Stove Testing Result

A Report on Controlled Cooking Test of Gonzie Stove

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List of Acronyms and Abbreviations

CCT	Controlled Cooking Test
EREDPC	Ethiopian Rural Energy Development and Promotion Center
ECO	Energy Coordination Office (of GIZ)
MoARD	Ministry of Agriculture and Rural Development
MoWIE	Ministry of Water, Irrigation and Energy
SNNPR	Southern Nations, Nationalities and Peoples Region

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Introduction

Controlled cooking tests were run on Gonzie stove. The tests were intended to assess the fuel saving potential of the stove when used for injera baking. As always, the baseline stove against which the improved stove is to be compared was also tested together. This is the three stones open fire which is still used by the majority of households in Ethiopia.

Gonzie was first developed in the early 2000 by the then Ethiopian Rural Energy Development and Promotion Center (EREDPC) as an alternative stove for *kocho* baking. Kocho is a type of bread made of *inset* tree (aka false banana). The *inset* stem is processed to obtain its juice which is full of fiber before making it into bread. This food is very common in many parts of SNNPR including Sidama, Gurage, Gedeo and Wolaita as well as in a few places in Oromia.

Although first developed for kocho baking, the stove is now being promoted as injera baking stove for its potential of adoption by low income households due to its cheaper price. ECO also is considering to promote the stove and practical activities have started. It is part of the activities of ECO to test and document the performances of all of the stoves it is promoting and it is with this objective that the current test has been conducted. No information could be found on same tests made by Ministry of Water, Irrigation and Energy (MoWIE) or by any entity else. Those made by the ERDEPC (at the time this center was under the Ministry of Agriculture and Rural Development-MoARD) were based on *kocho* baking. This is not surprising knowing the history of the development of the stove. At a latter time, they ran tests also based on injera baking but on different versions of the stove which were only under development and were not disseminated to users. The commonest Gonzie stove found where it is popular is the original version and this is the version tested here and considered for dissemination by ECO.

The tested stoves

As noted already injera baking tests were conducted both on Gonzie stove and the three stones open fire, which is the baseline stove used for comparison. Gonzie is made from ceramic clay having four parts which when assembled together form its basic circular enclosure. And that is

basically what the stove is. The four parts (quadrants) have a shape of an arc of a circle in one view (i.e. top view). Their cross section is trapezoidal (almost triangular) with the base standing on the ground and the vertex at the top on which the baking plate rests on the four risers on each of the quadrants. The bodies of the quadrants are not entirely solid. An air space is enveloped between the inner and the outer walls. This might be useful for the performance of the stove as an unnecessary mass has been avoided which might robe some of the heat of combustion. The basic dimensions of the stove are shown in figure 1.

