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The Developmental Patterns of Injera Baking Stoves: Review on the Efficiency, and Energy Consumption in Ethiopia

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Abstract: *Injera will continue to be the staple food for Ethiopians and Eritreans and some parts of east Africa in years to come. To efficiently bake, Injera using various types of stoves, research, and development work for Injera baking have been conducted so far and is critical. The use of energy sources is dominantly biomass is used for Injera baking followed by electricity yet. Electricity is mainly used in urban dwellers of the country which is a limited one. Alternative energy sources such as solar thermal and biogas can be used for baking Injera alternatively.*

There are different types of Injera baking stoves design in Ethiopia using biomass energy such as open fire three-stone stove, Mirt stove (includes improved one with high chimney, stand types), Burayou Injera baking stove Sodo, Awuramba, Tehesh indicating developmental patterns of stove based on the aim to reduce specific fuel consumption as well as efficiency by reducing energy losses during baking. Thus, it is determined that the average specific fuel consumption of three-stone open fire was 929 g/kg of Injera, Mirt stove is 535g/kg of Injera, Gonziye is 617 g/kg of Injera, Awuramba is 573 g/kg of Injera while Sodo is 900 g/kg of Injera. The other Injera baking stoves were developed for baking Injera using solar thermal energy and biogas sources are designed to attain the average required surface temperature of Injera baking pan or Mitad. It is found that the average surface temperature of the concentric type solar thermal Injera baking stove is 148 oC, parabolic type solar Injera baking stove is 200 oC, the electric stove is 225 oC using 3.75 KW electricity, WASS electrical is 220 oC consuming 1.4 KW electricity and biogas 210 oC.

Further investigation is needed to continue the developmental patterns of the Injera baking system by improving the efficiency of the stove by reducing energy losses there has needed that the baking pan or Mitad be improved.

keywords*: Baking, Energy, Fuel consumption, Injera, stove, Temperature*

I. INTRODUCTION

A huge number of people globally have been using traditional biomass energy resources for their daily energy demand yet. The numbers of people using traditional biomass energy resources in the world are 2.7 billion most of them are from Africa and other underdeveloped countries. Most rural Africa countries use traditional biomass energy sources for their household cooking and lighting and which account for 45.3 % [IEA 2017]. But, in Ethiopia, 95% of the population relies on the use of traditional biomass for cooking application among which 50% of the energy is used to bake Injera (traditional pancake-like bread). Due to the low efficiency of Injera baking biomass stoves, large amounts of firewood are used, resulting in high indoor air pollution, greenhouse gas emission, and rampant deforestation. From time to time attempts made to improve the Injera baking stove to increase efficiency by reducing fuel consumption and result in an incremental change in efficiency and reduction in emission of pollutants during cooking on it.

Injera together with its '*wot*' (sauce) is the major staple food used in Ethiopians and Eritreans as well as people from some east Africa areas like Somalia and Sudan both living within their country and abroad [1]. The standard single Injera weighs 310 g and it is average 52 cm in diameter. Injera is pancake-like thin bread that is flat from the bottom and has many holes or "eyes" on the top open side. The majority of Injera is prepared from the local indigenous grain teff, corn, sorghum, millet, and a mix of two or three of these.

The details of the Injera baking process start from the preparation of dough and ends in baking on the plate clay called *Mitad* usually having a diameter of 40-60 cm and finally have cooked Injera. Most of the people living in Ethiopia bake Injera using traditional biomass on the open-fire stoves. The inefficient open-fire stove consumes large amounts of firewood and produces high indoor air pollution and CO_2 emission due to its high energy losses. The three stones are put in a triangle to support or carry the baking pan having a diameter of 40-60 cm and a thickness of 20 cm on average. Then, firewood is inserted through the openings between the three stones of stands for burning. While burning is taking place below the pan, Injera is baked on it using the heat energy of the burning of fuels. In this process, almost 90% of the energy supplied is lost to the environment. Moreover, the cooker and her child are exposed to large amounts of CO and PM emission which is above the WHO standard set for safe cooking [2]. Researchers in Ethiopia and abroad have made attempts to improve the efficiency of Injera baking stoves to save energy, reduce indoor air pollution, and CO_2 emission.

