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Spicy Shiro flour and Berbere powder (an ethnic, indigenous food of Ethiopia)

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Abstract

Ethiopia is a multiethnic nation with a wide range of cultural traditions, as well as ancient indigenous culinary skills that have made a significant contribution to national and religious holidays, family get-togethers, community celebrations, funeral rites, and economical progress. The most extensively produced and consumed traditional meals in various regions of Ethiopia are Shiro flour and Berbere powder. The significance and reputation of Shiro flour and Berbere powder in Ethiopian culture cannot be overstated. Shiro flour and Berbere powder are consistently the most well-liked and essential components in Ethiopian cuisine. However, research on Shiro flour and Berbere powder was limited, and there was no scientifically compiled data on these food products. As a result, this study was undertaken to collect indigenous knowledge, practices, mode of preparations, and skills, as well as to generate baseline data on Shiro flour and Berbere powder at the national level by examining the physicochemical qualities, this study was conducted. A cross-sectional study design was used, and 220 respondents with prior experience preparing Spicy Shiro flour and Berbere powder took part. The findings of this study will use for interventions such as food supplementation, importing to international markets for revenue generation, setting national and international standards, formulating products, providing students and researchers with reference material, and creating jobs, particularly for young people and women. The bioavailability and recommended amount/dosage of herbs and spices to be added during Shiro flour and Berbere powder preparation, however, has not been studied in Ethiopia. Furthermore, the current study did not address the analysis of antioxidants, aflatoxins content from Berbere powder, amino acid profiles, value addition, and shelf life of both products.

Keywords Shiro flour, Berbere powder, Spices, Herbs, Minerals, Indigenous knowledge, Cultural values

Introduction

Ethiopia is a multiethnic nation with a variety of traditional food and drinks preparation techniques that significantly contribute to socioeconomic development [1].

Traditional meals and drinks have a long history in Ethiopia extending back to early crop domestication and agricultural innovation, and they are associated with special occasions including holidays, festivals, social gatherings, funerals, and honor guests [1].

Ethiopia is one of the largest producers and exporters of pulses in the world, according to FAO statistics. For instance, it is the sixth-largest producer of chickpeas and the second-largest producer of fava beans (after China). Moreover, one of the top ten exporters of chickpeas,

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dry beans, and peas, Ethiopia is also one of the top five exporters of fava beans [2, 3].

Production increased over the previous ten years, reaching 2.5 million metric tons in 2016–2017 (June–July). 340,000 metric tons, or over 14%, of the production of pulses were exported, bringing approximately \$255 million in foreign cash. Pulse exports are the third largest forex earner after coffee and oil seeds [2]. For humanitarian food relief, pulses are imported [2, 4]. Pulses are imported for humanitarian food relief [4].

The most significant vegetable that can be found in every Ethiopian's daily meal is hot pepper (*Capsicum frutescens*) [5, 6]. Due to the presence of various commercially available hot pepper varieties with distinct local names in various agro-ecological regions of the nation, Ethiopia is recognized as a source of pepper diversity [6]. The Ethiopian regions that produce the most hot pepper plants are Oromia, Southern Nations, and Amhara. The Southern Nations, Nationalities, and Peoples' Region (SNNPRS), which produces around 64% of the nation's total production of red pepper, produces the remaining 25%, according to the Amhara region [7]. The majority of Ethiopian food is flavorless without hot pepper, according to Beyene and David's 2007 study, and hot pepper (*Capsicum annum*) is a traditionally and economically significant crop in Ethiopia [5]. The fragrant fine powder serves as both a flavor and coloring agent in the widely used traditional sauce "Wot" (stew). The country has a very strong demand for deep red-colored cultivars for processing (EEPA [Ethiopian Export Promotion Agency], 2014) [5, 8].

Most Ethiopians include pulses in their everyday diets in significant amounts. Chickpeas, lentils, and fava beans are used to prepare a variety of traditional meals. For instance, most households have Shiro, a well-liked chickpea sauce, every day for lunch or dinner [9].

According to the Ethiopian National Food Consumption Survey, pulses have a long history among Ethiopians as a food source, making up about 5% of the daily diet [10]. Several regions of the nation produce and consume a vast range of indigenous traditional meals [11]. Traditional foods are those that are native to a specific region and were created by the local population using time-tested methods and raw components that were readily available there [11]. Shiro flour and Berbere (red pepper) powder are two examples of indigenous traditional foods that are frequently manufactured for usage in households and on the local market [7, 11].

