Introduction of Smokeless Stove to Gari Producers at Koryire in the Yilokrobo Municipality of Ghana

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Abstract— *This work sought to promote the construction and use of smokeless stove as well as record keeping among gari producers at Koryire, which is one of the 237 communities in the YiloKrobo Municipality of the Eastern Region of Ghana. The study employed Action Research Methodology with the formation of a 10 member group, comprising four men and six women.A prototype smokeless stove was constructed together with its flue in order to adequately equip the group members with the requisite skill for the stove construction. The cost of constructing the smokeless stove in the target community as at the time the study was carried out was One Hundred and Fifty Five New Ghanaian Cedis and Fifty Pesewas (Gh¢155.50) about One Hundred and Twenty Four US Dollars($124.00). It was concluded from the results obtained from the study that awareness on the use of smokeless stove in frying gari was adequately created in the target community. In terms of firewood consumption, the smokeless stove consumed about 20 % less firewood than the traditional stove in the community. The members of the target group became skillful in the construction, operation and maintenance of their own local stove by sourcing the required raw materials from within their locality. The use of the smokeless stove in frying gari created more comfort for the processors as they were no longer exposed to smoke and heat stress as was the case with the use of the traditional stove. Not only did the total involvement of the target group lead to the use of the indigenous knowledge, it also led to the re-invention of some key components of the research work especially the stove design, materials used for its construction and the construction process. The processors were encouraged to cooperate with the Municipality Agriculture Development Unit (MADU) in order to be able to derive the fullest benefit possible from their services available.*

Keywords— ***Smokeless stove, gari, fuel wood, smoke stress, sustainability.***

I. INTRODUCTION

Cassava (*ManihotesculentaCrantz)* is one of the world's most important food crops. Throughout the tropics, the plant's roots and leaves serve as essential sources of calories and income. Presently, approximately half of the world's production is in Africa where it is cultivated in about 40 countries; with Nigeria, the Democratic Republic of Congo, Ghana, Tanzania and Mozambique contributing about 75% of the total output (FAO and IFAD, 2005).

In Ghana, the root and tuber subsector contributes about 46 % of the Nation's Agricultural Gross Domestic Product (Adjekum, 2006). Available statistics indicate that the country produced about 23,076,000 metric tonnes of starchy staples in 2009 and out of this 53% was cassava (MoFA, 2010).

Resource poor subsistence farmers are the major producers of cassava and women are largely responsible for the work of processing it into gari, fufu, tapioca and other staple food products. According to Adjekum(2006), 23% of the cassava produced in Ghana is used for the production of gari, 55 % consumed fresh, 18 % used as Agbelima, 2% as Kokontey with only 1 % being used as Chips while another 1 % goes into industrial use under the Presidential Special Initiative.

Due to the high perishability of cassava, processing is a vital activity in the quest to increase its shelf life. Out of all the traditional food products into which cassava can be processed, gari is believed to be the one that gives the longest shelf life of about a year Adjekum, (2006).

Meanwhile, the most popular source of energy for frying gari among the processors is fuelwood. This has also made it to become a serious source of concern to numerous governments and environmentalists because of the fast dwindling forest resource due to its uncontrolled excessive rate of consumption without commensurate replenishment. It is in view of this that numerous researchers have been making frantic efforts to design more fuel efficient and less expensive fuel burning cooking stoves(TERI, 1982).

The government of Ghana through the Root and Tuber Improvement Program (RTIP) funded by the International Fund for Agricultural Development (IFAD) constructed 60 improved gari roasting stoves for processing groups in 12 communities in 4 regions of the country to serve as demonstration/test models for use in technology dissemination (RTIMP, 2007). Despite this development, there is still need for more prototypes of the improved stove to be constructed considering the fact that there are still far too many cassava producing communities in the country yet to be reached.

One of such is Koryire which is a small community with a population of 138 adults located in the YiloKrobo Municipality of the Eastern Region of Ghana (KCLR, 2012). The people of Koriye are predominantly small scale farmers producing cassava, maize, plantain, pepper, cocoyam and oil palm, although some of them also engage in the rearing of poultry and small ruminants like sheep and goat using native breeds.