Fig. 1: Injera baking process and Injera with *Wot* to final eat

This includes early efforts made by the Alternative Energy Development and Promotion Directorate under the Ministry of Water, Irrigation and Electricity and GIZ-Energy Coordination Office in the late 1980s and early 1990s. A significant achievement is registered by the GIZ-Energy Coordination office in Ethiopia in disseminating around 455,000 improved Injera baking stoves (*Mirt Midija*) throughout the country. Energy for Sustainable Development, a private UK firm also worked with a dedicated team of Ethiopian and developed the first national *excellent* charcoal cooking stove, *Lakech*, and Mirt injera baking stove and commercializing Ethiopia. Several studies were conducted and shown that the reduction of specific fuel consumption of Mirt stove comparing with open fire baking is 30–50%.

However, improving the performance of biomass stoves, especially for baking Injera remains to be a challenge for researchers. This review discusses the development of Injera baking stoves to improve efficiency, to reduce fuel consumption rate, operation simplicity.

Since the information collected is mostly from reports from governmental and non-governmental institutions in the country, most of the references are not published in peer-reviewed journals. Our effort will present significant benefits to a wider public. Besides, it will serve as a starting point for researchers who are interested in designing, manufacturing, and testing stoves particularly for baking not only in Ethiopia but also elsewhere in the world.

Objectives of the Study

The main objective of the study is to review the Stove development for baking Injera in efficiency based on stoves efficiency, specific fuel consumption, and operation simplicity.

Specific objectives are listed as follows;

- To identify different types of Injera baking stoves in based sequential development patterns in Ethiopia
- To determine their thermal efficiency and specific fuel consumptions of different Injera baking stoves
- To document the reviews of the Injera baking stoves sequence based on the energy consumption
- To recommend further development patterns of Injera baking stove

Methodology

The methodology incorporated to achieve the specific objectives listed above summarized as follows;

- ✓ Field observation for the primary data collection
  - Interviewing cookers for the fuel save energy consumption of all types currently in use Injera baking stoves
  - Identifying modern technology adoption and observe operational comfort
- ✓ Review of literature
  - Thermal analysis and efficiency of all types of stoves
  - Owners and developmental history and modification from the previous one

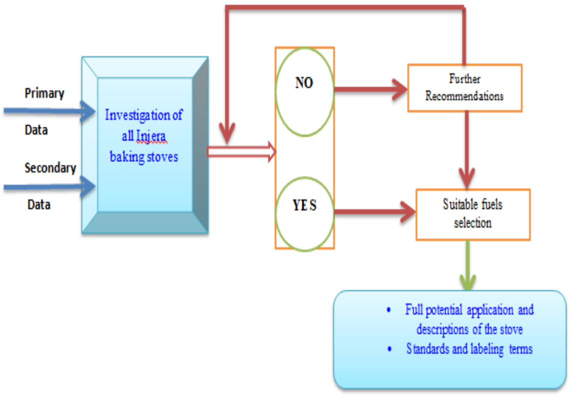

Fig.2: Methodology Design Flow Chart

II. LITERATURE REVIEW

Injera and its baking process

Injera is a flatbread with a unique taste; it is a circular pancake that is sour and tasty and has a soft-spongy like structure with a thickness of 2–4 mm and a diameter of around 40-58 cm depending on the diameter cooking pan or *Mitad*. Baking is done on a circular griddle or pan either a large black clay plate over a fire. The pan is known as a *Mitad* in Amharic or *Mogogo* in Tigrian. *Mitad* has been found at archaeological sites dating back as far as 600 AD. Nowadays, numbers of automated Injera baking machines are developed thus; *Mitad* is no longer always made out of clay, but can also be electric.