Shiro flour and Berbere powder were well-liked traditional dishes in Ethiopia and essential components of Ethiopian cuisine. Despite this, there is little information available regarding ingredients, preparation methods, Shiro flour, and Berbere powder, as well as indigenous

knowledge and rituals. Moreover, there are no national norms or regulations for Berbere powder and Shiro flour, as well as a dearth of accumulated scientific data, knowledge, and evidence. In order to gather baseline data on the chemical makeup and mineral content of Ethiopian Shiro flour and Berbere powder, as well as to assemble indigenous knowledge, preparation techniques, components, mode of preparation, and ancient customs. The objective of this study was to gather indigenous knowledge, practices, modes of preparation, and skills. It also aimed to generate baseline data on Shiro flour and Berbere powder at the national level by looking at their physicochemical properties.

History, Cultural and Ethnic Aspects of Shiro Flour

Ethiopia is home to more than 80 ethnic groups, each with their own distinct culture, which is reflected in traditional knowledge of the use of herbs for medicine and related knowledge [12].

In Ethiopia, legumes are eaten as a green vegetable (green immature), kollo (soaked and roasted), Nifro (boiled seed), kiki wot (split seed stew), and Shiro wot sauce made from spicy legume flour [13]. Ethiopians have a long history of using legumes in the form of Shiro flour [14].

Shiro flour is a blend of roasted fava beans, chickpeas, grass peas, field peas, and spices [15]. Roasted field peas and spices such as rosemary, tosign (thymus), kosere (lemon bush), nechazmud (bishops weed), besobila (basil), korarima (Ethiopian cardamom), minced onions (red), garlic, and depending on regional variation, ground ginger, and chili pepper are thought to be the primary ingredients for Shiro flour [16]. Shiro flour is used to make an instant stew with minced onions, garlic, and ginger or chopped tomatoes and peppers by cooking it in boiling water with edible oil [16]. Shiro is a typical, tasty, indispensable, and well-liked food among tourists [2], as well as an Ethiopian ethnic staple meal eaten throughout the country [17]. Shiro flour is an Amharic word; Ethiopia's official language, like Hebrew and Arabic, is Semitic. In this regard, Ethiopians have unique beliefs and attitudes toward foods; Shiro flour plays an important and prestigious role in Ethiopian culture [18]. Shiro flour recipes and preparation methods vary from place to place and among ethnic groups. Tradition, religion, and economic and social circumstances all play significant roles. Shiro flour and Shiro stew are typically prepared by Ethiopian mothers and women. Shiro flour is classified into two types: "Nech Mitin Shiro" and "Key Mitin Shiro" [2, 15].

The word "Miten" means "balanced". Mitin Shiro flour is a spicy Ethiopian seasoning made from dried and ground peas, vetch, and chickpeas, pepper (Berbere),

ginger, garlic, salt, and spices. Individual preferences, cultures, and experiences all influence how Shiro flour is prepared. Shiro allichu stew is made with Nech Mitin Shiro flour, which is a combination of those legumes without Berbere and spices such as dried and ground garlic, ginger, mekelesha (spice mixture), and salt.

Important Mitin Shiro flour is made from those legumes along with Berbere, ground garlic, ginger, various spices, and salt. Berbere makes it appear redder (red in color) and hotter. Shiro wot and Shiro Bozena are popular ethnic Ethiopian staple dishes. Shiro wot is the finished product made from Shiro flour, which is reconstituted in water (with a little oil) and boiled until slightly thickened. When preparing the meal, some cooks add additional spices or Berbere, as well as chopped onions or chopped tomatoes.

Shiro flour is high in protein, vitamins, and nutrients required by the body, such as enzymes and trace elements, and it is used to make a wide variety of foods, making it one of the nation's essential staples [17, 19, 20]. The amount and type of spices used, the roasting conditions, and the processing of Shiro flour are all highly dependent on household traditions and experiences. This variation is known to cause significant quality differences in the prepared Shiro flour and wot (cooked Shiro), but, as in our culture, most Ethiopian mothers and women follow generally accepted rules.

In general, Shiro flour is used to make are an important part of Ethiopian cuisine and culture, and play an important role in food security and nutrition. It is also only produced and known in Ethiopia and Eritrea.

History, Cultural and Ethnic Aspects of Berbere Powder

The history of pepper in Ethiopia is possibly the most ancient of any vegetable product [7, 8, 21]. Ethiopians have a strong attachment to dark red pepper, which is prized primarily for its pungency [6]. Pepper plants are grown in many countries, including Ethiopia, Nigeria, Ghana, China, India, Pakistan, Bhutan, Indonesia, Cambodia, Eritrea, and Thailand [6, 7] and [22]. Eritrea and Ethiopia are neighbors, and their cuisines share many similarities. One of them is this spice powder. Nonetheless, the process of making red pepper powder in Ethiopia is unique. During the preparation of red pepper powder in Ethiopia, a unique method of adding various types and quantities of spices and herbs is used. This method is so exceptional that there are significant differences in the way it is done across households.

