

**DEVELOPMENT OF AN IMPROVED SMOKELESS 'CHULA'
FOR BETTER HOME MANAGEMENT**

BY

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BERLINER MEDIZINISCHES
SYMPOSIUM



I. INTRODUCTION

The discovery of fire has been an important factor in human civilization, development and achievements. Aided by the application of fire, scientific advancement has made tremendous strides. Fire has always been associated with the preparation of food, religion and rituals. In the Upanishads ()¹ fire has been addressed as a knower and rewarder of all deeds, as revealed by the following:

"O Fire ! knowing as thou do, all our deeds lead us by the good path for the enjoyment of the fruits of our deeds".

From the primitive man's use of stones for making fire and roasting meat various cooking devices have been invented, to utilise different types of fuels such as: firewood, saw-dust, charcoal, coal, coke, kerosene, gas and electricity. As Lekanathan (1959)² points out, firewood is still the largest single source of domestic heat in the Indian kitchens, both urban and rural.

The kitchen is the heart of the work place of the house maker, where she carries on the day long activities. In spite of all changes of modern life in India, the

primary function of woman is still to look after the home, as Gandhi (1940)³ envisaged.

Devadas (1962)⁴ explains that looking after the home does not mean the home makers being confined to the domestic chores inside the home such as cooking and cleaning, but fulfilling many duties as home maker, mother, farmer, wage earner, and community worker. According to Uppal (1960)⁵ woman is man's partner sharing his arduous life, working perhaps longer and harder hours than him. The home maker can be helped to give more time for several constructive activities in which she is being called to participate as a citizen, if ways are found to reduce the time spent by her on household work, chiefly cooking.

This brings out the need for better management of the resources in a family. Management as defined by Knowles (1946)⁶ and Mallory (1956)⁷ is getting the most from family life by wise and judicious use of the financial, human and material resources to achieve the goals set. Judicious use means deriving maximum advantage with minimum expenditure. In relation to meal management, best use of resources depends upon the skill, intelligence and the notion-mindedness of the home maker, as well as the type of equipment she uses for cooking. Of all the pieces of equipment in the kitchen, the 'chula' or 'stove' is most important.

The traditional type of 'chula' used for cooking in the Indian homes has many disadvantages such as waste of heat and fuel, smoke and irritation to the eyes. As Raju (1953)⁸ suggests the solution to these problems lies in the evolution of a cooking stove which is simple, inexpensive and capable of utilising heat efficiently. Various efforts are being made in this direction in our country through several agencies. Many types of smokeless 'chulas' have been developed in recent years. The Gram sevikas and Mukhya sevikas who are working as women extension workers in Community Development Blocks have been trained in the use of the smokeless 'chula' as one of their targets in home improvement. Ever since the Community Development Programme was started in 1952, these workers have been endeavouring to introduce the smokeless 'chulas' in rural homes. However their attempts, as pointed out by Caldwell et al (1959)⁹, have been isolated, without an integrated purpose of general improvement of the household premises.

Ramas (1958)¹⁰ points out that most of the smokeless 'chulas' need further improvement in the direction of reduction of fuel consumption, maximum heat utilisation and proper outlet for smoke. As an extension worker, the investigator had many opportunities to visit rural areas. Her observations in the village homes had stimulated

her to study the factors favourable for the construction and use of smokeless 'chula' and to develop a smokeless 'chula' the operation of which will be easy and simple for an average home maker in any part of India.

Therefore this study was undertaken to evaluate the constructional features of the existing smokeless 'chulas' and to develop the "Improved Chula" based on an understanding of the shortcomings of the existing 'chulas' and the present day needs of the home makers. It is hoped that this study will help to eliminate the nuisance of smoke in the Indian kitchens and enhance the managerial ability of home makers.

II. REVIEW OF LITERATURE

Rao (1962)¹¹ observes that the 'chula' or stove is the part and parcel of the home and the main device occupying important role in the kitchen activities. It has been used since the beginning of civilisation, undergoing as much evolution as mankind itself (Walley 1960)¹².

The working of a 'chula' includes the sources of energy namely fuels, their combustion and utilisation, in stoves, use in food preparation and principles of management. The promotion of the Improved 'chula' is dependent on the agencies and extension services available. These aspects are reviewed in the following pages.

A. Sources of Energy Used for Cooking

According to Trivedi and Shah (1961)¹³ the sources of the heat are sun, interior of earth crust, mechanical, chemical, electrical and energy released during change of state. Energy is obtained from fuels which may be classified as domestic and commercial, primary and secondary or solid, liquid and gas.

According to Lokanathan (1959)² cowdung, firewood, charcoal and kerosene are the domestic fuels and, softcoke, gas

and electricity are the commercial fuels used in India. The consumption of cattle dung is higher in rural area and 35 million tons of coal equivalent of dung are burnt every year in the Indian villages, corresponding to 300 million tons of wet cowdung which could be converted profitably into manure. Hence cowdung should not be used as fuel according to Rao (1962)¹¹.

As pointed out by Sharma (1959)¹⁴ 16 crores cubic feet of firewood is produced in our country annually, and hardwood trees such as 'babul' (Acacia arabica), 'tamarind' (Tamarindus indica), 'irul' (Xylia xylocarpa), 'sal' (Shorea robusta) and 'neem' (Azadirachta indica) which give lasting and uniform heat, are preferred for household purposes. Stan (1961)¹⁵ cautions that in arid regions, the common use of desert shrubs for household cooking, deprives the land of fodder on which animals might be maintained. As a supplement stalks of cotton, redgram, sorghum and sugarcane br. gasse are widely used. A report of National Council of Applied Economic Research (1960)¹⁶ views that in order to supply firewood, planting of trees, rehabilitation of village tamarind and mango groves which were depleted seriously during the last war are undertaken. Caprihan (1960)¹⁷ remarks that firewood used in rural homes give dense smoke and hence recommends the provision of smokeless 'chula' for healthy and comfortable living. Charcoal is obtained when wood is destructively

distilled or by incomplete burning of wood. It is black and burns readily leaving little ash and emitting no smoke, according to Partington (1957)¹⁸.

