences. This paper aims to answer the following research questions:

- What is the position of *Teff* consumption among cereal crops?
- Is *Teff* still a luxury food item for rural households in the study areas?
- Is there a significant difference in *Teff* consumption among districts from different regions?

We hypothesised that *Teff* is a commercial crop and that the trend of its consumption among rural communities is increasing over time. In line with the research questions, we formulated and assessed the following hypotheses:

- Due to changes in the economy and *Teff* production, consumption of *Teff* shows an increasing trend among rural households.
- There is no significant difference in *Teff* consumption among different districts.
- *Teff* is a luxury food for rural households and the urban poor, while maize and wheat are necessity food grains.

The rationale for investigating *Teff* consumption at district level is to understand consumption levels by district. The data is vital for making informed decisions at local level. District level data is essential for planning and evaluating interventions as policy decisions related to production, nutrition and consumption are implemented at district level. Currently, district-level data on *Teff* consumption that allows for comparisons among districts, is unreliable and inconsistent. The lack of data points to a gap in knowledge regarding district level consumption of *Teff* using theory of consumption values.

Household economic well-being can be measured by the financial resources (income/wealth) available to the household or by the standard of living enjoyed by household members (consumption) (Jones et al. 2010).

This paper aims to analyse the *Teff* consumption in rural households and compare its consumption in relation to the consumption of other cereals in rural Ethiopia. We also explore the extent to which *Teff* consumption patterns vary by district.

This paper employs the theory of consumption values which is a means of explaining user decisions to consume *Teff*. The theory of consumption values (TCV) provides insights related to consumer's consumption behaviour through consumption values. The theory suggests that consumers make informed decisions on consumption after considering multiple value dimensions, such as enjoyment, quality, social, value for money, and their trade-offs (Sheth et al. 1991). The potential users follow intelligent cognitive decision processes and reflect on multiple value dimensions before they decide on consumption (Turel et al. 2010).

Two applications of the consumption theory are illustrated pertaining to choices involving *Teff* consumption (Bahoo et al. 2023). The illustrations entail the choice of consumption or lack of it and the choice of *Teff* over other cereals. Results of the operationalization of the consumption theory suggest that it may be used to predict consumption behaviour, and to describe and explain it (Sheth et al. 1991).

The study of *Teff* consumption covers a wide range of rural and urban consumers. However, this paper specifically focuses on the consumption of *Teff* among rural smallholder *Teff* producers. Due to time constraints and resources, the authors did not include all *Teff* growing areas and smallholder producers, but the sample examines how *Teff* consumption benefits the livelihoods of rural farmers in Ethiopia.

The paper contributes knowledge in agricultural economics, about smallholder farming and crop utilisation in Ethiopia. The authors present a novel analysis of *Teff* consumption in four distinct districts, adopting a multi-regional approach. The paper highlights the socio-economic and cultural value of *Teff*, thus providing a holistic perspective of its significance to the livelihood of local communities. The paper contributes to the literature on livelihoods in three ways. Firstly, it assesses the purpose of growing *Teff* at household level. Secondly, it highlights the level of consumption and its contribution to the livelihoods of smallholder farmers. Lastly, it compares the consumption of *Teff* with other cereals among smallholder farmers in selected districts.

Data about *Teff* consumption at district level is essential for designing appropriate strategies aimed at fully exploiting the opportunities for smallholder *Teff* producers in the value chain. The purpose of this paper is to understand the consumption of *Teff* among rural smallholder producers at district level, determine the

position of *Teff* among cereals in Ethiopian farmers' lives, and to explore its importance in the livelihood of the farming community. In this regard, the specific objectives are to:

- Describe the primary purpose of growing *Teff* at household level,
- Assess the importance of *Teff* and its contribution to the livelihood of smallholder farmers,
- Assess the level of *Teff* consumption among smallholder farmers, and
- Compare the consumption of *Teff* and other cereals among a group of smallholder *Teff* producers at district level.

The paper provides disaggregated data and basic information on *Teff* consumption. The study is exploratory and seeks to understand *Teff* consumption in different districts. The focus is on smallholder farmers, who are considered poor, disadvantaged, and vulnerable. The paper's use of a mixed-methods approach, which includes literature and document reviews, focus group discussions, in-depth interviews, and household survey that provide a rich and comprehensive perspective. This strength is particularly evident in the detailed qualitative analysis of the importance of *Teff* and its contribution to livelihoods. It draws from diverse voices within the community, highlighting its significance. The statistical analysis of *Teff* consumption compared to other cereal crops' consumption in different districts, provides valuable insights.

The paper compares the results of *Teff* consumption among farmers in four major *Teff*-producing districts from four different regions of Ethiopia. In addition, our study provides recommendations for policymakers and decision-makers regarding the improvement of sustainable *Teff* consumption in rural areas. The paper is divided into sections. The section that follows presents the methods and then the findings on *Teff* consumption in Ethiopia. The discussion section compares the findings against previous studies and highlights the policy implications for consumption. The conclusion section is a summary of the key ideas presented in this paper.

Materials and methods

Research design

Research design provides a logical structure for gathering and analysing data during research (Bryman 2008). In this study, a cross-sectional research design was used to guide the data collection of both quantitative and qualitative data (Bethlehem 1999). According to Bryman (2008), a cross-sectional research design represents the collection of data at a single point in time. In cross-sectional

research design, researchers investigate the situation in a population at a certain point in time (Bethlehem 1999). From a methodological standpoint, this study used a mixed methods approach for data collection and analysis. Mixed methods are approaches that focus on collecting, analysing and mixing both quantitative and qualitative data in a single study (Ndinda et al. 2017). The mixed-methods research design creates a broader picture (Ndinda and Ndhlovu 2020) by enhancing the depth and insight provided by the study participants through the inclusion of dialogue and narratives.

This paper used mixed methods to gather data that could not be obtained by adopting a single methodology. The data was triangulated and the findings from the data set were compared with others. The study used FGDs and KII for qualitative data collection and a household questionnaire for quantitative data. Concurrent data collection procedure was used as a strategy to obtain quantitative and qualitative data. In the concurrent procedure, researchers collect both forms of data at the same time during the study and then integrate the information in the interpretation of the overall results (Ndinda et al. 2017).

Study sites

A multistage sampling procedure was used to identify the areas for case studies, participants for FGDs and KIIs, and survey respondents. Multi-stage sampling is a process of moving from a broad to a narrow sample, using a step-by-step process (Ndinda et al. 2018). The unit of analysis for this study was rural heads of households who were involved in *Teff* production in 2017/18. The regional states, districts, and *kebeles* were purposefully selected. To determine the *Teff* production regions at national level, we considered several criteria, including the average cultivated area for *Teff*, *Teff* production by region, average production per hectare, and the percentage of each region's contribution to national *Teff* production. Firstly, the Oromia and Amhara regional states were purposefully selected as they are among the top *Teff*-producing regions and suppliers to the local markets (CSA 2017). SNNPR (Southern Nation and Nationalities and Peoples Region) and the Tigray regional states were selected as there is potential for *Teff* production in those areas (Gideon 2016). Moreover, to get the views of the federal level experts and wholesalers in relation to the *Teff* consumption, Addis Ababa region was considered as the study area. In this regard, Ehil veranda was purposefully selected from Addis Ababa regional state as it is the central market for *Teff* crop for the country in general and it is the place for the major wholesalers of the *Teff* crops.