The major ingredient of Injera is teff, though other cereals such as sorghum, corn, and barley are sometimes used in a mixture of two or three of them. Sometimes few grams of rice were added to enhance good flour and whitening Injera. The knowledge and skill of making Injera are well known by Ethiopians and it has been customizing transferred from generation to generation for a long period. The general structure of well-baked Injera is shown in Fig. 3. Injera is made from teff flour which is mixed with water and allowed to ferment by adding leftover ferment from the previous baking session dough to accelerate fermentation. When the dough is ready, the fire will be lit from the bottom of the claypan for biomass stoves, and in the case of an electric Injera baking stove, resistors will be turned on. When the pan's temperature reached about 200-250 °C, the dough will be poured onto the baking pan. The viscosity allows it to be poured into the baking pan rather than rolling out. Finally, the baked Injera will be taken out of the baking pan. The majority of Ethiopians still bake Injera using a three-stone traditional cooking stove in an open fire. Starting from1980s efforts have been made to improve Injera baking stoves and electric Injera baking stoves for urban dwellers have been introduced.

Fig.3: picture of newly baked Injera showing both upper and lower side

Early research and development patterns of improvements of Injera baking stoves

The need for efficient Injera baking stoves had not been addressed for a long time until governmental institutions laid the foundation in the 1980s having the government policy to improve the efficiency of along with energy-saving. Early efforts included manufacturing of mud Injera baking stoves by the Burayou Basic Technology Center (BTC), under the Ministry of Education in the early 1980s. The name of the stove given was ‘Burayou mud-stove’. Then The Ethiopian Science and Technology Commission (now Ministry of Science and Technology of Ethiopia) hired a consultant in 1981 to assess traditional closed stove in selected areas of the country [3]

Three-stone-fire Injera baking stove

As the name indicates, a three-stone open-fire stove uses three separate stones put in triangular to support the cooking pan or *Mitad* (claypan) for baking. The types and sizes of stones used would vary according to the availability of the stones and the diameter of the pan. Usually three (10–15 cm) high stones are used to support the mitad as shown in Fig. 4 below. A number of developers have used a three-stone open-fire Injera baking stove as a reference for showing the improvements with various versions of the *Mirt* stove. The specific fuel consumption of a three-stone open-fire stove on average is 929 g of wood/kg of Injera. During the tests conducted on *Mirt* and the three-stone open-fire, Injera baking stove obtained indoor air pollution parameters for three-stone open-fire stove as 80 ppm for CO and 1.10 mg/m3 for PM [4].

Fig. 4: Three stone open fire Injera baking stove

Burayou Injera baking stove

Early efforts included manufacturing of mud Injera baking stoves by the Burayou Basic Technology Center (BTC), under the Ministry of Education in the early 1980s. This stove was constructed out of a mixture of clay, and child (teff straw). All of the stove parts were made out of clay and *Chid* (straw of teff) and they named it Burayou mud-stove.

Fig. 5: Burayou mud Injera baking stove

The total weight of the stove is about 100 kg. The stove is massive and fragile, and it needs at least two persons for installation. This also makes transportation very difficult. The sketch of the Burayou Injera baking stove is shown in Fig. 5 above. In 1986, the Ambo team have been modified the Burayou mud-stove and came up with the Ambo mud-stove used for Injera baking. In the early 1990s, a team of experts at the then Ethiopian Energy Authority with consultants from abroad started a survey to make a starting point for the development of the Injera baking stove in the country. The assessment made throughout the country publicized that the Burayou, Ambo, and Tigrian mud stoves were the more efficient stoves at the time of the study,. When tests were performed on the above mentioned three Injera baking mud stoves, the variation in performance was associated with thickness and seasoning skill of the pan or *Mitad* [5].

Others traditionally developed enclosed Injera baking stoves are commonly used in the northern part of Ethiopia, mostly in Tigray (Tigray Regional State) and Wollo (a province in Amhara Regional State), and some parts of semen Shoa (Oromia Regional State). They are named after the area where they are most popular in Tigray and hence, it is commonly referred to as Tigrian stove. These stoves, unlike three-stone Injera baking stoves, are permanently built on the ground or a raised platform made up of mud and stones. Users build the stove according to one's estimate of dimensions. In some places, the height of the stove varies from 28 to 40 cm with one or two smoke outlets. A typical Tigrian Injera baking stove has usually two smoke outlets and a height of about 35 cm.