Berberere powder is primarily made up of dried red pepper, but other fresh and dried spices such as cardamom, sacred basil, cumin (black), bishops weed, garlic, rue, rosemary, ginger, cinnamon, fenugreek, and other locally available spices can be added depending on

personal preferences, culture, and economic status. The fresh spices are pounded together with a mortar and pestle until properly meshed and mixed, then the dried red pepper is pounded together with the meshed spices, and the mixture is sundried, mixed with the dried spices, and milled to Berbere powder [23]. The fine powdered pungent product is an essential flavoring and coloring ingredient in the traditional "Wot" sauce. According to MARC (Melkasa Agricultural Research Center), the average daily consumption of hot pepper by Ethiopian adults is 15 g [6].

Spices like Berbere carry tradition, memories, history, and culture that have evolved over generations in Ethiopia. These spices provide flavor while also serving as a reminder of the depth and richness of the history that we all share (Fetlework Tefferi). Among the distinctive Ethiopian ethnic staple dishes are Injera, Doro Wot (Ethiopian Chicken Stew), Shiro Wot (Ethiopian Shiro Stew), Asa Wot (Ethiopian Fish Stew), Misir Wot (Ethiopian spiced red lentils), Kik Wot (Ethiopian split legume stew), Timatim Sils/Wot (Ethiopian tomato based popular dish), Chechebsa (Ethiopian flatbread with Berbere sauce dish), Pasta be-Injera (pasta with flatbread), Fuul (Ethiopian fava bean stew), Dulet (Ethiopian combination of beef, liver, and lamb tripe), Kitfo (Ethiopian minced meat) and Enkulal firfir (Ethiopian scrambled egg with Berbere sauce) are widely used throughout the country, Ethiopia. As a result, Berbere powder and Ethiopian cultural foods are essential, and those foods would be organoleptically unacceptable and appealing without Berbere powder. Berbere powder also improves the flavor, taste, color, and appearance of Habesha (Ethiopian) cultural foods [17].

Materials and Methods

Study Areas

Shiro flour was gathered in places like Adigerat, Wukro, Mekele, Gondar, Debark, Debre Birhan, Debre Sina, Gebre Guracha, Assela, Hosaena, and Addis Ababa that might be producing and consuming locations of Ethiopia. As well as these locations, samples of berbere powder were also taken in Mekele, Gondar, Koladeba, Finotese-lam, Bure, Adama, Arertie, Wolkite, Hosaena, Koshe, Alaba, Azerenet, Hawassa, Butajira, Debre Birhan, and Addis Ababa. The primary sample sources for this study are households, manufacturers, shops, and retailers. Samples are gathered and processed in compliance with the sampling protocols specified in ES ISO 13690:2001.

Study Design and Sampling Techniques

Experts from various governmental and non-governmental organizations, universities, cooperatives, processors, associations, and research institutions participated in two consultative workshops. The workshops aimed to

instruct participants on areas known for superior Shiro flour and Berbere powder production, as well as to hear experts' perspectives on key Shiro flour and Berbere powder consuming and producing areas at the national level. A cross-sectional study design was conducted. The qualitative data (indigenous knowledge, skills, practices, ingredients used, and mode of preparation) were collected by trained data collectors using semi-structured questionnaires, interviews, and focus group discussions. The questionnaire was written in English by a senior researcher at EPHI who is also one of the authors of this manuscript. Trained data collectors translated the questions from English into local languages during sample collection. Furthermore, prior to sample collection, the authors checked and validated the translated questionnaire. Shiro flour and Berbere powder samples were purposefully collected from processors, households, markets, shops, and retailers in Adigerat, Wukro, Mekele, Gondar, Debark, Debre Birhan, Debre Sina, Gebre Guracha, Assela, Hosaena, and Addis Ababa based on predetermined inclusion and exclusion criteria. In order to describe the ingredients/materials used, method of preparation, indigenous practices, beliefs, and mode of preparation, the informants were questioned. During the interview and sample collection processes, regional tourism bureaus, woreda-level administrators, Regional Public Health Institutes, and local guides were actively involved. A total of 95 Shiro flour and 125 Berbere powder samples were collected from the selected sampling areas.

Method Validation, Sample Preparation, and Transportation

Shiro flour and Berbere (red pepper) powder samples were collected from 11 regions and two City Administrations, a total of 11 and 16 sampling areas, respectively. Each sample was collected in one-kilogram increments, placed in a Ziplock bag, properly labeled with a permanent marker, and stored under suitable conditions (4 °C) until transported to the Ethiopian Public Health Institute (EPHI). When the samples arrived at EPHI, a designated person checked them all according to the protocols that had been prepared. At EPHI's laboratory, a representative and homogenized sample was prepared, properly labeled, and stored at 4 °C until analysis. The standard methods and procedures were employed for the analysis of all samples at EPHI laboratory. Prior to sample analysis, analytical methods were validated, and reference material (durum wheat) was prepared for method validation. Durum wheat's physicochemical properties (moisture, protein, total ash, minerals, gluten and fibers) are well known and predictable. As a result, the Ethiopian Public Health Institute obtained this reference material

from Kality Food Complex Share Company in Ethiopia and used it during laboratory analysis. This durum wheat grain has been prepared and labeled as reference material (QC) at the Ethiopian Public Health Institute (EPHI). Before analyzing samples, various analysts performed quality control (QC) at various trials until the most precise results were obtained, and an average was taken and used as a reference. All analyses were performed at EPHI.