In stage two, districts were purposefully selected. We selected the Lomi district from the East Shewa zone of Oromia regional state as it is ranked 1st in *Teff* production at national level. We selected Minjar Shenkora district from the North Shewa zone of Amhara regional state as it is ranked 4th in *Teff* production in the Amhara region and 7th in *Teff* production at national level. These two districts are among the seven top *Teff*-producing districts at national level (Warner, et al. 2019). In addition, we selected Halaba zone from the SNNPR regional state and Tahtai Maichew district from the Tigray regional state as these are the top *Teff*-producing districts in their respective regions (CSA 2014).

Eight (8) *kebeles* (two *kebeles* from each district) were purposefully selected in consultation with the Offices of Agriculture and Rural Development at district level. We selected the Deke Bora and Tulu Re'ee *kebeles* from the Lomi district, Agirat and Bolo Silassie *kebeles* from the Minjar Shenkora district, Andegna Hansha and Guba *kebeles* from the Halaba zone, and Kewanit and May Brazio *kebeles* from the Tahtai Maichew district. The

selection criteria for the two *Kebeles* from each district were: areas with *Teff*-producing potential, areas that are geographically convenient, easy to find *Teff* producers, and have easy access to transport facilities. Purposive sampling was used to select participants for both the focus group discussions and the key informant interviews (Kitzinger 1994) (Fig. 1).

Sample size

In determining the sample size for our survey, we used the formula developed by Cochran. This formula ensures a representative sample for proportions in large populations (Cochran 2007).

The equation is:

$$n = \left(\frac{t}{d} \right)^2 p(1 - p)$$

where: n=sample size, t=values of standard variant at 95% confidence interval (t=1.96), p=the estimated proportion of an attribute that is present in the

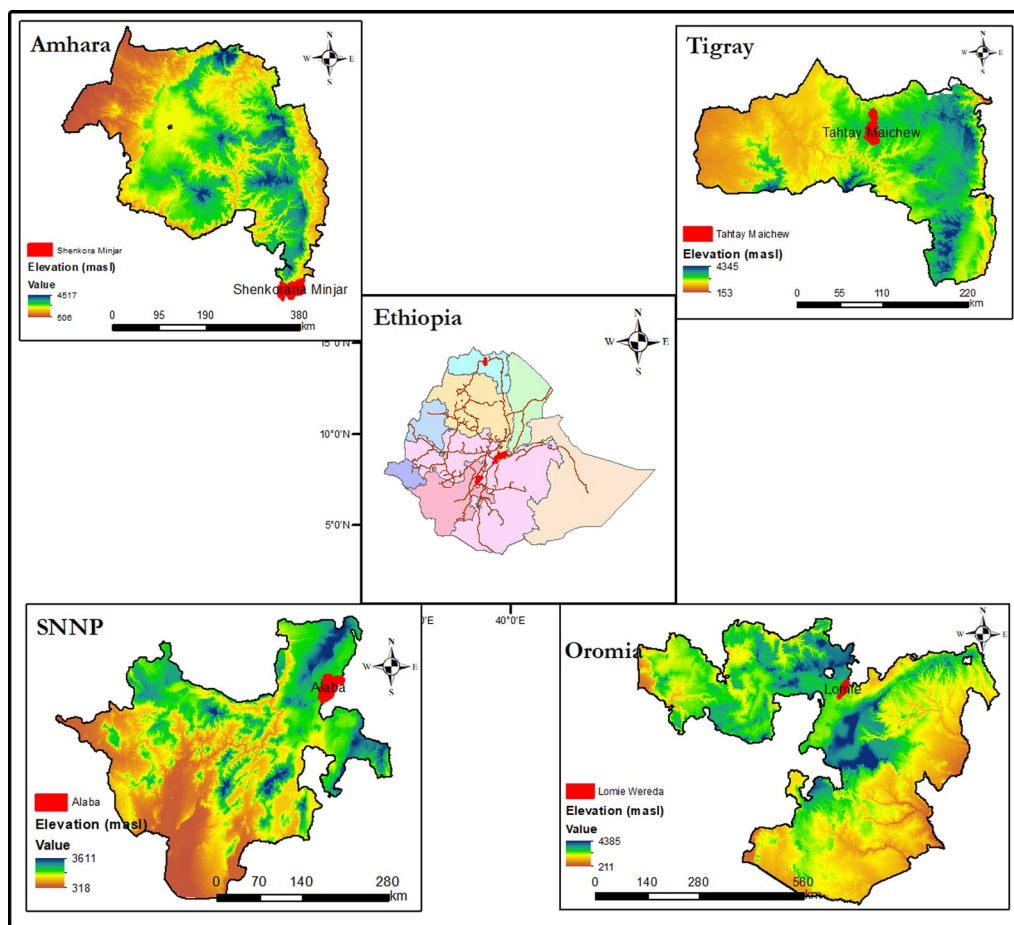


Fig. 1 Administrative map of Ethiopia and study sites. Source: Mekelle University, GIS section, 2019

population (e.g., 20%) and, d = acceptable margin of error for proportion being estimated ($d = 0.05$). We added 7.5% as a reserve for non-response rate.

The sample size for the survey was 264 households. To identify potential survey respondents, a list of 1073 heads of households (sample frame) who were involved in *Teff* production in 2017/18 and residing in the selected eight *kebeles*, was obtained from extension officers. Using simple random sampling, a total of 264 households were identified. The study was granted ethics approval (2017_DEVSTUD_Student_31) by the Research Ethics Review Committee, University of South Africa (UNISA). Also, an ethical clearance was obtained from Mekelle University, College of Health Sciences.

During the data collection process, eight (8) respondents declined to participate in the survey and four (4) respondents could not be reached at their homes despite repeated attempts to contact them. As a result, a total of 12 households were replaced. The completed questionnaires were reviewed on the same day, and any with incomplete responses or missing values were discarded. Out of the 264 households, 16 questionnaires were incomplete and therefore rejected (93.94% response rate). Only the completed questionnaires were kept for data analysis, resulting in a total of 248 randomly selected respondents (62 from each district) targeted for the survey. Additionally, 84 participants were purposively selected for FGDs, and 25 for key informant interviews. Overall, 357 participants were involved in the study (Table 1). In previous studies of the household survey, the sample sizes ranged from 200 to 300 households, and this was used as a base to determine our sample size.