The efficiency of a well-built enclosed Tigrian Injera baking stove is about 12% compared with the three-stone open fire Injera baking stove, and it consumes less fuel, and is easier to use, and protects from burns heat [6].

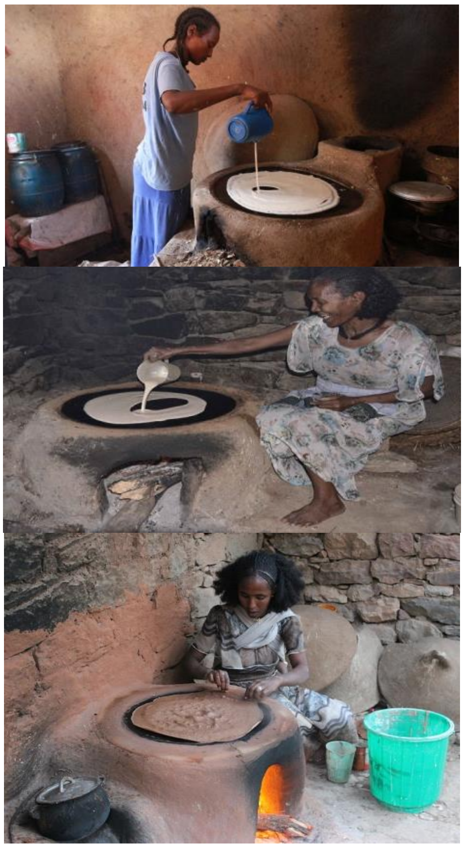

Fig. 6: Burayou, Wollo, and Tigrian enclosed Injera baking stoves

Tehesh Injera baking stove

Tehesh Injera baking stove was developed by GIZ (previously GTZ) and the Rural Technology Promotion Center of Mekelle. The idea of designing Tehesh came from improving the existing Tigrian injera baking stove such as the traditional three-stone stove, BOANR improved stove, and jet stove commonly used for baking Injera through the region [7].

The raw materials used for making of Tehesh Injera baking stove are mud, stones, and barley straw. A small amount of fresh dung is mixed together with mud to increase its adhesion and strength. This composition is smeared over the vertically stacked stone from inside and outside. The straw is used as insulation by placing it between the outer and inner walls of the stove and under the combustion chamber.

Fig. 7: Tehesh Injera baking stove

The Tehesh stove is more efficient than the others for two reasons:

- ✓ Increased heat retention due to inner double walls, reducing heat loss to the surroundings, and releasing useable heat sometime after all the fuel is burnt
- ✓ Reduced flue gas temperatures as baffle prolong the cooling time of the gases around the pan or *Mitad*

The Tehesh stove is recommended for those whom wood is their major cooking fuel and it can be simply adopted by the stove user if it is accompanied by training in construction and application.

Sodo Injera baking stove

Sodo Injera baking stove is made by the Rural Technology Promotion Center in Sodo. The name of the stove is taken by the name of the place it was first designed and produced. It is an enclosed stove made of 2 mm sheet metal. The Sodo Injera stove can support *Mitad* (stove) sizes between 54 and 56 cm. The total height of the stove is 42 cm. The combustion chamber is 60 cm in diameter and 15 cm in height. It has an ash-collecting box under the perforated metal grate as shown in Fig. 8. The controlled cooking test conducted by Sodo RTPC on a 45 cm diameter *Mitad* shows that the average fuelwood consumption of the stove was 0.343 kg wood per Injera [8].

Fig. 8: Sodo Injera baking stove

Mirte Injera baking stove

Experimental investigations were conducted on the Burayou, Ambo, and Tigrian stoves, and Ambo was found to be the most efficient compared to the other two Injera baking stoves, but the fuel consumption reduction was not satisfactory. Later on, important modifications were made and the team of experts came up with a mud Injera baking stove which is efficient, and they named it '*Mirt*', which means 'best' [9].

Consequently, the mud structure of *Mirt* is changed into a cement mortar mixture to build the fire chamber enclosure as shown in Fig. 9(a). And this stove is widely promoted by the GIZ-Energy Bureau Office in Ethiopia and it is named as *Mirt* stove. The specific fuel consumption of the *Mir*t stove has been determined by a number of researchers and developers. The average specific fuel consumption of the *Mirt* stove is 535 g of wood per kg of Injera.