Kerosene is a mineral oil prepared for illuminating purposes. It is distilled from petroleum or any crude mineral oil with flash point high enough (150°F) to make its use safe for domestic employment ()¹⁹. Kerosene is widely preferred in urban areas being quick and clean to operate. The proportion of kerosene to other fuels used for cooking varies from place to place but in rural areas it is used only for lighting, Lekanathan (1959)². In order to stop the usage of cowdung as fuel, substitutes ~~are~~ need to be promoted. One such attempt has come from the Regional Research Laboratories ()²⁰ at Hyderabad in their smokeless fuel 'kelsit' which is efficient in being smokeless, soot free and economical with the burning period long, burning easily controllable and yielding higher proportion of radiant heat.

Kamalaveni (1962)²¹ stresses the superiority of cattle dung gas in saving time, money and energy as compared to firewood. Rao (1962)¹¹ points out that cattle dung gas plant has limitation as it can be used only when cattle dung is available in plenty.

Avery (1955)²² states that electricity is the cleanest and the most convenient source of heat, which

furnishes quickly and conveniently. Krishnamachari (1960)²³ indicates that it is not yet available in remote villages and is still very expensive as fuel.

Avery (1955)²² points out that the use of infra-red radiation in cooking was introduced recently, and appropriate equipment has been designed according to Beveridge et al (1956)²⁴. However it will take time to be used by a common household.

Solar energy is the radiant energy from the sun. Telkes (1958)²⁵ points out that solar energy can be concentrated by using reflectors or mirrors, and the heat is utilised in solar oven where food can be cooked. Varalakshmi (1963)²⁶ states that solar energy mobilised in an oven is effective to maintain constant temperature and does not require much attention during cooking.

Schurr (1963)²⁷ opines that the time has come for the nuclear power to satisfy the world demand for energy, and the nuclear fuels contain an enormous concentration of energy per unit of weight but at present not within the reach of the common man.

B. Cooking Stoves.

A cooking stove is a closed chamber in which heat is produced by wood, coal, coke, kerosene or gas. The history of the cooking stoves specially those using fire wood, in the various parts of the world makes an interesting study.

1. Stoves Around the World:

A great similarity is seen in the structure of stoves using fire wood all over the world, although they differ in some ways according to Singer (1961)²⁸. A few are described below from the literature available.

Egypt: Valley (1960)¹² states that in ancient Egypt, the stove consisted of a horizontal stone laid flat on two or three vertical stones to form a cavity in which fire was lit and baking accomplished.

Italy: According to Ellacott (1957)²⁹ the Roman kitchen consisted of a huge brass cauldron kept on hearth fire to supply hot water, and a square hearth for cooking foods. The steam and smoke were carried away through the roof, wall vents and chimney.

The Caribbean Country: Haglund (1958)³⁰ reports that the 'Dover Stove' is used in the Caribbean country and is less common than open fire stoves. The open fire stove is

unsuitable due to its smoke and risks of inhaling carbon monoxide. Though kerosene and charcoal are available, the most common fuel used in rural areas is wood which is least expensive.

Japan: Yamamoto (1956)⁵¹ describes the 'Kamado' Japanese, traditional open cooking stove, made of clay. It consumes more firewood, for the collection of which much time and labour is spent. Therefore, it is inefficient. One of the achievements of the Japanese Home Improvement Programme is the introduction of the new Manchurian 'chula'. It has the radiant heat space, maintaining heat for a long time.

Indonesia: Singer (1961)²³ reports that in the old stoves made of fired clay with saw dust, rice husks and ashes, the heat cannot be utilized fully as it is an open stove. The new models have a good hearth, closed at the front by a flat stone and at the top by the cooking pots. The flue for the flame and fumes form a continuation of the hearth. According to Singer's study, new stoves as shown in Figure 1 are made of clay having two or three pot seats in which the smoke is directed towards the chimney. Chimney works as an outlet for smoke.

West and East Java: Singer's (1961)²³ description of the stoves used in West Java shows that they are constructed with cement and earth (Figure 2). Wood is used for fuel.