Data sources

To ensure the validity of the data, a mixed-methods approach was used, and efforts were made to include topics and/or questions that were relevant to the scope of the study. Two types of data were collected and processed. The sources for the primary data are FGD, KII and questionnaire while the source for the secondary data was a desk review of relevant documents. The four data sources used in this study are described below.

Desk review of relevant documents

This paper is based on literature and documentation review, and also empirical data collection. A total of 79 documents (58 published and 21 grey literature), were considered for screening. Out of the 79 documents, 20 were excluded because they were not relevant to *Teff* consumption and rural livelihoods. Finally, 59 documents (36 academic journal articles, 5 research papers, 1 dissertation, 2 plans and statistical documents, 4 UN reports, 4 working papers, 2 unpublished articles, 5 books) were reviewed. The search words we used to get the relevant journal articles and other materials include Ethiopia, *Teff*, cereals, production, consumption, livelihood, and smallholder farmers. The inclusion of such terms in the search word were their significance to the title of the study at hand. Production and consumption of other agricultural commodities such as vegetables, fruits, spices, etc. were not the subject of the study and were thus excluded. Moreover, the research words focused on smallholder farmers and thus medium and large-scale *Teff* producers were excluded from the study.

Table 1 Number of study respondents/participants by data collection method and place

Composition of participants	Data collection method	Number of respondents/participants by place					Total respondents/participants
		Tahtai Maichew	Minjar Shenkora	Lomi	Halaba zone	Addis Ababa	
<i>Teff</i> producers (farmers)	Survey	62	62	62	62	0	248
<i>Teff</i> producers (farmers)	FGD	16	17	17	18	0	68
<i>Kebele</i> administrators	FGD	2	2	2	1	0	7
Development agents	FGD	3	2	2	2	0	9
District experts	In-depth interview	3	3	2	2	0	10
Regional experts	In-depth interview	2	1	1	1	0	5
Federal experts	In-depth interview	0	0	0	0	4	4
<i>Teff</i> wholesalers	In-depth interview	0	0	0	0	6	6
Total	Survey, FGD and KII	88	87	86	86	10	357

Source: Fieldwork survey result, 2020

FGD denotes focus group discussion. KII denotes key informant interview

Qualitative data

Eight focus group discussions (FGDs) were conducted in 8 *kebeles* (84 participants). Among the FGDs participants, 68 were *Teff* producers, 7 were *kebele* administrators, and 9 were development agents. The discussions took place from January 2019 to February 2019. Four of the focus groups consisted solely of female-headed participants while the other 4 groups consisted of male-headed participants. Homogeneous male and female FGDs were conducted to ensure active discussions. It is known that participants of the same gender tend to freely express and share their ideas, perceptions, and experiences (Ndinda et al. 2018; Ndinda and Ndhlovu 2016). We conducted the FGDs to gain insight into the importance of *Teff* and its contributions to livelihoods.

Key informant interviews (KIIs) were conducted to gain direct access to deep, dependable, and valid information related to the significance of *Teff* and its contributions to rural livelihoods. The study guide covered questions about the importance of *Teff* and its consumption. After obtaining consent, 23 in-depth interviews were electronically recorded, and notes were taken during 2 interviews. On average, each interview took about 25 min.

Survey

A survey was conducted to collect data about the *Teff* production, distribution, consumption and livelihood. Data was collected from a total of 248 randomly selected respondents. The data was cleaned and edited to ensure its validity. The primary purpose of the survey was to collect specific information pertaining to *Teff* production, distribution, and consumption (livelihoods). A questionnaire and open-ended questions were used in the survey in the light of the research questions. Pre-testing of the questionnaire was undertaken to ensure its validity and about 10 *Teff* producers were involved from Tahtai Maichew district. This process helped to further refine the questionnaire and make it more effective for data collection.

Due to the large sample size and time constraints, the survey was conducted with the help of trained enumerators. Five experienced enumerators were selected, and they were trained and informed about the scope of the study and the importance of data collection before the survey. During data collection, the researcher accompanied the enumerators in the field to both supervise and take part in the survey process. The completed questionnaires were examined on the same day and those with incomplete responses or missing values were discarded. Only those questionnaires with all responses completed were retained for data analysis.

Methods of analysis

Thematic content analysis was used to analyse the qualitative data collected from focus group discussions and in-depth interviews (Ndinda and Ndhlovu 2016). This method involves extracting themes or categories from the data and using them to explain social phenomena. The audio recordings from the focus group discussions and in-depth interviews with extension agents, and senior experts at regional and federal levels, were transcribed in local languages (Tigrigna and Amharic). The recordings were transcribed verbatim and then translated into English before beginning the data analysis (Ndinda and Ndhlovu 2016; Simoons 1965).

The transcriptions were coded into concepts, which are words that represent groups or classes of objects, events, and actions that share major common properties. To achieve this, the transcribed data was thoroughly read multiple times to fully comprehend the true contextual meanings and to ensure that the concepts were accurately derived from the textual data. The derived concepts were then categorised into various categories aligned with the research questions which facilitated the creation of multiple concepts and themes from the data. Significant themes regarding the purpose of *Teff* cultivation, and the importance of *Teff* and its consumption, were extracted from the participants of the FGD and key informants. These themes played a crucial role in understanding the *Teff* consumption patterns of smallholder *Teff* producing households.

For quantitative data, descriptive analysis such as percentages, means, and standard deviations were used in the study. ANOVA (analysis of variance) was used to see whether there is a significant difference among the four districts in relation to the amount of *Teff* consumption and other cereal consumption. ANOVA is a powerful statistical technique for comparing means across three or more groups (Hae-Young 2014). ANOVA is the most efficient parametric method available for the analysis of data from experiments (Armstrong and Slade 2000). This is simply an example of the general linear model (GLM) which is commonly used for factorial designs (Henson 2015). Originally devised to test the differences between multiple groups of treatments, it avoids the issue of making multiple comparisons between group means using *t*-tests (Snedecor and Cochran 1980). A factorial design is one in which the experimental conditions can be categorised according to one or more factors, each with two or more levels (Winer, et al. 1971). It separates observed variance data into different components which can be used for additional tests. A one-way ANOVA is used for three or more groups of data to gather information about the relationship between the dependent and independent variables (Hae-Young 2014).

For comparing the means of more than two groups, the appropriate method is the one-way analysis of variance (ANOVA) rather than the *t*-test. Since the ANOVA is based on the same assumption as the *t*-test, it also focuses on the locations of the distributions represented by means (Hae-Young 2014).

In this paper, our goal was to find out if there were differences in consumption of *Teff* and other cereals based on district. We categorised consumption based on district into four groups, each with a different consumption. We used ANOVA to determine whether there were any significant differences in the average consumption of *Teff* between the groups. The research question was: Are there significant differences in *Teff* consumption among different districts? Why is this method called “analysis of variance” instead of “analysis of means”? This is because the relative location of the group means can be more easily identified by comparing the variance among the group means, especially when there are a large number of means to compare.