Mirt stove was tested at the Aprovecho Research Center; the experiment was conducted by using the water boiling test procedure where the time to boil is 35.8 min and 6,407 g of fuel was used. The CO observed was 192 g and PM was 5322 g. The improved design brought about a percentage reduction of 18% (time to boil), 81% (fuel use), 90% (CO), and 83% (PM). Fig 9(b). Shows the experimental modification made to the *Mirt* stove [10].

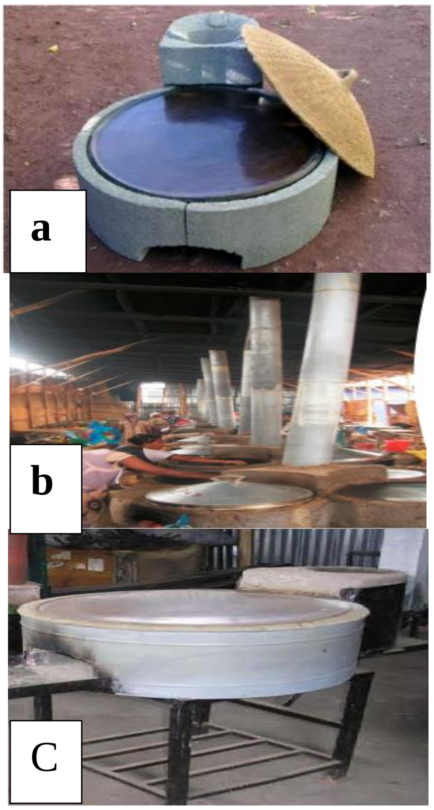

Fig. 9: a) *Mirt* stove, b) improved *Mirt* stove with chimney C) Yekum *Mirt* stove

Gonziye Injera baking stove

The other improved Injera baking stove is made out of clay and its name is Gonziye shown in Fig. 10 (a) below. It is a multipurpose improved Injera cooking stove to be used both for Injera baking and other types of cooking such as water heating, coffee making, and *Wot* making. The specific fuel consumption of the Gonziye Injera baking stove is 617 g/kg of Injera [17].

Awramba Injera baking stove

Awramba is the other improved injera baking stove which is named after the Awramba community in the Amhara Regional State of Ethiopia. This injera baking stove has been in use in the community since 1971. This stove also integrates other cooking applications in addition to Injera baking. It has a specific fuel consumption reduction of 35% compared to the open-fire Injera baking stove. Fig. 10(b) below shows the simultaneous operation of the Awramba Injera baking and cooking using the Awramba Injera baking stove [12].

Fig. 10: a) Gonziye Injera baking stove b) Awuramba Injera baking stove

Other than biomass Injera baking stoves

Biogas Injera baking stove

Biogas Injera cooking stove has a problem of imbalance of biogas consumption during cooking and unable to make uniform distribution of heat thus it is not yet popular for Injera baking. There are a number of efforts made by the Ministry of Water, Irrigation, and Electricity by Alternative Energy Development Directorate and SNV to develop a biogas stove for baking Injera.

The biogas Injera baking stove developed by the graduate student of graduation thesis in Bahir Dar University, Ethiopia has been made to solve the above problems of the biogas Injera baking system. The performance of the concentric three-ring Injera stove was determined by baking Injera as shown in Fig. 11 below. The power output of the stove was 11 kW, corresponding to the gas consumption of 41 liters/min. The gas consumption per Injera was 193 liters (3108 kJ/Injera). The average efficiency of the three-ring biogas stove was 16% in the range of improved biomass stove [13].

Fig. 11: Biogas Injera baking

Ethiopia has also recently established the National Biogas Program (NBPE) with support from the Netherlands Development Organization (SNV) to promote the use of biogas stoves for cooking. NBPE assisted a company to develop an Injera baking stove which uses biogas as a fuel. Combustion of methane using the proper fuel-to-air ratio will create a non-polluting and comfortable kitchen for Injera baking. The amount of biogas or the feedstock required for baking Injera for a household, on average 25–30 Injera at a time, is quite significant. Thus, improving the development of an Injera baking biogas stove requires further research and development efforts.