Gari producers in Koryire community have been experiencing short supply of fuel wood leading to high cost of the commodity. In addition, they have also been exposed to hazards associated with smoke inhalation and its associated diseases/ailments such as running nose, sleepless night, burning sensation in the eyes and respiratory tract infections. It has been very difficult, if not impossible, to eliminate or ameliorate these problems because of the type of stove they use for their gari processing operation (KCLR, 2012).

The aim of this study was to promote the construction and use of smokeless stove in conjunction with adequate record keeping among the gari producers in Koryire.

II. MATERIALS AND METHODS

The study was carried out in Koryire, which is one of the 237 communities in the YiloKrobo Municipality of the Eastern Region of Ghana. It is located 8 km West of Klo-Agogo, a community at about 51 km from Somanyaoff theObawale-NsutapongKlong road. The total population of Adults in the community was estimated at 138 comprising of 68 males and 70 females (KCLR, 2012). The rainfall pattern of the area is bi-modal with a total annual rainfall of 1446 mm (MADU, 2012) with the major season commencing in February and ending in July, whilst the minor season is from August to December.

The processing of cassava into gari in Koryire is predominantly a household business led by women in individual households. Out of about 73 households in the community, 61 of them (84 %) possess gari frying facilities (2 aluminium shallow pans, fuel wood-fired local earthen stoves, sieves and glazed metal bowls of assorted sizes). The women within each household start by processing the cassava root tubers harvested from family farms and went on to procure more from the Agogo market every market day when exhausted(Tuesdays and Wednesdays) for processing.

A group consisting of 10 processors was carefully selected on the basis of ease of effective communication, training and handling with the understanding that this group will propagate the new technology among the larger community later on.

The tools utilized were hand-hoe, shovel, jerry-cans, plastic bucket, blunt machete, measuring tape, ruler, spirit level and try square.

The materials used were maize cob, clay, and palm fruit fibre, water, 6 mm (¼ inch) iron rods, galvanized steel chimney (or flue) and wire mesh.

Fifty-threegari processors in the community were invited to a meeting which served as the forum where voluntary and purposive sampling procedure were used to select 10 on the basis of their interest, willingness to participate and commitment to the attainment of the research objectives.

With reference to MEMD(2004), the selected group members were taken through three important steps required when preparing to build smokeless stove viz: shelter, tools and construction materials. After going through a period of lengthy discussion on the materials (clay, palm fruit fibre, water, 6mm or ¼ inch rod, galvanized sheet metal and wire mesh) that could be used for building the smokeless stove and its chimney, it was realized that clay, palm fruit fibre and water were easily available in the community.

A shelter in form of kitchen was first constructed to house and protect the stove, when built, from intrusion and unfavourable weather conditions. A male member of the group, who was also the Assistant Chief of the Koryire Community, waschosen unanimously by the group to host the prototype smokeless stove.

A corner in the constructed kitchen was mapped out for the location of the stove after which an outline of its foundation was drawn on the floor.

The position to be occupied by the stove was wetted before building the stove on it from the foundation (the first layer) using the prepared mixture to lay the courses of the walls of the firebox, making sure that each course was level before putting another course on it.

The top of the stove was reinforced with 13 mm mild steel rods and chicken wire for added strength, after which the final course (100mm thick) containing 2 pot holes and chimney was laid (Fig. 1). The first pot hole was located at a distance of 150 mm from the inlet of the stove; the same distance was maintained between the first and the second pot hole as well as the chimney(or flue) and the second pot hole. A uniform wall thickness of 200 mm was maintained for the stove. The gari frying pans were used as the template for cutting out the pot holes. The length and breadth of the stove were 1600 and 700 mm respectively.

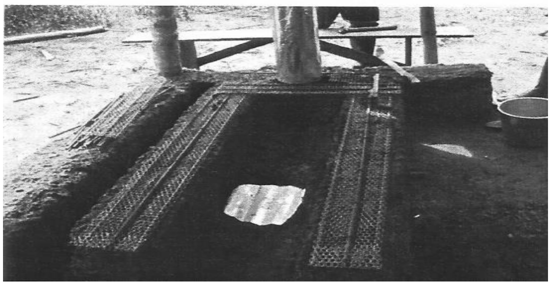

Fig .1: Installation of the top Reinforcement of the smokeless stove

The chimney with a total height of 800 mm was constructed out of galvanized steel sheet and installed before covering with mud insulation up to the roof levelof the kitchen. Although the length above theroof level was not insulated, it was covered with a cone-shaped cap to prevent the ingress of rain water and allow the smoky exhaust gasfrom the stove to flow out of the shelter over and above theroof (Fig. 2).