The ANOVA method assesses the relative size of variance among group means (between-group variance) compared to the average variance within groups (within-group variance) (Hae-Young 2014). In our one-way ANOVA analysis, the null hypothesis states that “there is no difference among the means of all groups”. This analysis produces a test statistic and *p*-value to assess the statistical significance of the data. The data was checked for normality and homogeneity of variances. A larger F-value implies that the means of the groups are significantly different from each other compared to the variation of the individual observations within each group. This statistic represents the ratio of the between-group variance to the within-group variance. A higher F-statistic indicates a stronger effect of the factor we are interested in. If the F-value is larger than the critical value, it suggests that the differences between group means are larger than what would be expected by chance (Hae-Young 2014). Finally, we use the F-statistic and a *p*-value to determine if the observed differences between groups are statistically significant. A *p*-value less than 0.05 (a common threshold) suggests that the differences are unlikely due to chance and that the factor you are interested in has a real effect. The results may be interpreted as indicating a statistically significant difference among the means of the groups at the α error level of 0.05. The result suggests rejection of the null hypothesis that all the group means are the same, and coincidentally supports that at least one group mean differs from the other group means (Hae-Young 2014).

An ANOVA test was used to test the significant difference in the mean consumption of *Teff* and other cereals among the four districts. ANOVA table testing:

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$ (all population have equal means).
Versus (against the alternative).

H_1 : At least two means are different.

To test the null hypothesis of equality of four group means, the researchers calculated the ratio (F-ratio). The multiple comparisons table indicates all the possible comparisons for the four groups of participants. The significance column enables us to assess whether the mean differences between the groups are significant. The assumptions of independence, normality, and homogeneity of variances were assessed to ensure valid results.

Results

Purpose and origin of growing *Teff*

Teff is primarily used as a major food staple and it is consumed in the form of *injera*. Despite having lower yields compared to most cereal crops, smallholder producers have dedicated themselves to its production (Roseberg, et al. 2005). A key informant from Tigray regional state said the following in relation to the origin of *Teff*.

Teff is an ancient and indigenous cereal crop grown in Ethiopia. It has been grown for centuries because of its various merits; otherwise, it could have been extinct. However, the exact day of its origin is not known clearly. But there are different research evidences, which say that the history of Teff is estimated to go back to six thousands of years back. It is well known that Teff is an ancient, native and indigenous crop to Ethiopia. Thus, there is no dilemma about the origin of Teff (Tigray_expert_1).

This result is similar to previous research findings of scholars that state Ethiopia is the native home of the *Teff* crop, and it has been grown as a food crop in East Africa for thousands of years (Baye 2014). It is also aligned with the research results of Simoons (1965) that state *Teff* originated and was domesticated in Ethiopia between 4000 and 1000 BC (Simoons 1965) (Fig. 2, Fig. 3).

Teff can be stored for many years without being significantly damaged by common storage insect pests (FAO. 2015). In this regard, discussions were held with the FGD participants and key informants. Study participants agreed that the purpose of growing *Teff* was to guarantee food security and support the livelihoods of households. Rural communities in the *Teff*-growing regions also agreed that the crop was used for both household consumption and generating income by selling it to local traders in Tahtai-Maichew, Minjar Shenkora and Halaba. In fact, Halaba had become so commercialised that its residents considered *Teff* as a cash crop.



Fig. 2 Teff cultivation, Kewanit kebele, 2019



Fig. 3 Threshing of Teff, Deke Bora kebele, 2019

The primary purpose of growing Teff is feeding households, and it is also used as a major source of income for the households. The straw of Teff is also used for animal feeding (Tahtai_Maichew_FGD_14).

We use it for both consumption and market. Most farmers change their lives by selling Teff and it is the main cash crop (Minjar_Shenkora_FGD_17).

The primary purpose of Teff production in our area is for marketing purposes and generating income from it. Thus, farmers produce Teff for the market (Halaba_FGD_8).

Government officials and key stakeholders argued that *Teff* had shifted from being a staple food crop to

farmers cultivating it as a cash crop. It had become so profitable that farmers now grew it primarily for profit, using the proceeds to improve their livelihoods and purchase food that was not grown in the *Teff*-growing region. However, to ensure that *Teff* consumption was not completely abandoned, rural households had become innovative. Instead of consuming *Teff* products, they mixed *Teff* flour with flour from wheat or maize to maintain the crop's place in their diet. An official from the Ministry of Agriculture and Rural Development explained the shifts in *Teff* production and consumption:

It is well-known that most of the crops are produced by rural communities and smallholder farmers. When it comes to Teff, this crop is primarily grown for profit rather than for personal consumption. Since it has a high value in the market, farmers choose to sell it in the market so that they can buy other crops. They also use it for festivities and ceremonies. Therefore, the main reason for producing Teff crops in rural areas is to generate income rather than for personal consumption (Federal_official_KII_1).

An official in the Ministry of Trade and Industry confirmed the transformation of *Teff* from a staple food crop consumed by rural households to a cash crop. Farmers cultivated *Teff* as a cash crop due to its higher price compared to other cereal crops:

Often farmers produce Teff for the market, even though they also use it for personal consumption by mixing it with other crops. This is due to the high demand in the market, which allows farmers to get a better price and revenue compared to other cereal crops (Federal_official_KII_4).

Communities emphasised that *Teff* was their main staple food, produced for both consumption and trade. Government officials who were knowledgeable about the economic trends of the product, highlighted that *Teff* was primarily grown as a cash crop. The proceeds from its sale were used to meet household needs and improve household food security. To ensure that rural households are getting the benefits of nutrition from *Teff* consumption, they developed innovative ways to mix *Teff* with other cereals, allowing them to continue consuming *Teff* rather than supplying all *Teff* products to the market. The high demand for *Teff* resulted in higher prices compared to other crops. *Teff* became the source of income for rural farmers, transforming their lives through the profits generated by this crop. Additionally, the straw/hay of *Teff* are used as animal fodder (Fig. 4).



Fig. 4 *Teff* marketing, Arerti, Minjar Shenkora, 2019



Fig. 5 Baking *Teff* Injera, Mekelle, 2024

Importance of *Teff* production to the livelihoods of smallholder farmers

Culturally, *Teff* holds a central position in Ethiopian cuisine. It is a staple food for both rural and urban Ethiopians, serving not only as a source of sustenance and income but also as an integral part of cultural ceremonies. The significance of *Teff* in Ethiopian culture is evident during important cultural and religious festivals where it takes centre stage in the cuisine that is served. *Teff* is not only nutritious for humans, but it is also highly valued as fodder for livestock. The growing demand for *Teff* has led to low-income households mixing it with other cereals. Additionally, *Teff* has exposed class divisions among Ethiopian households. Those who can afford to consume it in its pure form are considered to have a higher economic status than those who mix it with other cereals:

Teff has numerous benefits. Culturally, it is one of the most respected crops. In rural areas, it is used for ceremonies and not incorporated into everyday livelihoods. They use it during ceremonies and festivities such as serving special guests and at weddings. Most of the time, farmers use it by mixing it with other crops. Its values are not only in its grains but also in its straw which is a high-value crop for animals. It is preferable for feeding cows and farming oxen. It has a high nutrient with two-thirds of the protein consumed by Ethiopians coming from this crop. Therefore, it holds significant value as a protein source for the population. Additionally, it serves as an indicator of a family's economic status (Federal_official_MoARD_2).