Solar Injera baking stove

The other non-biomass Injera baking stove made is a thermic-fluid parabolic trough solar collector Injera baking stove. It uses indirect heating for baking Injera energy from solar radiation with intermittent heat storage and thermic-fluid and steam as a working fluid (Fig. 12(a)). This was verified experimentally at two locations in Ethiopia; *Addis Ababa* and *Mekele*. In the first case, the solar energy was simulated with an electric heater to supply heat to the thermic-fluid so that Injera is baked before the whole system is connected to the parabolic trough since the overall objective of the project was baking Injera using solar energy using thermic-fluid. The surface temperature of the baking pan or *Mitad* was in the range of 180–220 °C. The test result showed a reasonable Injera texture with a surface temperature of 215 °C [14 15]

The second solar thermal Injera baking stove which generates hot steam by concentrating suns ray using a parabolic dish solar collector on the receiver. The stream flows through a pipe to the Injera baking stove on the backside and condensed by transferring heat to the baking pan or *Mitad* which is placed on the steel plate that is in contact with the hot steam as shown Fig. 12(b). The important conclusion drawn from this project was the possibility of baking Injera using indirect steam in a temperature range from 135-160 °C. The indicated temperature was less than the literature or experimental values obtained earlier by other researchers or developers working on an Injera baking stove [1 13]. The usual operation temperature was around 250 °C to obtain a well-baked Injera. As it has been stated in this study, it requires further testing and verification.

The other one is a direct solar radiation Injera baking stove through which a mirror was also tried in the USA using a frying pan for baking Injera. A prototype was tested using a baking pan having 46 cm diameter. The reported baking time was 2 min and stated that it's a baking capacity of 4 kg per hour shown Fig. 12(c). The researcher states that the design is scalable to any required. It is a good attempt to be explored and verified for a larger scale application [16]

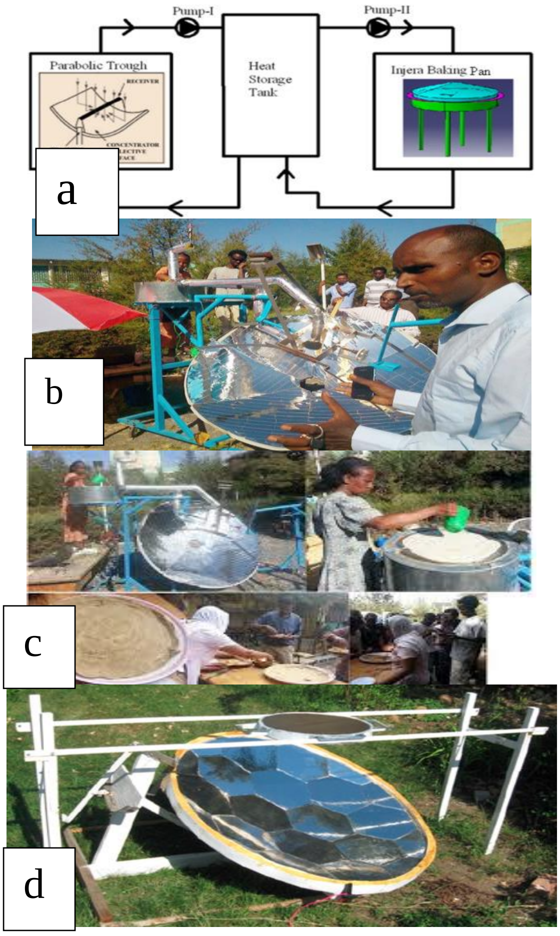

Fig. 12: a) Parabolic trough solar Injera baking b) Concentric solar Injera baking c) Solar direct Injera baking using concentric solar collector d) Concentric solar Injera baking