(a)

(b)

Fig.2:(a) Smokes from traditional stove are circulated within the shelter (b) Smokes from smokeless stove are exhausted above the roof top via the chimney

The stove is described as smokeless because it does not allow any smoke to go inside the shelter occupied by the processors and not because it does not give out smoke. The stove was initially left to dry for two days after the installation of the chimney. Thereafter, the external surfaces of the walls were lightly splashed with water and smoothened out with dry maize cob and machete.

The stove was finally left to dry for four weeks after baking with fire during the first one week with a view to hastening the drying and hardening process.

III. RESULTS AND DISCUSSION

Group formation

A group of 10 gari processors consisting of four males and six females was selected. The group whose membership was based on interest and willingness to learn was found to be very cohesive.

The size of the group is very much in agreement with the findings of MoFA (2004) that the ideal number of members in a group is between 5 and 15 although the average of 10 members is preferable in a small group because all the members will have equal chance of speaking out and contributing their energy and ideas to group development.

The knowledge of the benefits that will accrue from the use of any technology will assist an individual in making an informed decision. The fact that the group members were not even aware of the existence of the smokeless stove technology made it impossible for all the ten (10) members to take the next step of knowing the benefits/relative advantages (Table 1).

Benefits/Advantages of Using Smokeless Stove

According to Rogers (1995), the diffusion of an innovation is an uncertainty-reduction process because when individuals or an organization pass through the innovation-decision process, they are motivated to seek information to decrease uncertainty about the relative advantage of an innovation.

Table 1: Level of awareness on the advantages of using smokeless stove

Awareness	Frequency Before Intervention	Frequency After Intervention
Number of processors who know the benefit of using smokeless stove	0	10
Number of processors who do not know the benefit of using smokeless stove	10	0

The level of awareness of the group members on the benefits of using smokeless stove is as shown in Table 1. From the results, none of the group members had an idea on the numerous benefits/relative advantages of using smokeless stove. This result proves the importance and idea of the project's objective of discussing the advantages of using smokeless stove over the traditional type as stated in Barnes *et al*. (1994) and MEMD (2004).

Rogers, (1995) confirms that the relative advantage of an innovation, as perceived by members of a social system, is positively related to its "rate of adoption".

Construction of the smokeless stove

The selection of the Assistant Chief to host the prototype smokeless stove in order to promote its diffusion and adoption is consistent with the statement of Toborn (2011) that both the opinion leaders and change agents are central actors in diffusion of innovations. Most individuals evaluate an innovation not on the basis of scientific research by experts but through the subjective evaluation of peers who have adopted the innovation. These peers thus serve as role models and opinion leaders whose innovative behaviours tend to be imitated by other individuals in their group (Hoffmann, 2011). The regular attendances of the project participants in meetings (Table 2) made it possible to train and allocate members on the component tasks required to ensure accurate construction of the stove.

The acquired training also had a spillover effect on the participants as three of them went on to construct their individual smokeless stoves. The Chief of the Koryire community and other community leaders have agreed to replicate the construction of the smokeless stove in all their primary schools under the School Feeding Programme of the community.

The cost of constructing smokeless stove in the target community at the time of the project implementation was One Hundred and Fifty-Five Ghana Cedis, Fifty Pesewas (Gh¢155.50) [US$124.40] as detailed in Table 3.

Comparative Cost of Fuel Wood Consumption

The savings in fuel wood consumption per kg of dewatered cassava mash fried with the use of the smokeless stove over those fried with the traditional stove was determined in specific fuel consumption and cost test and presented in Table 4. The savings in mass of fuel wood consumed with the use of smokeless stove over the use of traditional stove was 0.214 % per kilogram of dewatered cassava mash brought in for frying. In terms of monetary value, this translated to 0.213 % per kg of dewatered cassava mash brought into the centre for frying.