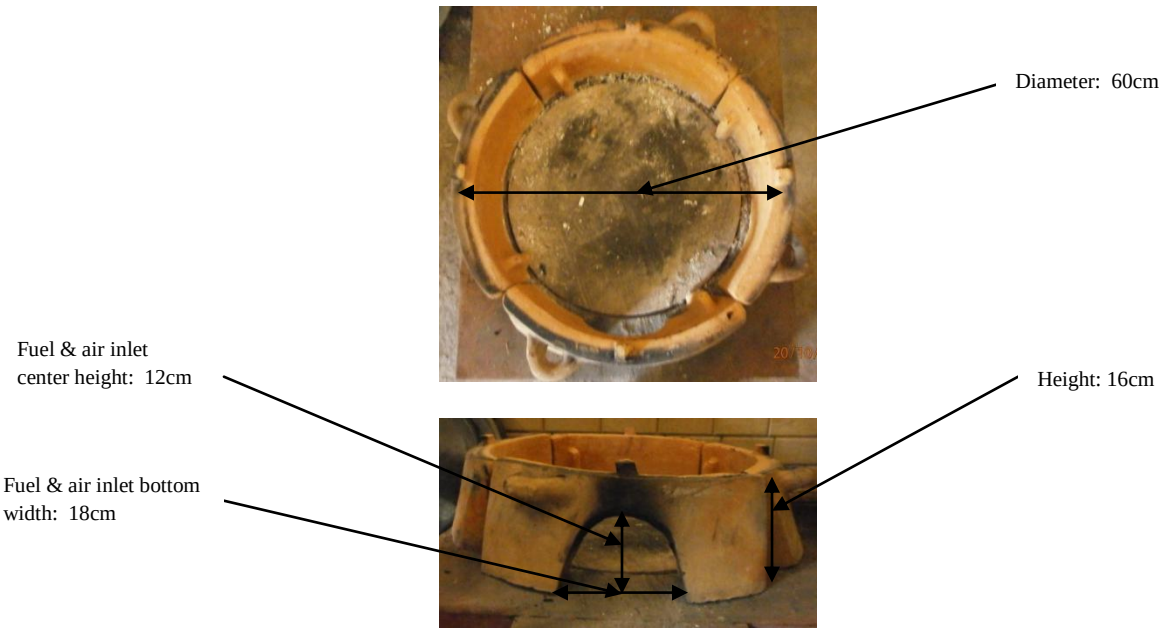

Figure 1 Gonzie stove main dimensions

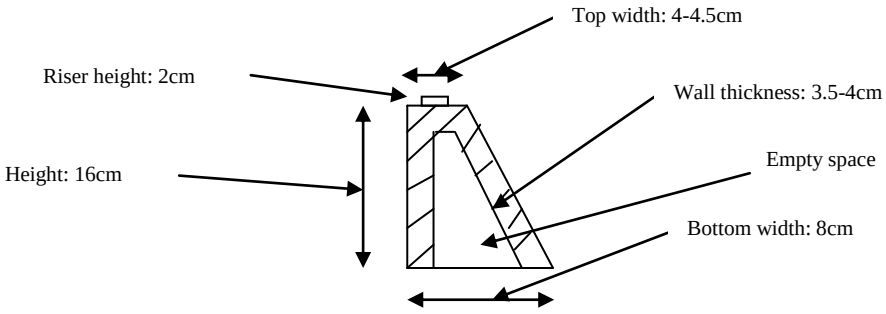

Figure 2 Vertical cross-section through the walls of Gonzie

The fuel and air inlet is a semi-elliptic opening on one of the quadrants, and has its widest dimension at the bottom at 18cm. Its longest height at the center is 12cm. The risers, which protrude from each of the centers of the quadrants at their tops, are about 2cm high. These risers create the gap necessary to for the smoke to be removed from the stove around its perimeter.

The obvious attraction of Gonzie is its price. It may vary from place to place but the range is 70-140Birr in many places it is sold. Because traditional clay makers can produce it, it may be available anywhere such makers are available and in this way it is independent of expensive raw materials like cement which are used to produce mirt. The stove also is used for pot based cooking by re-arranging its parts as shown in figure 3 below. This could be considered an additional benefit of the stove.

Figure 3 Gonzie for cooking

Three stones open-fire arrangement is the baseline stove against which we compared our improved stove (Gonzie). It is a common rudimentary "stove" used by households in many parts of poor countries where people don't have other alternatives. It is an arbitrarily arranged three stones (or as is the case here, purpose made clay materials) sitting at a distance from one another. This distance varies according to the size of the cooking utensil used. The three stones sit relatively closer when the utensil's size is smaller and relatively far apart (at ca. 52cm apart in our case here) when the utensil is bigger. This stove is easy to "make" and is very adaptable for the cooking needs. But it obviously is very inefficient with its wastefulness exacerbated further when the environment it is being used is windy, for example, which steals more heat of the fire

or when, for example, the size of stones used are bigger which can easily take the heat from the fire, etc. Figure 4 below shows the configuration as used in the test.

Figure 4 Injera baking on three stones open fire

In the above shown arrangement of the three stones stove, the clay risers (otherwise stones) are sitting equidistantly at about 52cm from each other and each of them are 14cm high from the floor level thus leaving the same space for both air-fuel entry and smoke exhaust, respectively, to and from the stove system.

Test procedures and equipment used

Controlled Cooking Test (CCT) protocol version 2.0 has been used. The main objectives of this type of test are to obtain the amount of fuel used, in units of mass or volume, to prepare a unit amount food in units of again mass or volume (the result is called specific fuel consumption) as well as the time it takes to do the typical food preparation done on the stoves. These shall be done for both the baseline and the improved stoves and the results will be compared to see whether there are significant differences between the baseline and the new (hopefully improved) stove. Normally at least three tests should be performed on each of the stoves and the results should show consistency (i.e. must be repeatable) so that they will be statistically significant. In

our test, injera baking is the food preparation activity of interest and specific fuel consumption values in grams per kilograms as well as time of food preparation in minutes were obtained.