Inclusion and Exclusion Criteria

The inclusion criteria were knowledge, practices, skills, and mode of preparation for Shiro flour and Berbere powder. Participants over the age of 20 were considered who possessed indigenous knowledge, experiences, and skills in the preparation of Shiro flour and Berbere powder. Respondents under the age of 20 who lacked experience, knowledge, and skills in the preparation of these products, on the other hand, were not taken into account during the current study's interview.

Spicy Shiro Flour and Berbere Powder Physicochemical Analysis

Proximate Analysis

The moisture content, crude fiber, crude protein, and total ash of Shiro flour and Berbere powder were determined using the standard procedure of [24], with official method numbers 925.09, 2001.11, 4.5.01, 920.169, and 923.03, respectively.

Mineral Content

The mineral (Ca) content of Shiro flour and Berbere powder was determined at the EPHI laboratory using an Atomic Absorption Spectrophotometer and method no. 985.35 for Ca, as described in [24]. [25] describes how to determine sodium content using a flame photometer and a wet ashing technique. As a result, the sodium content was determined at EPHI using this method.

Beta-Carotene

The total beta-carotene content of Berbere powder was determined using the methods described in the Harvest Plus handbook [26], with acetone and petroleum ether extraction.

Data Analysis

All analyses were exposed and evaluated using analysis of variance (ANOVA) in SPSS version 20 software. All analyses were performed in triplicate, and the results were expressed as mean \pm standard deviation. In the figures and tables, the results were presented as percentages (Figs. 1 and 2).



Fig. 1 Preparation of Spicy Ethiopian Shiro Flour. Shiro flour is typically made from roasted and split peas, grass peas, fava beans, and chickpeas, either alone or in a blend of two or more legumes. Clean, sort, wash, sundried, roasted, cooled, de-hulled, split, winnowed (separating the cover of the legumes), and mix with spices and herbs. The fresh spices will be pounded together until properly meshed and mixed, after which the medium roasted de-hulled pea, fava beans, chick pea, and/or grass pea will be pounded together with the meshed spice, and the mixture will be sundried and ground/milled to make the spicy Shiro flour. *Sources* The mode of preparation, types, and names of the spices and herbs were obtained from local producers at the household level in various regions, as well as from the Ethiopian Public Health Institute (EPHI) and the Ethiopian Traditional Cuisine page



Fig. 2 Basic and common ingredients for making Berbere (red Pepper) powder. The amount, type, and quality of pepper, spices, and herbs used in the preparation of Berbere powder can all make a difference. Red pepper is the main ingredient in the preparation of Berbere powder. Depending on personal preferences, culture, and economic status, spices such as cardamom, sacred basil, cumin (black), bishops weed, garlic, rue, rosemary, ginger, cinnamon, fenugreek, and other locally available spices can be added. The fresh spices will be pounded together by mortar and pestle until properly meshed and mixed, then the dried red pepper will be pounded together with the meshed spices, and the mixture will be sundried, mixed with the dried spices, and milled to Berbere powder. *Sources* Mode of preparation, types and name of the spices and herbs are taken from the local producers at household levels from different regions and from Ethiopian Public Health Institute (EPHI), and from Ethiopian Traditional Cuisine page

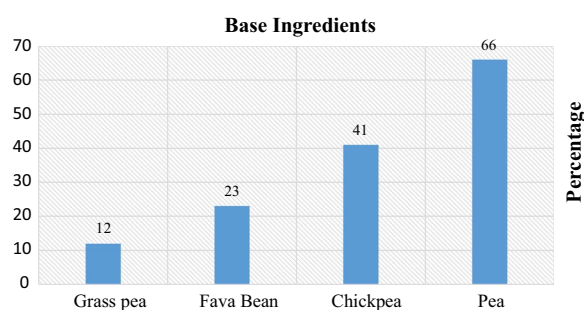


Fig. 3 Basic ingredients for making spicy Shiro flour. This study included 95 respondents who are spicy Shiro flour producers. Thus, 12% of respondents used grass pea as a base ingredient, 23% used fava/faba bean as a base ingredient, 41% used Chickpea as a base ingredient, and the majority (66%) used pea as a base ingredient during Spicy Shiro flour preparation. This implies that the most popular and tasty base ingredient was pea. In Ethiopia, grass pea was the least commonly reported base ingredient used in the preparation of spicy Shiro flour. *Sources* Results from interviews and focus group discussions with Spicy Shiro flour producers were analyzed (95 respondents participated in this study)

Results and Discussion

Shiro Flour

Documentation of Recipes

Base ingredients, spices, and herbs used for Shiro flour preparation are presented in Figs. 3 and 4, respectively.