Electrical and other automated Injera baking system

Electric Injera baking stoves

Electric Injera baking stove (electric Injera *Mitad*) was introduced to Ethiopia 40 years back through the then Ethiopian Electric Light & Power Authority (EELPA). To adopt the electric Injera stove, various government and private organizations manufactured the stove and sold it to the market. Since the electric Injera baking stove is not standardized, the performance of the electric Injera baking stove depends on the experience of the company and the quality of the workmanship. The average power demand of a single household electric Injera baking electric stove is 3-4 kW. The Ethiopian Energy Authority is in the process of preparing the Ethiopian standard for labeling electric injera baking stoves to create awareness for the users to select their preference according to their interest based on the performance of the stove (MWIE, 2016).
The other small home-based electric Injera baking stove in practice today is WASS digital *Mitad*. This Professional Grade grill is available to be shipped to your home and will withstand extended use within the restaurant environment. The WASS *Mitad* is being used in Wassie's Restaurant in Hamilton, Ontario CANADA.

Fig. 13: Non-automated electric Injera baking stoves

There are also different types of automated Injera baking stoves are designed, manufactured, implemented, and patented so far are in detail listed in table I below.

TABLE-I
LISTS OF PATENTED INJERA MAKING STOVES [13]

Title of the invention	Major Inventions
Method and apparatus for making bread By Mengistu A. Kindie, Robert J. Sweeney, and Jim Aitken	A stove is used to bake *Injera* and bread by using a dispenser. The dispenser pours the dough on the baking surface which is heated by an electric power supply from the bottom bake continuously automatically.
Method of and apparatus for making Ethiopian bread By Emiru Y. Desalegn	A proper amount of dough dispensed onto a horizontal moving conveyor where *Injera* is baked on and transported to a cooling zone. The machine is automated to bake *Injera* continuously with the help of electric power.
***Injera* manufacturing system By Wundeh Mulugeta**	A continuous *Injera* baking machine consisting of storage, dispensing, baking and cooling stages. The machine is capable of producing *Injera* in mass continuously.
***Injera* baking machine Yoseph Temesgen**	Automated continuous *Injera* baking machine starting from polishing the surface of the baking pan, dispensing and removing using spatula attached to a reciprocating conveyor. The dough dispensing mechanism can rotate and reciprocate simultaneously.
Rotary baking system and method Wassie Mulugeta	An automatic rotating *Injera* baking machine which consists of a movable dispensing unit with a rotary system for baking using a gas burner. The gas will be fed to each baking surface from the gas cylinder.
Method and apparatus for rapid production of *Injera* bread Michael Ma	*Injera* baking machine with a mass production capacity having of a dough dispenser coupled with a perforated cylinder with a convey belt for takeout... The baked *Injera* will be transferred into a cooling and packaging unit after baking.

III. RESULTS AND DISCUSSIONS

Research on improving the efficiency of the Injera baking stove has been increased in recent years due to its environmental impacts and health concerns in addition to the effort for the reduction of the number of energy losses and total energy consumption. The development patterns of the Injera baking stove in recent researches are concerned with the optimization to reduce the specific fuel that is by improving the energy losses which also improves the efficiency of the specific stove. The average specific fuel consumption of developmental patterns of some Injera baking stoves is shown in Fig. 14 below.

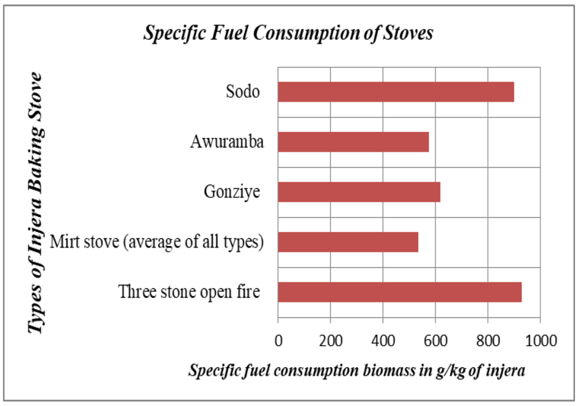

Fig. 14: Specific fuel consumption, g/kg Injera

Proper baking of Injera depends on the uniform surface temperature of the cooking pan or *Mitad*. However, the researchers and developers have worked to achieve the average surface temperature of cooking pan or *Mitad* around 200-250 ºC for these types of Injera baking stoves developed by using solar radiation and other energy sources as an input energy source. The average surface temperature of the cooking pan or *Mitad* of the stoves is shown in the figure below.