This relatively simple test involves preparation of the injera ingredients, fuel and other test materials and measuring, before and after baking, the raw materials for the injera and the prepared injera as well as the amount of fuel before and after the test to determine the net fuel consumption. Fuel moisture and any remaining charcoal would have also to be measured. As indicated above time measurements were also taken and these were done not only for the start and finish of the baking process, but also for each cycle of the injera baking, that would be an activity corresponding to 25-30 injera preparation per one test.

Figure 5 Injera baking on Gonzie stove

Injera baker is involved in the food preparation since the activity requires special skills. This is always the practice in conducting CCT. It is of an advantage because the result will then have a close to real representation of actual fuel saving in real kitchens of households whilst the test is maintaining its touch of "control" (as a CCT test) that tries to isolate the effect of the new (improved) stove thereby ensuring the standard nature of the results.

Injera baking raw materials and other materials used during the test are listed below:

- Dough, prepared from *teff* flour and water. Out of about 16kg of dough used about 60% is water and the rest is the *teff* flour. This should be sufficient to bake about 25-30 injeras per one test session, which is the number of injeras baked in a typical Ethiopian household.
- Firewood enough to bake the stated number of injeras (normally up to about 15kg for the baseline stove and about 10kg for Gonzie)
- Containers for the dough and for the injera

The measuring materials used are listed below:

- Weighing balance (digital, 30kg range, and 100g accuracy level) to weigh the firewood and food
- Fuel moisture meter (Protimeter Mini) to determine the moisture content of the firewood
- Fluke 51II type thermometer with point thermocouple to measure the ambient temperature
- Timer (stop watch) to record time
- Measuring tape to measure the size of firewood used
- Digital camera to make images of the progress of the testing

Presentation and analyses of results

The test results are attached to this report in the appendix section. The summaries are tabulated and illustrated below.

Table 1 Test average specific fuel consumption and average baking time for three stone open fire and Gonzie stove

Stove	Specific fuel consumption, gm/kg	Time to complete one baking session, minutes	Fuel saving over three stones open fire	Time saving over open fire
Three stones open fire	1038	114	-	-
Gonzie	617	106	41%	7%

It could be seen that there is a reduction of fuel required to bake a unit amount of injera on Gonzie stove by 41% at specific fuel consumption value of 617gm/kg. This is compared to the corresponding value of 1038gm/kg for the three stones open fire. When it comes to time of completing one baking session, there is a small difference (reduction) by the Gonzie stove, but it is not significant. At 106 and 114 minutes respectively, for Gonzie and for the open fire, this is only a 7% difference and is too insignificant both in value and statistically to be a valid claim at a confidence level of 95%.

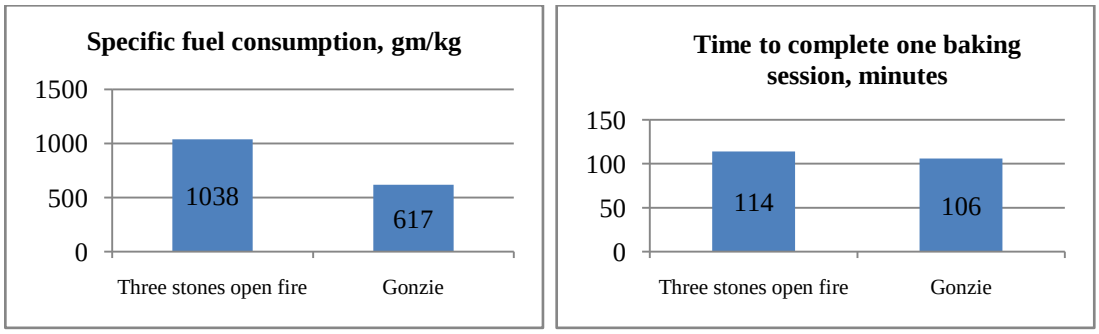

Figure 6 Average specific fuel consumption and average time to complete baking on three stones and Gonzie stoves

As noted above, the time to bake each injera at each cycle of baking one injera was also recorded. Such information might be interesting to, for example, study which part of the baking cycle (i.e. the actual time spent by the dough on the baking plate or the time it takes to reheat the baking plate to the level of suitable temperature for the next pouring of the dough) takes more time and how do these differ across the two stoves.