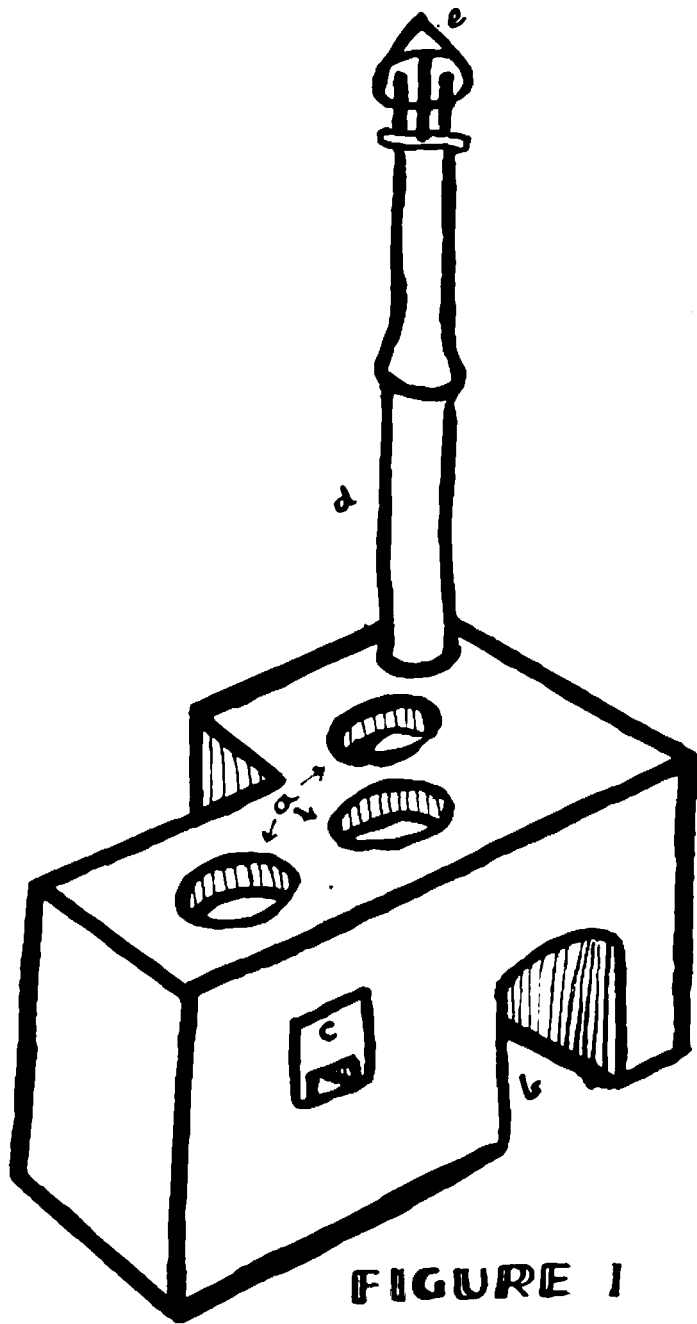


FIGURE 1

FAO/SINGER (SMOKELESS) STOVE

- a. COOKING POT SEATS.
- b. FUEL FEEDING MOUTH
- c. HOLE FOR AIR INTAKE
- d. CHIMNEY
- e. COW.

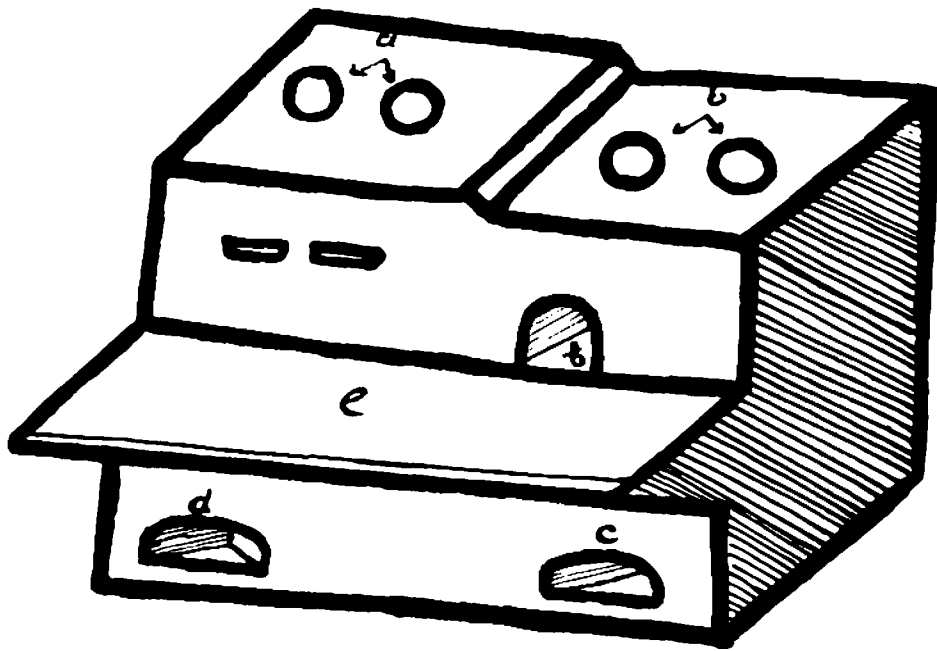


FIGURE 2
STOVE USED IN WEST JAVA

- a. POT SEATS WITH CHARCOAL
- b. COOKING WITH WOOD
- c. STORAGE FOR WOOD
- d. STORAGE FOR CHARCOAL
- e. WORKING TABLE
- f. FUEL FEEDING MOUTH

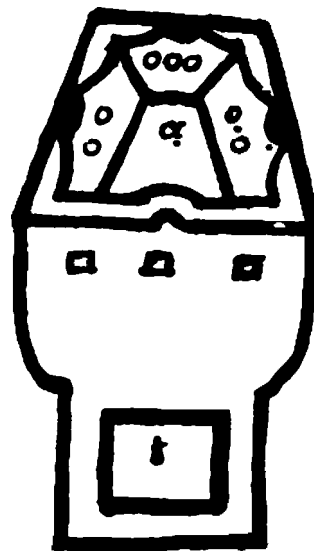
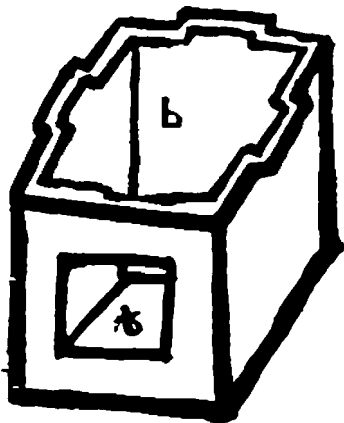


FIGURE 3

COOKING WITH WOOD

COOKING WITH CHARCOAL

STOVES USED IN EAST JAVA

They are difficult to keep clean due to smoke. The stoves used in East Java (Figure 3) are made of rock, and charcoal is used as fuel (Singer 1961)²⁸.

Bali: The stoves in Bali are made of cement. They consist of a working table with three or four pot seats. Stoves are quick to construct, easy to clean and give good ventilation. Coconut wood is used for working table, the surface of which is plastered with mud (Figure 4). Coconut tree and dried branches are used as fuel.

Sumatra: Stoves in Sumatra, shown in Figure 5 are made of earth and lime mixed with sugar. They are mobile and economical, with good ventilation. Wood is burnt as fuel.

Philippines: Jurade (1955)³² reports that the native stove is an open fire type, without any safeguard from flames and highly inflammable materials of 'Nipa' and 'Bamboo'. Clay stoves, charcoal stoves are common. 'Mayon' type of smokeless stove made of clay or cement and used with chimney is an improved firewood stove according to Fabiere (1955)³³.