Participants reported peas, chickpeas, fava beans, and grass peas as the main ingredients for Shiro flour preparation, based on results obtained from both commercial and household consumption.

The majority of respondents stated that pea was the most popular and preferred base ingredient for Shiro flour preparation. Among the legumes used to make Shiro flour, grass pea was the least commonly reported base ingredient. Furthermore, as shown in Fig. 4, numerous spices and herbs were added during Shiro flour preparation to enhance the taste and flavor of the Shiro flour. Among the spices and herbs listed, the majority of respondents have used garlic, cardamom, and pepper more than the other flavor enhancers.

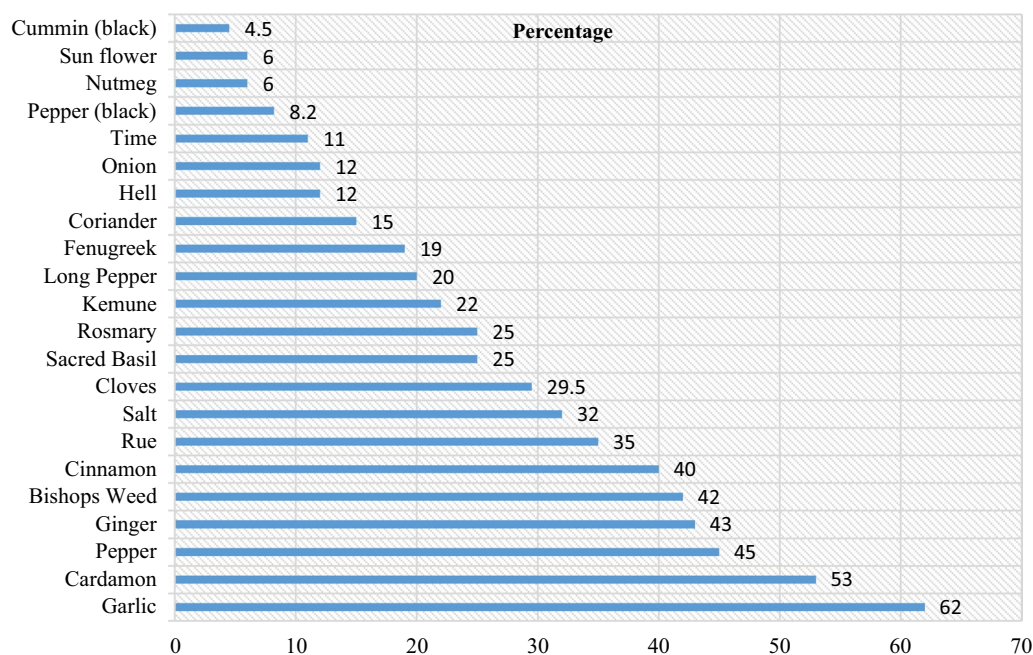


Fig. 4 Spicy Shiro flour is prepared with spices and herbs. Black cummin, sunflower, nutmeg, black pepper, time, onion, hell, coriander, fenugreek, long pepper, kemune, rosemary, sacred basil, cloves, salt, rue, cinnamon, bishops weed, ginger, red pepper, cardamom, and garlic are the most common spices and herbs used to prepare the spicy Shiro flour. Ninety-five households were sampled, and all households (respondents) were interviewed. Thus, during the preparation of Spicy Shiro flour, 4.2% (4/95) of respondents used black cummin as a major spice, 6.3% (6/95) used sunflower and nutmeg as a major spice, 40% (38/95) used cinnamon as a major spice, and 62% (59/95) used garlic as a major spice. This indicates that garlic was the most commonly used spice. Black cummin, on the other hand, was the least commonly reported major spice used in Ethiopian Shiro flour preparation. *Sources* This is the analysis of the results obtained from the respondents who took part in this study (95 participants). However, this spice list for spicy Shiro flour preparation may also be found in other unpublished sources

Table 1 Shiro flour chemical composition and mineral content ($n=95$)

Parameters	Mean \pm SD	Median	Range		Q1	Q3
			Min	Max		
Moisture content %	6.1 \pm 1.20	6.1	3.3	5.9	5.2	7.1
Crude fiber %	5.3 \pm 1.32	5.6	2.5	8.4	4.9	6.2
Crude protein %	25.7 \pm 2.34	25.4	21.5	32.9	23.9	27.3
Ash %	6.6 \pm 3.21	5.2	1.6	13.5	3.4	8.5
Ca (mg/100 g)	28.6 \pm 29.34	12.8	7.0	114.0	9.7	49.3
Na (mg/100 g)	1899 \pm 889	1408.7	889.9	3736.1	1199.2	2827.3

The Chemical Composition and Mineral Content of Spicy Shiro Flour

Table 1 shows the results of the chemical composition and mineral content of Shiro flour.