The health benefits of *Teff* were discussed in the communities of Tahtai Maichew and Minjar Shenkora. Study participants made a distinction between red and white *Teff*. The red *Teff* is considered valuable in treating anaemia and healthcare workers advise women to consume red *Teff* soup after giving birth as it is believed to increase their blood levels. This advice is based on the cultural use of *Teff* as a nutritious meal that aids in women's recovery after giving birth. *Teff* is also culturally recommended for lactating mothers and children due to its high nutritional value, serving as a good source of protein. Additionally, *Teff* has medicinal value and is recommended for improved blood circulation, increased blood levels, and as a source of nutrition for lactating mothers and children. *Teff* can be processed into various food products, including soup, bread, and the popular traditional Ethiopian meal, *injera* (Fig. 5).

One of the advantages of *Teff* is its positive impact on health. Secondly, white *Teff* has a high market demand, making it a profitable crop. By selling it, farmers can fulfil their socioeconomic obligations (Tahtai_Maichew_FGD_1).

Teff is important as a food source for people, and its straw is used to feed cattle. Its straw can also generate income in certain cases and can be used for building houses through a combination with soil and sand for plastering, but hard to find it (Minjar_Shenkora_FGD_13).

Red *Teff* is believed to have medicinal properties for mothers who have recently given birth. They are advised to drink it in the form of a soup. Additionally, it is important for children to consume

it in the form of local bread. People believe that it contains valuable vitamins (Haleba_FGD_5).

As a cash crop, *Teff* was in high demand and fetched decent prices compared to other cereals. White *Teff* had become the dominant source of income for smallholder farmers, who used the by-products of *Teff*, as building materials. When mixed with soil and sand these stalks provided strong construction materials in the study areas. *Teff* also provided straw stalks which farmers used as fodder for cattle and served as an additional source of income for farmers. The commercialisation of *Teff* proved profitable and significantly improved the quality of life for farmers in rural areas. In relation to the health benefits of *Teff*, some authors highlighted that despite its nutritional and health benefit *Teff* has relatively high concentration of phytic acid, an anti-nutritional factor, which can compromise the bioavailability of vitamins and minerals (Awulachew 2020). In addition to its high levels of iron, *Teff* contains antioxidant properties beneficial to human health in reducing the risk of degenerative diseases such as cancer, cardiovascular disease and osteoporosis (Sridhara et al. 2021).

Teff production and consumption in the study areas

The average *Teff* production per household was 1104.13 with a standard deviation of 757.39. There is a statistically significant difference among districts. *Teff* production is the highest for the Lomi district (1861 kg per household) followed by the Minjar Shenkora district (1217 kg per household) and then the Halaba zone (911 kg per household). The Tahtai Maichew district is the least producer (427 kg per household). When we see the regional contribution to the overall national *Teff* production, 48.86%, 38.6%, and 7.01% are the contributions from the Oromia regional state, Amhara regional state and the SNNP regional state, respectively. The contribution of the Tigray regional state is 4.88% while the contribution of the other regions is only 0.65% (CSA 2017).

The average *Teff* consumption per household for all respondents is approximately 297.26 kg per year with a standard deviation of 197.52. This suggests that, on average, households consume around 26.92% of their *Teff* crops, while the remaining portion is sold in the market. When examining *Teff* consumption by district, the highest amount is observed in the Lomi district respondents, with an average of 449.84 kg per household per year (93.52 kg per person). This is followed by the Minjar Shenkora district with an average of 321.77 kg per household per year (74.66 kg per person) and the Tahtai Maichew district with an average of 287.90 kg

per household per year (54.63 kg per person). The least consumption is found in the Halaba zone with an average of 129.52 kg per household per year (21.23 kg per person) (Fig. 6). These results are higher compared to previous studies which recorded consumption levels of 35 kg per person in Oromia, 36 kg in Amhara; 38 kg in Tigray and 19 kg in SNNP (Fikadu et al. 2019). Previous studies reported low consumption levels in the SNNP (a region known for the consumption of root crops). Previous studies also indicated that the urban consumption was about 61 kg per year while in rural areas, was 20 kg per capita per year (Berhane, et al. 2011). The Food and Agriculture Organisation (FAO) reported that *Teff* contributes about 600 kcal per day in urban areas and 200 kcal per day in rural areas (FAO. 2015). This shows the high consumption rates of *Teff* among urban households. Our findings are consistent with previous studies which suggest that *Teff* consumption has been increasing in general (Mottaleb and Rahut 2018). The increase in *Teff* consumption among rural households points the shifts in farmers' attitudes towards *Teff* and appreciation for it. This change is due to improved income, and greater awareness of the health benefits associated with *Teff*. The analysis of variance comparing *Teff* consumption among the districts indicates a statistically significant variation.

We compared the consumption of *Teff* with other cereals using ANOVA (Table 2). On average, households consume 76.05 kg of cereal crops per month (Table 3). Compared to other cereals, *Teff* is the most consumed crop, accounting for 32.54% of the total cereal crop consumption, with an average of 24.75 kg per month per household. Maize is the second most consumed crop making up 25.61% of the total cereal crop consumption, with an average of 19.48 kg per month per household. Wheat is the third most consumed cereal crop representing 20.81% of the total consumption, with an average of 15.83 kg

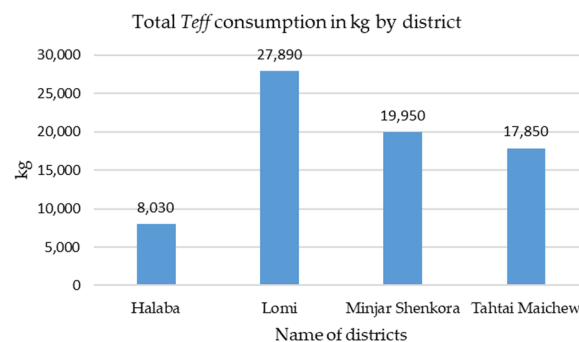


Fig. 6 Total amount of *Teff* consumed in kg by district. Source: survey result, 2020

Table 2 Family size and average monthly consumption of cereal by district (ANOVA)