Korea: The Korean stove has a radiant heat space of 12 square yards. It maintains the heat throughout night when used to prepare three meals a day, says Yamamoto (1956)³¹.

2. 'Chulas' in India:

The 'chula' is defined as a cooking fireplace or stove by Raju (1953)⁸.

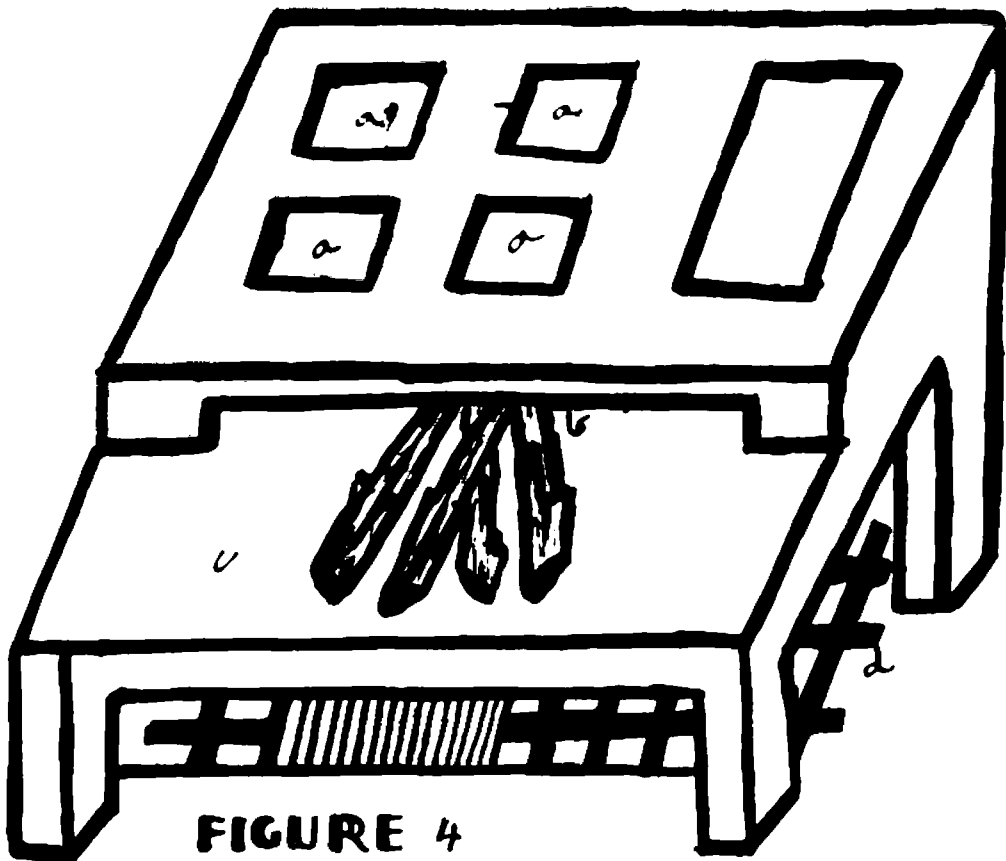


FIGURE 4
STOVE USED IN BALI

- a. COOKING WITH WOOD
- b. FUEL FEEDING MOUTH
- c. WORKING TABLE
- d. STORAGE OF WOOD

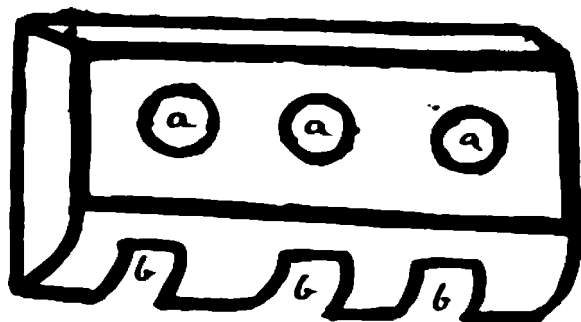


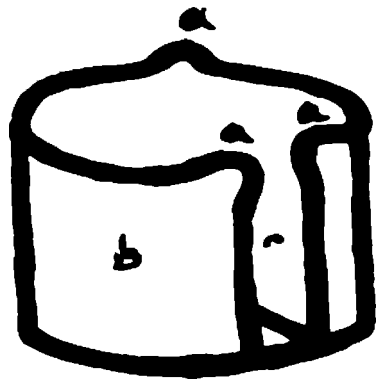
FIGURE 5
STOVE USED IN SUMATRA

a) The Ordinary 'chula':

Rao (1962)¹¹ describes the ordinary 'chula' (Figure 6) as a horse shoe shaped structure made of mud to protect the flames against draught. Guruswamy (1955)³⁴ mentions that it is semi-cylindrical wall with three projections to support pots. Sometimes it is extended on the sides to provide second pot seats, making it efficient in the utilisation of heat. Raju (1953)⁸ states that the open smoky 'chula' call for frequent blowing, causing fatigue to the person in addition to the nuisance of smoke and soot. In India several types of smokeless 'chulas' are in use to avoid such defects.

b) The Smokeless 'Chulas':

Kumarappa (1943)³⁵ reports that in a smokeless 'chula' the flame is directed through a controlled passage, rendering the kitchen smoke free and waste of heat. Raju (1953)⁸ states that smokeless 'chula' is a device evolved to keep the kitchen free from smoke to afford hygienic environment and to save fuel. Devadas (1961)³⁶ has pointed out that with the introduction of new type of smokeless 'chula' the farm housewife has been able to economise the fuel and maintain clean and healthy kitchens. Raju (1953)⁸ designed a smokeless 'chula' in the Hyderabad Engineering Research Laboratories in 1946, to evolve simple scientific devices to improve daily