Comparative Analysis of Gari Quality and Health of Processors

Although there was no difference between the level of crispiness in the gari samples fried with the smokeless stove and those fried with traditional stove, all the ten participants reported that they did not experience any heat and smoke stress with the use of the smokeless stove unlike what used to be their major problems with the use of the traditional stove. This is because smokeless stove burn the fuel wood with clean air in the shelter as illustrated in Figure 3.

Table 2: Group members' attendance at meetings during project implementation

Meeting Days	Expected Number	Actual Number	Attendance, %
1	10	10	100
2	10	7	70
3	10	5	50
4	10	6	60
5	10	8	80
6	10	6	60
7	10	7	70
8	10	8	80
9	10	8	80
10	10	6	60
11	10	10	100
12	10	10	100
Total	120	91	-
Average Actual Attendance			75.8%

Table 3: Cost of Constructing Smokeless Stoves with Two Burners

No.	Item	Quantity	Unit Cost Gh¢	Total cost Gh¢
1	Galvanized sheet($3m^2$)	1	24	24
2	M.S. rod (6 mm)	3	12	36
3	Chicken wire	2.7 m^2	1.5	4.5
4	Labour for Chimney construction (man-days)	1	15	15

5	Labour for cutting M.S. Rod (man-days)	1/4	12	3
6	Clay mixing (man-days)	2	6	12
7	Stove construction (man-days)	5	10	50
8	Material transportation	-	-	11
To tal				155.5

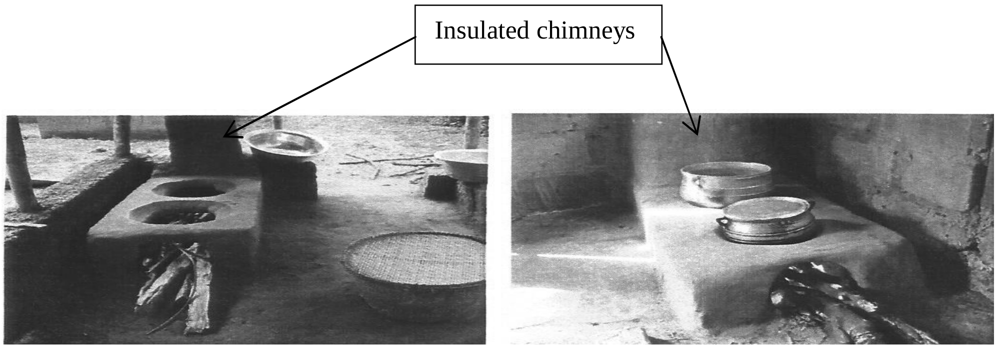

Fig. 3: Smokeless stove burning the fuel wood with clean air in the shelter

This observation is consistent with those of Rehfuess, (2006) which states that smokeless stove eliminate smoke which makes the processors suffer daily from difficulty in breathing, stinging eyes and chronic respiratory disease from the processing hut.

They also observed that the traditional stove became very hot to touch during frying whilst the smokeless stove was much cooler and therefore, easier to touch during frying because of the high insulation embedded in it.

This is also consistent with the statement of Barnes *et al.*, (1994) that because of the greater insulation, most improved stoves are less hot to touch and hence, safer for the users and their children.

When the project participants were asked to respond to the need for an assistant to fan the fire box of the stove occasionally during frying, only 3 of them responded that it was necessary for the smokeless stove while 7 said it was not necessary(Table 5)

Table 4: Comparative Specific Fuel Consumption and Cost of Fuelwood

Samp le	Weigh t of	Traditional Stove		Smokeless stove	
		Mass of	Cost(	Mass of	Cost(

No.	dewat ered cassav a mash(kg)	fuel wood consume d(kg)	Gh¢)	Fuel wood Consume d(kg)	Gh¢)
1	87	87.5	7.5	70	6.0
2	87	70	6	63	5.4
3	87	70	6	52	4.5
Total	261	227.5	19.5	185	15.9
Aver age	87	75.8	6.5	61.7	5.3
%		100	100	81.4	81.5
Specific savings in fuel wood in terms of mass of fuel wood consumed.				0.214 % per kg of dewatered cassava mash	
Specific savings in fuel wood in terms of cost offuel wood consumed.				0.213 % per kg of dewatered cassava mash	