Household size and average cereal consumption	District of the respondent (n = 62 per district)				F	Prob > F (α)
	Tahtai Maichew	Lomi	Halaba zone	Minjar Shenkora		
	(A)	(B)	(C)	(D)		
	Mean	Mean	Mean	Mean		
Household size of the respondents	5.27 D	4.81	6.10 B D	4.31	11.00	0.0000
Average <i>Teff</i> consumption in kg per year per household	287.90 C	449.84 A C D	129.52	321.77 C	41.02	0.0000
Wheat consumption in kg per month per household	4.92	30.89 A C	2.58	24.92 A C	76.37	0.0000
Maize consumption in kg per month per household	32.06 B D	9.95 D	35.16 B D	0.73	57.19	0.0000
Sorghum consumption in kg per month per household	9.84 B	0.00	8.47 B	15.44 B C	13.83	0.0000
Barley consumption in kg per month per household	1.05 B C D	0.08	0.00	0.00	4.50	0.0043
Rice consumption in kg per month per household	0.00	0.00	0.00	0.00	0	0
Small millet consumption in kg per month per household	0.16	0.00	27.34 A B D	1.61	146.90	0.0000
Total cereal crops consumption in kg per year per household	864.39	940.45	1011.29	834.19	2.39	0.0698

Source: Fieldwork survey result, 2020. Note: Usually, statistical significance is calculated using a standard 95% confidence level. When an answer option is deemed statistically significant, it means that the difference between the groups has a probability of less than 5% of occurring by chance or sampling error alone. This is often represented as $p < 0.05$. If the p -value is less than or equal to the significance level, we will reject the null hypothesis and conclude that not all population means are equal. If the p -value is greater than the significance level, we do not have enough evidence to reject the null hypothesis that the population means are all equal.

Table 3 Monthly consumption of cereal crops in kg per household

Types of cereal crops	Average monthly consumption of cereal crops in kg per household		Percentage of total cereal crops	Rank
	Mean consumption	SD		
<i>Teff</i>	24.75	16.47	32.54	1st
Maize	19.48	22.69	25.61	2nd
Wheat	15.83	17.69	20.81	3rd
Sorghum	8.44	14.52	11.09	4th
Small millet	7.28	14.49	9.57	5th
Barley	0.28	1.94	0.37	6th
Rice	0.00	0.00	0.00	
Other cereal crops	0.00	0.00	0.00	
Total cereal crops	76.05		100.00	

Source: Fieldwork survey result, 2020

per month per household. Sorghum, small millet, and barley follow with an average monthly consumption of 8.44 kg, 7.28 kg, and 0.28 kg, respectively (Table 3).

The average cereal consumption per household in Halaba is about 84.27 kg. The two main cereal crops consumed are maize (35.16 kg per month per household) and small millet (27.34 kg per month per household). In the Lomi district, the monthly average cereal consumption is about 78.37 kg per household. The two major cereals consumed are *Teff* (37.45 kg per

month per household) and wheat (30.89 kg per month per household).

In the Minjar Shenkora district, the monthly average cereal consumption is about 69.52 kg per household. The two major cereal crops used for consumption are *Teff* crops (26.82 kg per month per household) and wheat (24.92 kg per month per household). In the Tahtai Maichew district, the monthly average cereal consumption is about 72.03 kg per month. The two major cereal crops used for consumption are maize (32.06 kg per month per household) and *Teff* crops (24.00 kg per month per household).

As the primary cereal crop consumed, *Teff* is also a source of livelihood in three districts excluding the Halaba zone. Wheat is consumed in the Lomi and Minjar Shenkora districts, while maize is consumed in the Halaba zone and in the Tahtai Maichew district. Small millet is also consumed in the Halaba zone.

The consumption of cereal crops is 84.27 kg per month for the Halaba zone (6.1 family size) followed by the Lomi district where the consumption is 78.37 kg per month (4.81 family size). The Tahtai Maichew district has a consumption of 72.03 kg per month (5.27 family size). The least cereal consumption of 69.52 kg per month is in the Minjar Shenkora district (4.31 family size). The monthly average cereal consumption for all respondents is 16.12 kg per person.

The average monthly cereal consumption per person is the highest for the Lomi district (17.96 kg per person) followed by the Minjar Shenkora district (17.91 kg per person). The monthly average cereal consumption

for the Halaba zone is 14.38 kg per person. The least monthly cereal consumption per person is in the Tahtai Maichew district (14.24 kg per person) (Table 2). There is a statistically significant difference of cereal consumption among districts (Table 2).

As shown in Table 2 above, there are statistically significant differences in the variables of family size, average *Teff* consumption in kg per year, *Teff* consumption in households in kg per month, and the consumption of wheat, maize, sorghum, barley, and small millet among smallholder farmers in the four districts. However, there is no statistically significant difference among smallholder farmers in the four districts regarding rice consumption and total cereal crop consumption in kg per month per household.

In our case, the null hypothesis states that the mean *Teff* and cereal consumption values of the four different districts are equal. Since the p -value (of the F-test) is less than 0.05, the null hypothesis is rejected, and the authors concluded that there is a significant difference in means among the four districts for the variables of household size, average consumption of crops including *Teff*, wheat, maize, sorghum, barley, and small millet. However, there is no significant difference in means among the four districts for the variable total cereal crop consumption in kg per year per household ($p > 0.05$) (Table 2). In our analysis, we used Bonferroni correction, and it is a statistical adjustment made when performing multiple hypothesis tests simultaneously. It addresses the problem of increased risk of Type I errors (false positives) that arises when multiple tests are conducted. From the analysis, we can see that *Teff* is consumed more in the three districts whereas its consumption is low in Halaba zone. Wheat is consumed more in the Lomi and Minjar Shenkora districts. Maize is consumed more in the Tahtai Maichew district and Halaba zone while small millet is consumed more in Halaba zone compared to the other three districts.

The variations in *Teff* consumption among districts were attributed to the following:

- Areas with favourable climates for specific *Teff* such as the Lomi and Minjar Shenkora districts may experience higher production and consumption. On the other hand, Tahtai Maichew and Halaba which have challenging environments for *Teff* production, may depend on alternative staples like maize and small millet crops.
- Cultural and culinary traditions heavily influence food choices, and this is particularly evident in districts that have historically relied on *Teff* as a staple food, such as Lomi, Minjar Shenkora and

Tahtai Maichew. These districts tend to have higher *Teff* consumption rates. Cultural practices in Halaba zone may restrict the consumption of *Teff*, leading to variations in consumption rates.

- District level preferences favour *Teff* over other cereals, impacting consumption patterns. For instance, in the Tahtai Maichew district, the production of *Teff* is low while the consumption is high in comparison to its low production.
- Awareness of the nutritional value of *Teff* and its role in a balanced diet can also influence consumption choices.
- Lower-income areas such as Tahtai Maichew district and Halaba zone may rely more heavily on affordable staple cereals like maize and small millet, while wealthier districts can afford greater dietary diversity including *Teff*.