- a. PROJECTIONS
- b. MUD WALL
- c. FUEL FEEDING MOUTH

FIGURE 6
ORDINARY CHULA

- a. COOKING WITH WOOD
- b. PROVISION FOR HOT WATER
- c. FUEL FEEDING MOUTH
- d. CHIMNEY

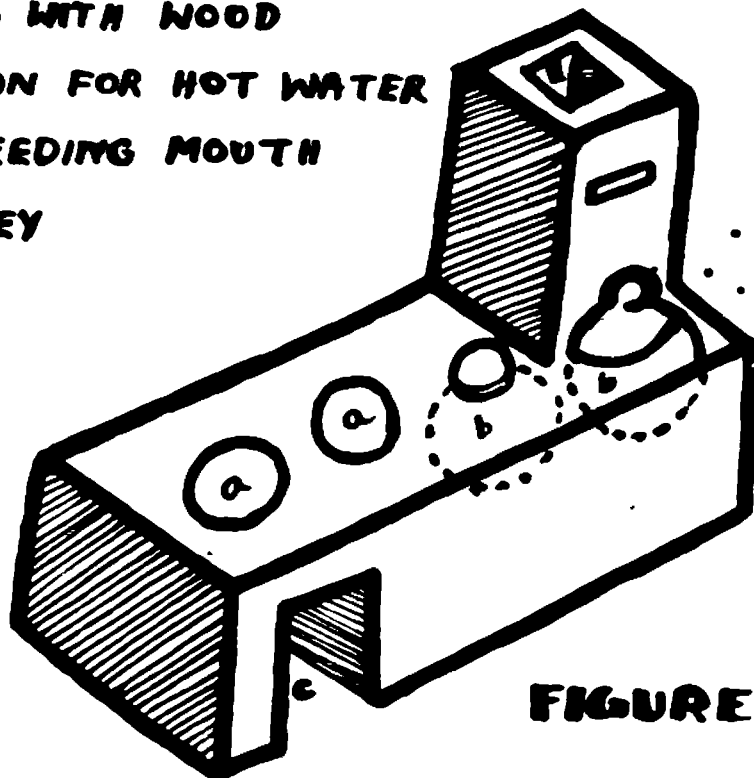


FIGURE 7

SUDHARA HUR SASTA CHULA

domestic life of a planned village home. Ali (1958)³⁷ consider that the design of the Raju 'chula' exhibits a rare combination of efficiency, simplicity and low cost. Nagori ()³⁸ noted that according to the experiments in the Sarwadaya Ashram the Raju 'chula' was completely smokeless. Efforts were made in developing a smokeless 'chula' in Naganwadi, Pottery Department, Wardha in 1947 as reported by Kumarappa (1948)³⁵. Experiments were conducted in 1955 in the light of previous findings to improve the smokeless 'chula' further at pottery section of Gandhi Niketan Ashram, T.Kallupatti. The primary object was to regulate the transmission of smoke from the stove which resulted in the propagation of more improved and portable type of smokeless 'chula' (Guruswamy 1955)³⁴.

Jhalvan (1948)³⁹ describes a smokeless 'chula' design in the Engineering Department, Agriculture Institute, Allahabad with four pot seats, the first two for cooking purposes and the last two for hot water (Figure 7). The water pots are inside the flue pipe upto the neck so as to allow the full utilization of the hot gases escaping through it. Dampers are used to regulate the flame.

The Samadhan 'chula' was developed in Kelhapur in 1956 under Community Development Programme to satisfy the demands of Maharashtra methods of cooking. Here (1956)⁴⁰ recommends that the smokeless 'chula' ^{is economical} as it minimises fuel consumption by 25 per cent.

Ramdas (1958)¹⁰ reports that the development of the MKI 'chula' as the result of the experiments carried out in Bakshi-ka-Talab Training Centre (U.P) with different types of smokeless 'chulas'. The comparative efficiency of 'chulas' under similar laboratory conditions were determined. Two workable designs found best were picked up for final experimentation at Planning Research and Action Institute, and MKI was proved to be the best for general adaption in Uttar Pradesh. Comparing the efficiency of Magan 'chula' with ordinary 'chula', with regard to amount of time taken for cooking, cleaning the utensils and quality of the cooked foods, the Magan 'chula' proved to be superior in Menalatha's (1962)⁴¹'s study.

Thus the ideal smokeless 'chula' viewed by Rao (1962)¹¹ should be simple and suitable for cooking methods with provision to heat water, to bake, and to warm food by best utilization of heat. It should have smoke directed out through chimney, the flames not escaping outside the pot seat, and the soot deposition only at the bottom. It should not need blowing and should retain heat to warm logs of firewood, if necessary, and adaptable for locally available fuel and material.

C Different Designations Given to Parts of a Smokeless Chula

The main parts of the smokeless 'chula' are a closed hearth, flue and a chimney.

The Hearth is the area to hold the burning end of the wood and the embers, giving the flame enough room to grow and is also called the fire place by Rao (1962)¹¹. This has an opening called hearth door or stoke hole by Singer (1961)²³ or fuel feeding mouth. A shutter for the fuel feeding mouth serves as a controller to allow free air inside. A circular plate of iron bars placed at the first pot seat in the fire place is called a grate and functions to support firewood and permits ash to fall down. Guruswamy (1955)³⁴ states that the grate separates the ash tray from the fire place. Raju (1953)⁸ describes the a grate as helping the wood to stand in inclined position making it convenient for the removal of ash and aiding in ventilation. Ash outlet or ash pit is constructed at the base of hearth to facilitate the removal of ash when necessary. At the top of the hearth is the place to put utensils called cooking holes by Singer (1961)²³, pot seats by Rao (1962)¹¹ and holes by Raju (1953)⁸.

The Flue is the passage providing the heat between the pot seats. It must be designed to concentrate the flames and the fumes at the pot seats before they are carried out of the stove. Accessories for the flue are

the damper, a square metal sheet of iron or galvanized sheet used to regulate the draught into the flue according to Ramdas (1958)¹⁰, and the baffle wall is vertically placed in the flue at the centre of second pot seat for the better distribution of heat, and serves as a hurdle for gases to be lifted and transmit more heat towards the pot according to Raju (1953)⁸ and Ramdas (1958)¹⁰.