Chemical Composition.

According to the findings of this study, the moisture content of Shiro flour is (6.1 \pm 1.2 g/100 g) on a dry basis, with inter-quartile ranges Q1 and Q3 of (5.2 g/100 g and 7.1 g/100 g). Despite the current study results, the Ethiopian Food Composition Table [27] reported Shiro flour's higher moisture content. Moisture transfer in food is proportional to the food's water activity (aw). Water activity (aw) is a thermodynamic property defined as the ratio of water vapor pressure in a system to pure water vapor pressure at the same temperature [28].

The crude fiber content of the Shiro flour obtained ranges from 2.5% to 8.4% in dry bases, with a mean value of (5.3%). According to [29] and [30] some Ethiopian processed chickpea varieties had lower crude fiber content. This implies that the addition of herbs and spices during preparation may increase and improve the Shiro flour's crude fiber content (Table 1). Furthermore, the findings of this study revealed that the crude fiber content of the analyzed Shiro flour samples collected from various areas of Ethiopia varied greatly.

The crude protein content of the Shiro flour sample analyzed ranged from 21.5 to 32.9 (%) on a dry basis per 100 g, with a mean value of 25.7 (%) (Table 1). The crude protein content varied greatly among the samples examined. This suggests that indigenous knowledge, practices, and modes of preparation may differ from culture to culture and even region to region. Furthermore, the findings of this study indicated that the addition of spices and herbs may reduce the crude protein content of Shiro flour. According to [2], pulses provide two to three times more protein per gram than staple cereals like rice and wheat. The crude protein content of Shiro flour, on the other hand, is determined by the type and amount of spices and herbs used, as well as the indigenous knowledge and practices of individuals within the community.

The mean total ash content of the analyzed Shiro flour sample ranged from 1.6 to 13.5 (%) on a dry basis in this study. The total ash content of the current study agrees with previously reported values [31, 32]. In addition to taste, flavor, aroma, and appearance, herbs and spices can improve and enhance the inorganic matter (total ash content) of Shiro flour. A related study was published in the Ethiopian Food Composition Table [27].

The results of this study revealed a wide range of mineral concentrations in Shiro flour samples. Shiro flour contained 7 to 114 and 889.9 to 3736.1 mg/100gm of mineral (Ca, Na) in dry bases, respectively. The mineral content of this study is significantly higher than the reported mineral values of [33, 34]. The researchers also discovered that herbs and spices improve the mineral profiles of Shiro flour. As a result, Shiro flour's main ingredient is legumes, which are also high in minerals (such as calcium and sodium). The mineral content of Shiro flour can be increased by adding herbs, spices, and sodium chloride. Adding sodium chloride, in particular, significantly increases the sodium chloride content of Shiro flour.

Ethiopians have distinct food beliefs and attitudes; Shiro's role in Ethiopian culture is significant and prestigious. Ethiopians always observe national and religious holidays, as well as family gatherings such as weddings, birthdays, public festivals, and funerals. In all circumstances, Shiro flour is the most popular and essential food ingredient in Ethiopian cooking. Herbs and spices can also improve the quality of Shiro flour and its overall organoleptic properties. In Ethiopia, however, the bio-availability and recommended amount/dosage of herbs and spices to be added during Shiro flour preparation have not been studied.

Berber (Red Pepper) Powder

Documentation of Recipes

Indigenous knowledge, practices, skills, mode of preparation, equipment, and utensils used in the preparation

of Berbere powder were thoroughly researched and collected using a key informant questionnaire format. In addition, a complete description of the added spices and herbs, as well as an estimated portion of each ingredient from each sampling area, was properly recorded and collected.

Furthermore, this research looked at indigenous knowledge, practices, and modes of preparation (the method of selecting raw materials, drying mechanisms, mixing of different spices and herbs, selection or preferences of spices and herbs, estimation of the amount of spices and herbs to be added) during the preparation of Berbere powder.

According to the findings of this study, 21 different spices and herbs were used in the preparation of Berbere (red pepper) powder. Furthermore, the amount and type of spices and herbs used in the preparation of Berbere powder is determined by personal preference, local availability, culture, and economic status. The most commonly reported spices and herbs used in the preparation of Berbere powder are cardamom, sacred basil, cumin (black), bishops weed, garlic, salt, rue, rosemary, ginger, and cinnamon. Hell, nut mug, onion, cloves, and cumin seeds, on the other hand, are

the least frequently reported spices and herbs (Fig. 5). The current study results were consistent with the previously reported list of ingredients used in the preparation of Berbere powder [23].