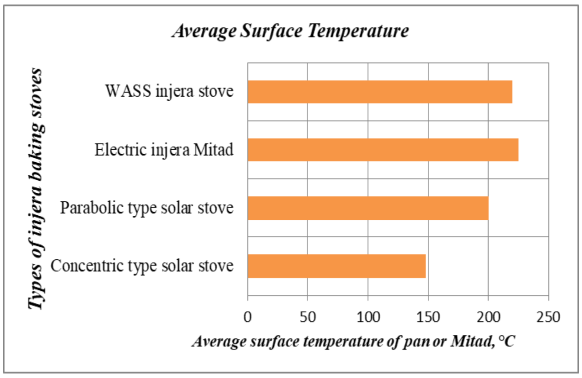

Fig. 15: Average cooking pan or *Mitad* temperature, °C

The modern automated Injera baking stoves are developed for the mass production of Injera. These are many designs and also developed, and patented with different Injera production and introduction of some parts to improve operation simplicity to reduce the number of additional workers need.

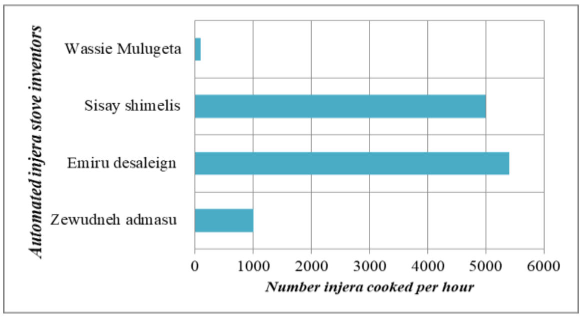

Fig. 16: Injera baking rate in one hour of some inventions

CONCLUSIONS AND RECOMMENDATION

Injera will continue to be the staple food for Ethiopians and Eritreans and some parts of east Africa in years to come. To efficiently bake, Injera using various types of stoves, research, and development work for Injera baking have been conducted so far and is critical. The use of energy sources is dominantly biomass is used for Injera baking followed by electricity yet. Electricity is mainly used in urban dwellers of the country which is a limited one. Alternative energy sources such as solar thermal and biogas can be used for baking Injera alternatively.

As it has been stated in the early section of the Injera baking stove, and subsequent studies using numerical methods, improving the efficiency of the Injera baking pan will directly minimize the losses associated with baking. A number of efforts are being undertaken to improve the performance of the baking pan, such as ceramic materials and combinations of metal chips combined with clay and glass that will increase the conductivity of the cooking pan or *Mitad.* Research directions could also focus on improving the thermal conductivity of the baking pan or *Mitad* without compromising the quality of Injera. A composite Injera baking pan or *Mitad* could also be an area to be explored in further investigations.

The case of electric Injera baking is relatively well established except for possible improvements in efficiency and reduction of energy consumption. Solar thermal, gasification and biogas, which are potential future research areas to be focused on, will have enormous contributions for improvements on the health of cooking women and their children exposed to indoor air pollution. However, most research efforts on Injera baking stoves were focused on improving specific fuel consumption and little attention was given to the reduction of indoor air pollution such as CO and PM as well as reducing carbon emissions. Therefore, future research efforts should also address such indoor air pollution issues as these which are also important factors in the development of Injera baking stoves.

Although the long term solutions for developing countries such as Ethiopia is connecting electricity to all of its inhabitants, the short and middle-term solution is improving the performance of biomass stoves through research collaborations of the governmental institutions with other partners. The development of biomass technology will be instrumental in the energy mix in the long term solution strategy, particularly for decentralized energy generation systems. Specifically, the use of clean biomass stoves for baking Injera is a vital issue for alleviating air pollution, greenhouse gases, and energy efficiency. This is a grave concern not only for the majority of Ethiopians but also for people living in rural parts of the world, such as most developing countries in Africa and abroad. Besides, biomass is a key factor in the energy source; it requires further research undertakings for more efficient utilization of energy.

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