The Chimney is the chief feature of smokeless 'chula' to direct smoke out of the kitchen. Kumarappa (1948)³⁵ pointed out that chimney should go piercing the roof of the kitchen, erect and one foot above the roof. Raju (1953)⁸ suggested a cover at the top, called cowl, for protecting against rain. Matthew (1949)⁴² and Warland (1951)⁴³ and Margana et al (1953)⁴⁴ explained the chimney as 'when the fire is lit, air in chimney gets warmed, expands, becomes lighter and rises up the chimney, which in turn draws in more air from the room'. Thus the movement of air is due to the difference in weight of the flue. The draught is better drawn when the chimney is tall within limits. Ali (1955)³⁷ recommends the minimum height for chimney as 3.6 metres whereas Singer (1961)²⁸ proposes 4 metres with cowl on.

According to Cauley (1955)⁴⁵ and Vartak (1960)⁴⁸, draught supplies oxygen and keeps fuel burning, and smoke is expelled. Fault in the chimney ()⁴⁷ draught may result in sluggish fire, poor performance of the appliance, and escape of smoke and flames into the rooms. The main causes for such defects are due to the too high fire place opening or it being too large or irregular in shape.

d Combustion and Transfer of Heat:

A knowledge of the principle of combustion helps to understand the working of the smokeless 'chula'.

Combustion as defined by Morse (1947)⁴⁸ is the rapid chemical union of fuel with oxygen, accompanied by the release of substantial quantities of heat energy and an ignition temperature is necessary to initiate combustion. Cauley (1955)⁴⁵ pointed out that a continuous supply of air is necessary for combustion. The temperature at which the production of heat is accompanied by the production of light is known as the kindling temperature. Cauley (1955)⁴⁵ and Bogert (1958)⁴⁹ report that other by-products of combustion are smoke consisting of steam, carbon dioxide, soot and ashes, being the incumbustible material. Francis and Morse (1959)⁵⁰ mention that fire may be extinguished either by withdrawal of the contact between oxygen and the fuel or by lowering the temperature of the burning material below the kindling temperature of the reacting particles.

Heat, thus produced by combustion is transferred from one part of space or body to another, by three methods

namely, convection, conduction and radiation. Osborn(1929)⁵¹ defines convection as the transfer of heat by the actual movement of the heated body, a property shown by liquids when heated. Whitman (1951)⁵² explains conduction as that heat flowing from a body at a high temperature to one at a low temperature, when these two come in contact. Radiation is the process by which heat energy is transmitted through vacuum, Black and Little (1956)⁵³.

C. Application of Heat in Food Preparation:

Cooking involves application of heat in two ways, namely, wet method of treatment such as boiling and steaming and dry methods of treatment such as frying, roasting and baking, Aykroyd et al (1963)⁵⁴. The results of the Diet Surveys carried out in India by Indian Council of Medical Research (1951)⁵⁵ indicate that cereals and millets are usually boiled to the consistency of cooked rice, or to a thick fluid resembling well cooked 'porridge' in the form of gruel. Millets are cooked also as coarse chapatties (unleavened bread or 'Roti') or boiled along with pulses, the flour paste is made into balls and steamed. Pulses are boiled or roasted and made into paste. Aykroyd et al (1963)⁵⁴ reports that vegetables may be cooked using minimum amount of water, the cooking water used in either soups or gravies. The vegetable may be cut, added immediately to the water which has already been brought to boil and cooked within a short time as possible.

Child (1914)⁵⁶ remarked that cooking might be made easy through use of proper kitchen equipment. Pond (1945)⁵⁷ stressed that preparation and serving of meals, arrangement of the equipment and supplies in the kitchen should be organized. Efficiency ()⁵⁸ defined as the ratio of work produced to the energy expended, can be measured in terms of speed, accuracy or quality, effect and satisfaction. According to Nash (1957)⁵⁹ it may be attained in the kitchen by reducing waste, labour and fuel. Fuel waste is often due to unsuitable equipment. Menon (1962)⁶⁰ points out that work done with improper equipment gives rise to frustration and unhappiness. On the other hand, work well done is satisfactory and rewarding which helps in better management.

D. Agencies in Promoting the Use of 'Chula':

Devasias (1958)⁶¹ views that Home Science extension carries knowledge from colleges, institutions and laboratories to rural homes in a form easily assimilable and applicable by families. She further states that community gives direction for educational and scientific research through its needs and demands. The two way process is being carried on by Gram sevikas, a village level worker, who are required to construct a smokeless 'chula' depending upon the size and type of the family, the type of staple food and fuel used.

Hehemiah (1958)⁶² opines that Gram sevikas have to

stimulate the desire and drive for creating better and healthier homes in rural families. Rao (1962)⁶¹ considers that the efforts should be made by Government and Social Service Agencies to see that the improved 'chulas' find wide acceptance. Residences built at Government cost or aid should have an improved 'chula' incorporated in a functionally designed kitchen, as Sehgal ()⁶³ stresses the construction of the smokeless 'chula' in every house. Families should be given financial or technical assistance to install improved 'chulas' in their homes. The women in the villages should be encouraged to take interest in adopting better living techniques suited to their traditions and customs and discarding bad customs to help women to move forward towards advanced womanhood according to Lam (1962)⁶⁴. Gram Mahila Mandals (1962)⁶⁵ may try through demonstrations and by conducting classes in the betterment of home management.

III. SELECTION OF THE REFERENCE 'CHULA'.

In order to select the Reference 'chula'^{*} the following steps were undertaken.

- A. Evaluation of the smokeless 'chula' by homemakers.
- B. Appraising the information available in published literature.
- C. Construction of the three 'chulas'.
- D. Comparison of the three 'chulas' constructed.

A. Evaluation of the Smokeless 'Chula' by Homemakers.

In order to elicit the opinion of homemakers about 'chula', ten families in 'Rahatgoan' (Anaracti District), and 15 families in 'Kalappanaickenpalayam' (Coimbatore District) who had smokeless 'chulas' in their

* The designation Reference 'chula' is purposely given to the 'chula' selected to serve as reference in this study for the construction and comparison of the Improved 'chula' developed by the investigator.

homes were interviewed with the help of an interview schedule developed for the purpose given in Appendix I. The interview schedule called for information on the type of smokeless 'chulas' used, materials used for their construction and evaluation of the causes for using or not using the smokeless 'chulas', and the types of fuels used.