Table 5: Comparative gari quality and exposure of processors to heat and moisture stress

Indices	Number of group members	Smokeless stove	Traditional stove
Good and crispy.	10	10	10
Presence of ash and other foreign matters.	10	0	0
Smoke stress.	10	0	10
Heat from stove.	10	0	10
Need for an assistant during frying.	10	3	7

IV. CONCLUSION

1. Awareness on the possibility of using smokeless stove to fry gari has been effectively created among gari producers at Koryire in the YiloKrobo Municipality of the Eastern Region of Ghana.
2. A prototype smokeless stove was successfully built in the community using the labour and resources of the community after educating them on the benefits/advantages of using smokeless stove.
3. The level of awareness raised was so high that three(3) of the members opted to and build their own smokeless stoves during the short period of the project.
4. The cost of building a smokeless stove with two(2) burners in the target community during the time of project implementation was Gh¢ 155.50 (US$ 124.40).
5. The use of smokeless stove resulted in fuel wood savings in terms of mass amounted to 0.214 % per kg of dewatered cassava mash fried which translated to 0.213 % per kg of dewatered cassava mash in monetary terms.
6. The use of smokeless stove in frying gari has the potentiality of improving the comfort and health status of the processors in addition to improving the quality of the processed gari.

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REFERENCES

[1] Adjekum, A. A. Cassava Processing and Marketing: Experiences from Ghana. Available at :http://www.fidafrique.net/IMG/pdf/RTIP_Ghana_Cassava_En-2.pdf2006. Accessed April 23, 2012.
[2] Barnes, D. F., Openshaw, K., Smith, K. R., Plas, R. What Makes People Cook With Improved Biomass Stoves? A Comparative International Review of Stove Programs. World Bank Technical Paper Number 242- Energy Series. World Bank. Washington D. C.1994.
[3] FAO/IFAD.Proceedings of the Validation Forum on the Global Cassava Development Strategy, Volume 2: A Review of Cassava in Africa with Country Case Studies on Nigeria, Ghana, United Republic of Tanzania, Uganda and Benin. Food and Agriculture Organization of the United Nations, Rome. Available at: http://193.43.36.44/docrep/fao/009/a0154e/A0154E00.pdf2005. Accessed 23 April, 2012.
[4] Hoffmann, V. Knowledge and Innovation Management. Module Reader. Hohenheim University. Available at:https://studieninteressierte.unihohenheim.de/uploads/tx_uniscripts/25720/A7020_KIM_2011.pdf#page=372011. Accessed 23 April, 2012.
[5] KCLR. Community Labour Register. Unpublished Koryire Community Labour Register, Somanya. 2012.
[6] MADU Annual Report. Municipal Agriculture Development Unit. YiloKrobo, Somanya. 2012.
[7] MEMD. How to Build the Improved Household Stoves. Ministry of Energy and Mineral Development. Uganda.2004.
[8] MoFA. A Guide Book on Group Formation and Development for Agriculture Extension Agents. Ministry of Food and Agriculture. Accra. Ghana. 2004.
[9] MoFA. Twenty Sixth National Farmers' Day Celebration. Ministry of Food and Agriculture, Accra, Ghana; .2010. Pp. 16-23.
[10] Rehfuess, E. Fuel for Life: household Energy and Health. World Health Organization. Geneva.2006.
[11] Rogers, E. M. Diffusion of Innovations. (4^{th}ed.). The Free Press. New York.1995.
[12] RTIMP. Available at:http://doccassava.fidafrique.net/RTIMP_Processing_en.ppt; 2007.Accessed 25 May, 2012.
[13] TERI. (Pilot ed). Consolidation of Information: Cooking Stove Handbook. UNESCO. Paris. Available at:http://unesdoc.unesco.org/images/005/000530/053052eb.pdf; 1982. Accessed March 23, 2012.

[14] Toborn, J. Adoption of Agricultural Innovations, Narratives and the Role of SwedishAgricultural Research for Development. Discussion Paper, version 2011-01-28.Available at: http://www.slu.se/ Documents/externwebben /overgripande-slu-dokument/samverkan-dok/agric-sci-global-dev/Adoption %20of%20agricultural%20innovation 201110128.docx; 2011. Accessed April 20, 2012.