Chemical Composition and Mineral Content of Berbere Powder

Chemical Composition According to the findings of a [35] study, moisture content influences the taste, texture, weight, appearance, and shelf life of foods. In this study, the mean moisture value of Berbere (red pepper) powder was 6% on a dry basis, with an inter-quartile range (Q1 and Q2) of 4.3 and 7.9%. This implies that the Berbere powder had a very low moisture content, which is typical of most food powders, typically around 5% or lower [29, 36]. The findings of this study were also consistent with the reported values [37]. On a dry basis, Berbere (red pepper) powder has an average crude protein value of 11.9%, which is consistent with previously reported values [29, 38]. According to [39, 40], dietary fiber-rich food products are linked to physiological actions in the small and large intestines, which have significant implications for human health. According to this study, the mean crude fiber content of Berbere (red pepper) powder was 23.15% on a dry

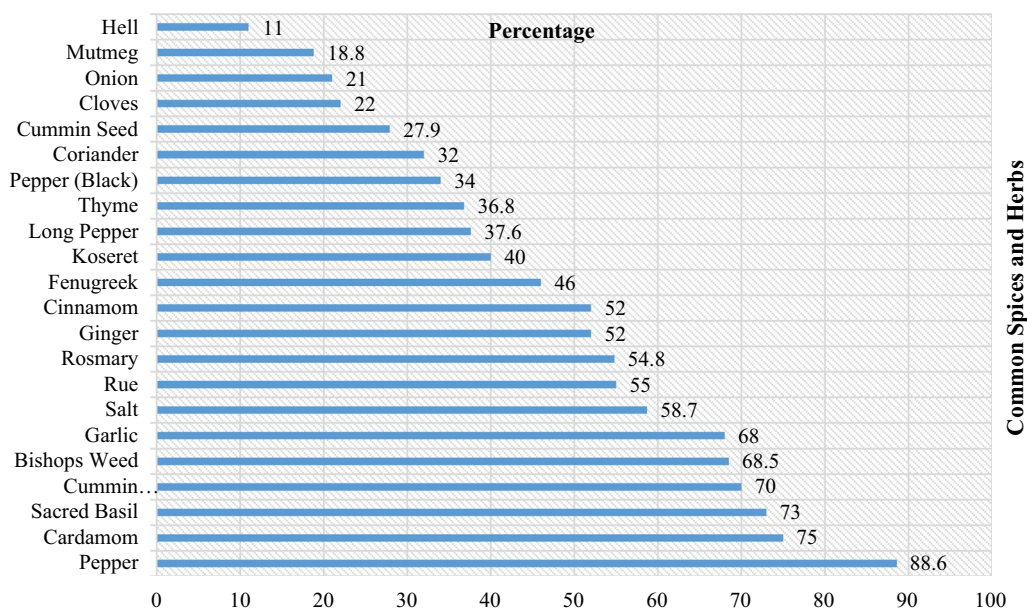


Fig. 5 Spices and herbs commonly used in the preparation of Berbere powder. The most common spices and herbs used to prepare berbere powder are hell, nutmeg, onion, cloves, cumin seed, coriander, black pepper, thyme, long pepper, koseret, fenugreek, cinnamon, ginger, rosemary, rue, salt, garlic, bishops weed, cumin, sacred basil, cardamom, and red pepper. Samples were collected from 95 households, and all households (respondents) were interviewed. Thus, during the preparation of Spicy Shiro flour, 10.5% (10/95) of the respondents used Hell as a base ingredient, 36.8% (35/95) of the respondents used Thyme as a base ingredient, 74.7% (71/95) of the respondents used Cardamom as a base ingredient, and 88.4% (84/95) of the respondents used red pepper as a base ingredient. This suggests that red pepper is the primary major base ingredient. In Ethiopia, Hell was the least commonly reported spice used in the preparation of Berbere powder. *Sources* This is the analysis of the results obtained from the respondents who took part in this study (125 participants). However, this spice list for spicy Shiro flour preparation may also be found in other unpublished sources

Table 2 Berbere powder chemical composition and mineral content on a Dry Basis ($n = 125$)

Parameters	Mean \pm SD	Median	Range		Q1	Q3
			Min	Max		
Moisture content %	6 \pm 2.15	6.1	2.4	9.9	4.3	7.9
Crude fiber %	23.1 \pm 3.4	22.7	16.9	38.7	21.3	25
Ca (mg/100 g)	103.9 \pm 76.2	68.5	10.6	243	35.6	165
Na (mg/100 g)	2320 \pm 1433	2139	857	15,936	1741	2591
Beta-carotene (mcg/100 g)	39.16 \pm 11.73	40.87	12.36	59.48	31.52	48.38

basis. The reported value of [41, 42] supported the findings of this study. The crude fiber content of Berbere (red pepper) powder determined in this study revealed that it is a good source of crude fiber (Table 2).