It was found out that per cycle, on average, open fire takes 3:49 minutes and Gonzie takes 3:19 minutes. Assuming equal number of injeras being baked in each stove (say 29 injeras), this unit cycle time leads to total time respectively of, 1:50:34hr and 1:30:00hr for open fire and Gonzie stoves. This is about a 20.5minutes (18.2%) difference in Gonzie's advantage.

When split between actual injera cooking and reheat times, the times for open fire, respectively, are 03:07minutes and 00:42seconds. The corresponding times for Gonzie are, 02:40minutes and 00:39seconds. Obviously, much of the contribution for the reduced overall time required for baking equal number of injeras (29 injeras) comes from the time difference in the actual baking

of the injera per cycle (i.e. 3:07minutes-2:40minutes=27seconds versus 0:42seconds-0:39seconds = 3seconds).

Conclusions and recommendations

The advantage of Gonzie in terms of fuel saving is vividly evident. The calculated 41% saving is significant. The time saving cannot be claimed as such an obvious advantage at least for household use of the stove as it is insignificant. This is not however bad either since in most cases, due to the disproportionately large amount of power generated inside the baseline stoves (a lot of fire due to a lot of fuel in the stove) they generally seem to be faster. This is especially more evident for the cooking activities that require relatively less time (may be in the order of 30minutes). It is, however, not the case here in the injera baking practice which takes relatively more time and the avoided slowness of our improved stove is, therefore, in a way an advantage.

As indicated in the results section above, however, there is a potential for Gonzie to significantly reduce the time of baking when more injeras are to be baked such as by commercial injera sellers. This is because the total time reduction is the product of the unit cycle time reduction (to bake a single injera) and the number of injeras to be baked and it will be more significant when more injeras are to be baked.

Now we have the clear idea about the fuel saving potential of Gonzie, then our next consideration for its dissemination is its affordability and due to this and other factors, its accessibility potential. As already indicated, currently Gonzie is selling for prices in the range 70-140Birr in different places of Ethiopia with the lower end prices are in places like Leku (near Awassa town) and with higher end prices are in places like Legetafo (at the north-eastern periphery of Addis Ababa). Fortunately in many parts of rural areas, the available information is that prices are more to the lower end and this could be a selling point in these areas.

Not only is the stove relatively cheaper, but is also more accessible in terms of easy local production by local potters as they do not have to depend on not easily available and expensive

raw materials imported from cities (such as cement as for mirt production). The potters could also be trained to produce and sell other cheaper cook stoves such as Upesi, another stove being contemplated also for dissemination by ECO.

In summary, the activities already underway by regional ECO offices to support initiatives by the government to support local Gonzie producers are recommended to be maintained and reinforced so that more alternative stoves could be present to and disseminated in especially rural communities.

Annex 1 Test results summary

Results of CCT comparing two stoves

Stove type/model: Stove 1	**Three stones open fire**
Stove type/model: Stove 2	**Gonzie**
Location	**GIZ - ECO**
Wood species	**Eucalyptus globulus (Southern Blue Gum, Fever Tree)**

Three stones open fire	**units**	**Test 1**	**Test 2**	**Test 3**	**Mean**	**St Dev**
Total weight of food cooked	g	10215	9805	9790	9937	241.2
Weight of char remaining	g	880	1130	1350	1120	235.2
Equivalent dry wood consumed	g	10242	10002	10681	10308	344.0
Specific fuel consumption	g/kg	1003	1020	1091	1038	46.8
Total cooking time	min	120	105	117	114	7.7

Gonzie	**units**	**Test 1**	**Test 2**	**Test 3**	**Mean**	**St Dev**
Total weight of food cooked	g	10715	10305	10115	10378	306.6
Weight of char remaining	g	440	590	645	558	106.1
Equivalent dry wood consumed	g	6523	6278	6389	6397	122.3
Specific fuel consumption	g/kg	609	609	632	617	13.1
Total cooking time	min	99	104	116	106	8.7

Comparison of Stove 1 and Stove 2		**% difference**	**T-test**	**Sig @ 95% ?**
Specific fuel consumption	g/kg	41%	15.03	YES
Total cooking time	min	7%	1.16	NO

Summary of comments on stove 1

Summary of comments on stove 2

References

1. Controlled Cooking Test Protocol Version 2.0 (http://www.pciaonline.org/node/1050)
2. Final Report on Improved Gonzie for the Year 2003, Ethiopian Rural Energy and Development Center, Ministry of Rural Development, Household Energy Efficiency Improvement & Conservation Project, Wossenu Areda (2004)