Teff is used as the primary food staple and is the most preferred food among smallholder farmers. It is also the most consumed crop by rural farmers in terms of volume (24.75 kg per month per household), surpassing other crops (Table 3). This result contradicts the earlier findings of Roseberg, et al. (2005) which showed that the *Teff* crop is the most preferred cereal among wealthier households, particularly in urban areas. The reason for such variation could be there is a shift in the consumption of *Teff* which might be due to improved standards of living of the farmers, improved productivity of *Teff* crop, a health-conscious community, and better income.

Teff is the most consumed cereal among rural farmers in terms of volume. On average, each household consumes 297.26 kg per year (Table 4) with an average family size of 5.12. This accounts for about 32.54% of the total cereal crops consumed (Table 3). These numbers indicate that *Teff* is the preferred means of livelihood for rural farmers (Table 3). Furthermore, the average *Teff* consumption per person per year among rural farmers is approximately 58.06 kg.

The ANOVA analysis (F-statistic) indicates that there is strong evidence against the null hypothesis ($p < 0.05$), suggesting that at least one district has a different mean for most of the variables (Table 4). Thus, the authors concluded that there is a significant difference in means among the four districts for the variables *Teff* production in kg, average *Teff* consumption in kg per year per household, and monthly consumption of cereal crops per person. However, there is no significant difference in means among the four districts for the variable total cereal consumption in kg per month per household ($p > 0.05$).

Table 4 Comparison of the means of *Teff* production and consumption by district

List of independent variables	District of the respondents				All respondents	ANOVA	
	Tahtai Maichew	Lomi	Halaba	Minjar Shenkora		Mean ± SD	F
	(A)	(B)	(C)	(D)			
	Mean	Mean	Mean	Mean			
<i>Teff</i> production in kg	427.02	1861.29 A C D	911.29 A	1216.94 A C	1104.13 ± 757.39	73.09	0.000
Average <i>Teff</i> consumption in kg per year per household	287.90 C	449.84 A C D	129.52	321.77 C	297.26 ± 197.52	41.018	0.000
Total cereal crops consumption in kg per month per household	72.03	78.37	84.27	69.52	76.05 ± 34.08	2.385	0.070
Monthly consumption of cereal crops per person	14.24	17.96 A	14.38	17.91 A	16.12 ± 7.81	4.665	0.003

Source: Fieldwork survey result, 2020. Note: Results are based on two-sided tests assuming equal variances. For each significant pair, the key of the smaller category appears in the category with the larger mean. Significance level for upper case letters (A, B, C): .05 (Tests are adjusted for all pairwise comparisons within a row of each innermost sub table using the Bonferroni correction)

Discussion

Teff production

The results on *Teff* as a high-value crop that earns high income for smallholder farmers are consistent with the findings of previous studies (Berhane, et al. 2011). Some scholars argue that *Teff* is a commercial crop mainly because of the high price it fetches (Berhane, et al. 2011). It is among the indigenous cereals in Ethiopia that are nutritionally rich containing high levels of iron, calcium, and protein. It ranks low on the glycaemic index making it suitable for consumption by Type II diabetics. *Teff* is also gluten-free and has a high fibre content (McGuire 2015). *Teff* is a tiny cereal, and its production and post-harvest management face several challenges. Like previous studies (Cheng and Mayes 2017), the production and processing of *Teff* is labour-intensive compared to other cereals grown in the study areas.

Staple food and cash crop

The findings on *Teff* as a food staple are consistent with previous studies that show *Teff* is one of the most important cereal crops in Ethiopia. It is preferred for its contribution to food and nutrition security and its high price in the market makes it an attractive cash crop for farmers (FAO 2015; Crymes 2015). The findings are consistent with previous studies that indicated that despite having significantly lower yields than most cereal crops, *Teff* smallholder farmers persist in the production of the crop (Assefa 2015; Roseberg, et al. 2005).

Teff is an ancient and indigenous cereal crop grown in Ethiopia. It has been grown for centuries because of its various merits; otherwise, it could have been extinct. *Teff Injera* is delicious, enjoyable and soft as compared to *Injeras* composed of other cereals or *Teff* mixed with other types of cereals. Also, *Teff Injera* is preferred food by the community. Culturally, *Teff* has been the main

source for food in the northern part of the country (Tigray and Amhara) including Eritrea for thousands of years which is similar to the findings of Simoons, Frederick (Simoons 1965) that stated *Teff* is originated and was domesticated in Ethiopia between 4000 and 1000 BC.

Our findings indicate that there is a difference in *Teff* consumption among the districts. Such differences can be associated with the difference in tradition of feeding (culture), religion and status of households. In terms of religion 182 households (73.39%) were adherents of the Ethiopian Orthodox Tewahido church from three districts, 62 (25%) were Muslim (all from Halaba zone), 2 (0.81%) were Catholic and 2 (0.81%) were Protestants. Among Christians, *Teff Injera* is consumed during religious festivals such as baptism, new year, Christmas, Epiphany, and Easter. On special ceremonies such as engagement, weddings, and monthly religious festivals, *Teff Injera* is the preferred meal of honour to serve the guests. For daily consumption, *Teff* is mixed with other cereals, such as maize and wheat. In Halaba zone (southern region), *Teff* consumption levels were relatively low. This finding is consistent with previous studies which indicate that *Teff* consumption is low in the Southern and Western parts of the country (regions where maize is commonly consumed) (Fikadu et al. 2019).

This paper argues that *Teff* is one of the most important cereal crops in Ethiopia. The significance of *Teff* lies in its multiple uses, including as a food, protein, fodder for cattle, and for medicinal use in improving blood circulation. Additionally, *Teff* provides cash income for farmers; its straw is used as building material, particularly for plastering. *Teff* production remains labour-intensive compared to other cereal crops.

Teff is crucial for the livelihoods of rural households in the districts where it is produced. It is a food staple

and the most preferred food among rural farmers. It is consumed in higher volumes compared to other crops. The significant consumption (58.06 kg per person per annum) implies that it is not only a staple in rural households but also a means of livelihood for farmers. Our findings contradict the findings of Berhane, et al. (Berhane, et al. 2011) who reported that rural *Teff* consumption was approximately 20 kg per capita, per year and that *Teff* was preferred by wealthier households, particularly in urban areas. The significant levels of *Teff* consumption among rural households suggest that farmers' attitudes towards *Teff* consumption have changed. This change can be attributed to increased income and improved living standards among farmers, as well as greater awareness of the health benefits associated with *Teff*.

The integration of qualitative and quantitative data highlights an innovative contribution to understanding the topic. In this paper, we used a variety of datasets to gain insights into the topic. While previous studies relied on quantitative data, our paper enhances existing knowledge by incorporating qualitative findings from focus group discussions and key informant interviews. Most previous studies on Ethiopia adopted a quantitative approach, but our study employed mixed methods. The qualitative elements explained why *Teff* is grown, the importance of *Teff*, and the contribution of *Teff* to the livelihoods of farmers. The quantitative analysis computed the rates of *Teff* consumption, its significance among rural households, and compared *Teff* consumption rates in different districts. Quantitative analysis provided the volume of *Teff* consumption and other cereals at both district and household levels.