Berbere (red pepper) powder had a total ash value of 23.11% on a dry basis, with inter-quartile ranges (Q1 and Q3) of 16.3 and 28.9%, respectively (Table 2). This result is also consistent with the total ash value of Berbere powder reported in the Ethiopian Food Composition Table [27]. According to [36], different total ash values were obtained from the Berbere (red pepper) powder samples analyzed, which contradicts the current study findings. This could be due to the amount, type, and level of salts to be added, as well as individual practices during the Berbere powder preparation. On a dry basis, the mineral (Ca and Na) values ranged from 10.6 to 243 and 857 to 15,936 (mg/100 g), respectively (Table 2). The findings of this study revealed a wide range of mineral concentrations in Berbere powder samples collected from various areas of Ethiopia. This is due to differences in individual practices, skills, mode of preparation, income, interest, quantity, and type of herbs. This could be due to the amount, type, and level of salts to be added, as well as individual practices during the Berbere powder preparation. The Berbere powder contains both macro and microelements (Table 2). The presence of carotenoid pigments such as capsanthin, capsorubin, β -carotene, cryptoxanthin, violaxanthin, zeaxanthin, and others is responsible for the red color of berbere (red pepper) powder [36]. In this study, the β -carotene content ranged from 12.36 mcg/100 g to 59.48 mcg/100 g, with an inter-quartile range (Q1 and Q2) of 31.52 to 48.38 (%) on a dry basis. Berbere (red pepper) powder, as shown in (Table 2), is also a good source of carotenoid (-carotene) precursors of vitamin A.

In general, the nutritional profiles of Berbere (red pepper) powder samples collected from different sample areas of Ethiopia varied greatly. It is also high in both macro and microelements. The nutritional content varies due to indigenous knowledge, the amount

and type of herbs and spices used, and individual interests and practices within the community.

Conclusions and Recommendations

In conclusion, Ethiopians have unique beliefs and attitudes toward food; Shiro and Berbere play an important and reputable role in Ethiopian culture. Ethiopians always celebrate national and religious holidays, as well as family gatherings such as marriages, birthdays, public festivals, and death ceremonies. Shiro flour and Berbere powder are the most popular and essential food ingredients in Ethiopian cooking in all circumstances. Shiro flour and Berbere (red pepper) powder are important in various parts of Ethiopia. However, research on Shiro flour and Berbere powder was limited, and there was no scientifically compiled data on these food products. As a result, the purpose of this study was to gather, record, and compile data on the chemical composition and mineral content of Shiro flour and Berbere powder.

This study also suggests that these products could be used in complementary food products, income generation through exports, value addition, and food insecurity interventions. Furthermore, this study will benefit governmental and non-governmental institutions, product standardization agencies, universities, research centers, product exporters, product developers, entrepreneurs, academicians, students, and regulatory bodies. These institutions can use the study findings for interventions such as food supplementation, importing to international markets for revenue generation, setting national and international standards, formulating products, providing students and researchers with reference material, and creating jobs, particularly for young people and women. The bioavailability and recommended amount/dosage of herbs and spices to be added during Shiro flour preparation, however, have not been studied in Ethiopia.

As a result, more research will be required on the recommended amount/dosage of spices and herbs, value addition, food supplementation, and use of these products in international markets. Furthermore, the current

study did not address the analysis of antioxidants, aflatoxins content from Berbere powder, amino acid profiles, value addition, and shelf life of both products.

Abbreviations

CSA	Central statistics agency
EPHI	Ethiopian public health institute
ENI	Ethiopian nutrition institute
ES	Ethiopian standards
ISO	International standards organization
AOAC	Official methods of analysis of the association of official's analytical chemists

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Author contributions

Tesfaye Zeru contributed to investigation, data curation, conceptualization, data interpretation, article drafting (original draft and revised manuscript), and development of sample collection tool. Temesgen Aweke contributed to creation of a data collection tool (questioner format), data collector training, and validation of the prepared questionnaire. The remaining co-authors carried out fieldwork, supervised data collection processes, validated methods, prepared reference samples, performed laboratory analysis, and cleaned data. All authors read and approved the final manuscript.

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Availability of data and materials

This study includes all data collected.

Declarations

Consent for publications

We declare and confirm that this article and the entire study route were completed without difficulty. Any academic material included in the manuscript has been properly cited. We certify that this work is unique and has not been previously published. Furthermore, it is not currently being considered for publication elsewhere.

Informed consent

Human and animal studies are inapplicable.

Competing interests

The authors state that they do not have any conflicts of interest.

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