Data integration of the current study demonstrates that studies like these require research designs that allow for rigorous analysis using comprehensive quantitative and qualitative data. The use of mixed methods allowed for triangulation of data, thereby enhancing the validity of the study. Therefore, the use of mixed methods strengthened the study and as a result, the methods employed in this study also contribute to the literature on qualitative and quantitative research.

Compared to previous studies, our findings indicate:

- On average, households consume 26.92% of their *Teff* production per year. This suggests a shift in *Teff* consumption which may be due to an improved income among farmers, a more health-conscious community, and higher income levels.
- *Teff* is produced for consumption and is a source of livelihood for households in three districts but not in the Halaba zone. The analysis of variance test for the average yearly consumption of *Teff* crops across the

four districts shows a significant statistical difference between Halaba zone and the other three districts.

- *Teff* is the most consumed cereal by rural farmers in terms of volume, with an average consumption of 297.26 kg per year per household for an average family size of 5.12. The average *Teff* consumption among rural farmers is about 58.06 kg per person per year, contradicting the finding of Berhane, et al. (2011) which states that the consumption for rural areas is 20 kg per capita per year.
- *Teff* is the most consumed cereal, accounting for 32.54% of total cereal crops. On average, each household consumes 24.75 kg of *Teff* per month. This indicates that *Teff* is the preferred means of livelihood for rural farmers. These findings contradict previous studies by Roseberg, et al. (2005) which found that *Teff* was the most preferred cereal among wealthier households, and Berhane, et al. (2011) who argued that *Teff* was considered a luxury food for rural households and the urban poor, while maize and wheat were seen as essential food grains.
- There is a statistically significant difference among districts in relation to *Teff* consumption which goes against our hypothesis. This could be due to the variations in *Teff* production between districts, the socio-economic status of households, feeding habits, the purpose of growing *Teff* and changes in the national economy.
- The average monthly consumption of cereal crops per person in Tahtai Maichew is statistically different from that of the Minjar Shenkora and Lomi districts.
- The analysis of variance for the monthly average consumption of cereal per household indicates that there is no statistical difference among the four districts.

Conclusion

Ethiopia is the largest producer of *Teff* and has adopted it as a staple crop. Despite being consumed for centuries in the study areas, few studies have explored the significance of *Teff* in the lives of smallholder farmers. Empirical evidence about *Teff* consumption at district level is crucial for designing appropriate interventions to improve the nutrition and livelihoods of the producers. This study is based on a relatively small sample size of about 357 households, which were surveyed only once (cross-section data). Despite these limitations, this paper provides insight into the contribution of smallholder farmers to *Teff* production and consumption. Further research is required to determine the effectiveness of farmers across the entire country.

Unlike previous studies which claimed there was a class dimension to the consumption of *Teff*, the view

is negated by our findings which show that both rural households and wealthier urban households consume *Teff*. The difference occurs among those who choose to mix the *Teff* flour with flour from maize or wheat. High levels of *Teff* consumption among rural households suggest a change in attitude among rural households. This change can be attributed to increased income, improved living standards, and greater awareness of its health benefits. There is a significant difference in *Teff* production and consumption among farmers in different districts. Understanding the reasons for these regional variations is crucial for designing effective interventions and policies to reduce disparities and promote food security. By addressing factors such as production capacity, market access, education, and economic opportunities, we can work towards a more equitable distribution of this essential food source across regions.

The policy implications of the paper might be seen from the positive spin-offs and challenges of increasing *Teff* consumption in rural Ethiopia. Some of the positive spin-offs include the fact that *Teff* is rich in protein, iron, calcium, and fibre, potentially improving the nutritional status of rural population, especially children and pregnant women. Moreover, an increased domestic *Teff* production could contribute to food security in rural areas, reducing reliance on imported wheat and its price fluctuations. This could be further enhanced by dietary education programs promoting balanced consumption alongside *Teff*. Rising demand for *Teff* could also incentivize farmers to increase production, boosting incomes and contributing to rural development. Policies supporting improved farming practices, storage facilities, and access to markets would further strengthen this impact. *Teff* holds cultural significance in Ethiopia. Increased consumption could support the preservation of cultural foods and agricultural practices.

Higher *Teff* consumption increases demand and rising prices that could make it less accessible to poorer households, exacerbating food insecurity. Moreover, an increase in *Teff* production puts pressure on land and water resources thereby making sustainable land management practices and water conservation technologies necessary. Overreliance on *Teff* increases vulnerability to climate shocks and market fluctuations and thus policies promoting crop diversification and encouraging consumption of other nutritious options are important. Research and development in high-yielding varieties, efficient processing technologies, and value addition remain vital. Effective policymaking also requires robust longitudinal data on *Teff* production, consumption, and market trends. There is need for government to prioritise and allocate funding for *Teff*

research and development in addition to overall funding for agricultural research.

Considering *Teff's* contribution to nutrition and livelihoods, it is important to design interventions that minimise the gaps in consumption among districts. However, there is no one-size-fits-all solution to minimise the gap in *Teff* consumption among districts. The best approach varies depending on the specific circumstances of each district. Following is recommended methods to minimise the gap.

1. Production: *Teff* breeders and other concerned experts need to develop new varieties of *Teff* seeds and technology that are suitable for farmers in low-consumption areas. This includes providing access to improved seeds and fertilisers as well as investing in irrigation and other agricultural technologies.
2. Invest in agricultural infrastructure, research, and extension services in regions with low *Teff* production. This could involve providing improved seeds, fertilisers, irrigation systems, and training for farmers.
3. Nutrition education: Implement education programs to raise awareness about healthy eating habits and the importance of dietary diversity can help individuals make informed choices about the foods they consume.
4. Promoting the consumption of *Teff*: This involves educating people about its importance as a source of protein, and that it is gluten-free and has a high fibre content, making it a valuable food in reducing malnutrition.
5. To make *Teff* more affordable and improve health, targeted subsidies for *Teff* consumption should be implemented in areas with low *Teff* production.
6. Understanding the disparities in food insecurity and malnutrition among districts can create an environment that encourages farmers to increase both *Teff* production and consumption.

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Author contributions

Nahusenay Teamer- Conceptualisation, methodology, data collection, qualitative and quantitative data analysis, interpretation and writing of original draft. Catherine Ndinda- Conceptualisation, methodology, qualitative data analysis, interpretation and writing of original draft. All authors have approved the final manuscript.

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Data availability

The datasets generated during and/or analysed during this study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study is based on a study approved by Research Ethics Committee of the University of South Africa (UNISA), reference number 2017_DEVSTUD_Student_31. Moreover, an expedited approval with reference number 1107/2017 was obtained from Mekelle University, College of Health Sciences, Health Research Ethics Review Committee. Written Informed Consent was obtained from all subjects.

Consent of publication

Not applicable.

Competing interests

The authors declare no conflicts of interest.

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