Eight out of the ten homemakers in Rahatgoan, and 12 out of 15 homemakers in Kalappanaickenpalayam village were regularly using the smokeless 'chulas', while the remaining few used it occasionally. The homemakers were not aware of the type or name of the smokeless 'chula' used by them and just called any smokeless 'chula' as 'Magan chula'.

The material commonly used for constructing the smokeless 'chula' was a mixture of mud, hay and cowdung, and found to be satisfactory. The evaluation of the smokeless 'chulas' in terms of the advantages as pointed out by the homemakers is summarised in Table I.

TABLE I

EVALUATION OF THE SMOKELESS 'CHULAS' BY THE HOME MAKER.

Points	Number of Homemakers mentioning		Total
	Rahatgaon	Kalappanaicken palayam	
1. Two items can be cooked at a time	8	10	18
2. Saves time	7	12	19
3. Absence of smoke	8	10	18
4. Clothes and hands are clean	5	8	13
5. Freedom from soot	5	8	13
6. Consumes less firewood	3	3	6

As can be seen from Table I, the homemakers using the smokeless 'chula' were aware of their saving of time, and enjoying freedom from soot and smoke.

The evaluation of the smokeless 'chulah' in form of disadvantage as pointed out by the five homemakers who were using the smokeless 'chula' occasionally was as follows.

The smokeless 'chula' :

Has more than one pot seat and we do not need more than one pot seat.

Is difficult to construct and operate.

Cannot be used to bake 'Chappati'.

Cannot be used with rubbish as fuel.

Consumes more firewood.

It is not absolutely smoke free.

The fuels used for the smokeless 'chula' were fire wood by 13 families, agricultural waste such as dried branches, twigs, dried leaves, and cane-sugar baggasses by three families and both according to the availability by four families.

The above evaluation of the smokeless 'chula' by the homemakers was helpful in testing the utility of the smokeless 'chula' in the study.

**B. Appraisal of the Information Available Through
Literature.**

The references available in the literature on the constructional details of the smokeless 'chulas'^{*} were studied. The summary of the information collected is given in Table II.

* Hence forth the term 'chula' is used to designate smokeless 'chulas'.

Out of the smokeless 'chulas' mentioned in Table II three smokeless 'chulas' namely 'Samadhan', 'BKT' and 'Raju' were selected for construction and further study in order to select one among them as the Reference 'chula'. These three 'chulas' were chosen because their inventors and users have stressed several advantages with regard to their performances.

C. Construction of the Selected Smokeless 'Chulas'.

In the construction of the three selected 'chulas' some features were found to be common to all the three in the literature reviewed; while others were different. The common features were mixture of red clay, cowdung and hay used in the proportion 10:2:1 respectively. The clay, cowdung and hay were mixed with just enough water and to obtain a mouldable paste and kept for three days in the shade to ferment. With the wet mixture a platform was constructed to the dimensions specified and allowed to set for a day. The platform was marked with the dimension of the pot-seats with chalk.

With a suitable iron cutter, the clay was scooped from the mark up to the pot-seats.

The pot-seats were then connected with each other cutting out passages or flue large enough for the flames to cross.

The baffle wall was also cut out where the design called for it. Each 'chula' constructed was allowed to dry for 30 days.

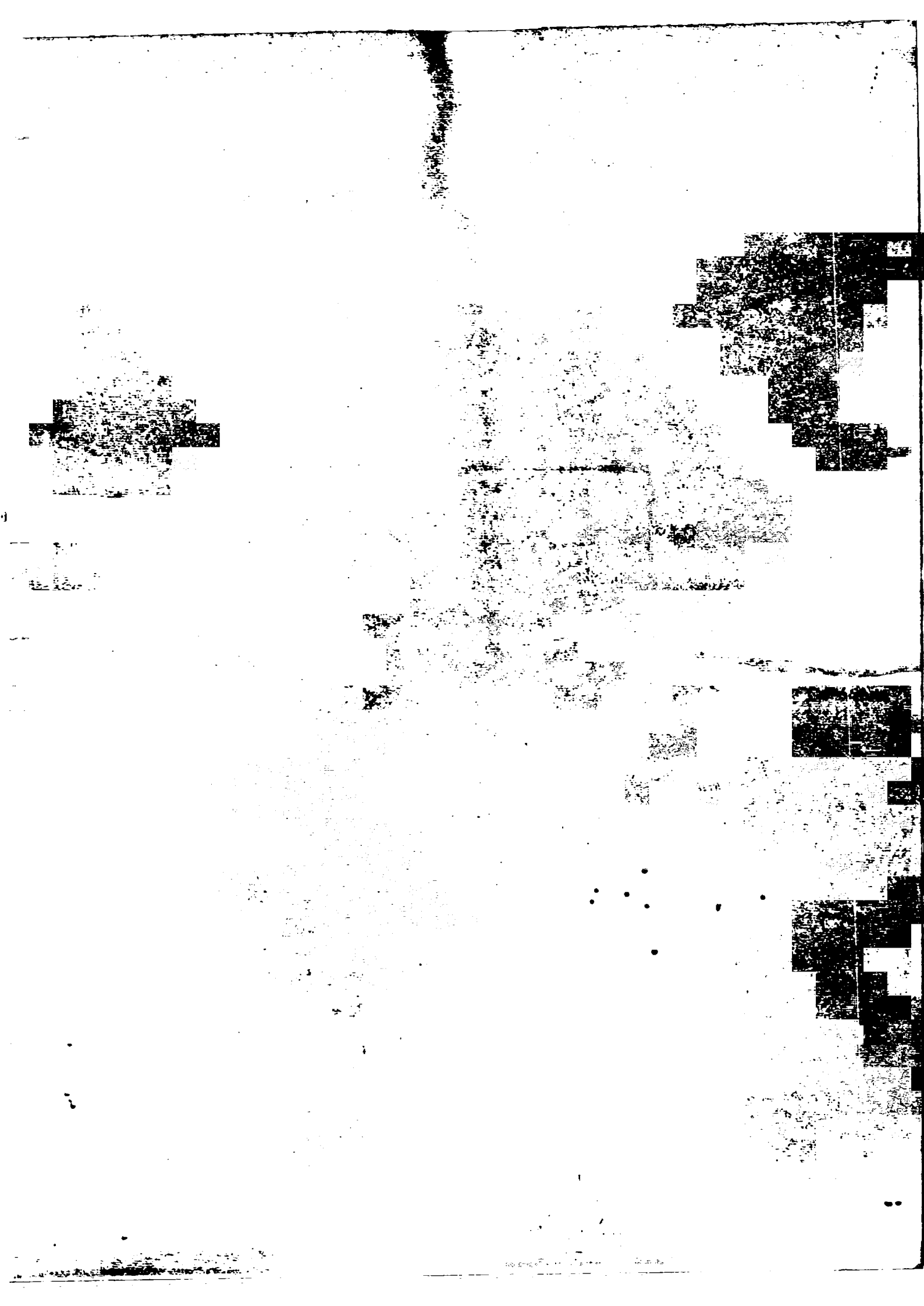
The Distinguishing Features:

1. The KMT 'chula'

The details of the construction of the 'chula' are given in figure 8, a-b. The first pot-seat and the second pot-seat were carved out. Fuel feeding mouth (c) was scooped out. The flue (d) which is the passage connecting the two pot-seats was carved. The chimney (e) was made of galvanized iron and the chimney base (f) was carved sloping towards the fuel feeding mouth. The cowl (g) was placed on the top to protect the chimney. The dampers were provided, one plain square (h) between first and second pot seat to act as a control, for transfer of heat between them and to avoid free escape of smoke. The second perforated damper (h₁) was placed between the second pot seat and chimney base, to retain hot gases for a longer time in the flue. The baffle wall (i) was erected at the second pot seat so that the flames would strike the pot and the smoke would find its way to the chimney.

2. The 'Samadhan' 'Chula':

The construction of the Samadhan 'chula' in the steps outlined for 'KMT' is illustrated in Figure 9. The



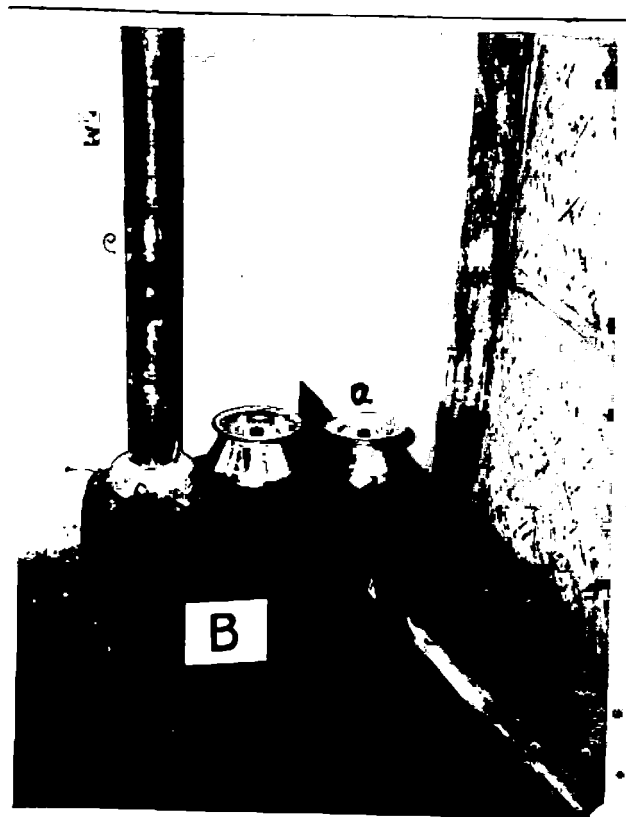
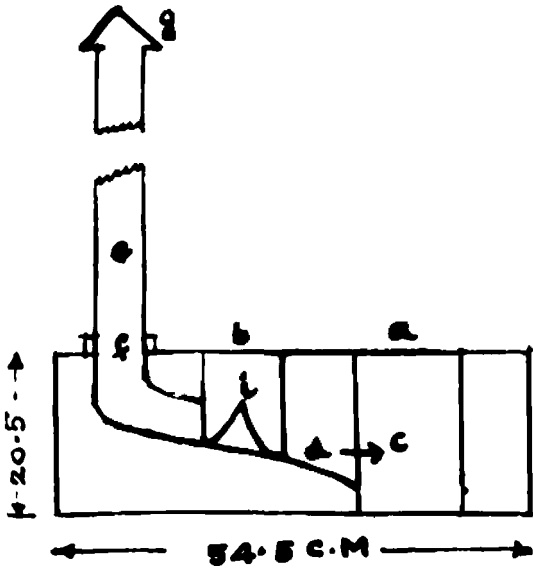
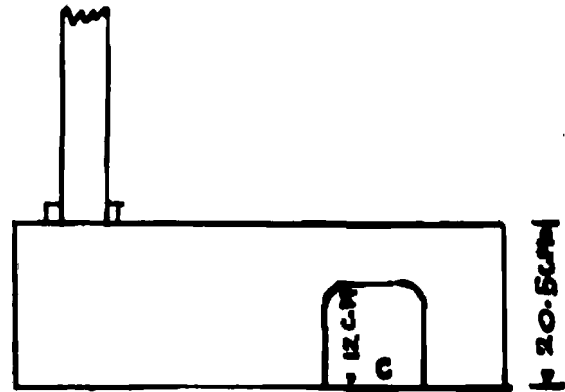


FIGURE-8 ,
B.K.T. CHULA

DETAILS OF REFERENCE CHULA
SCALE 1 C.M. = 8 C.M.S



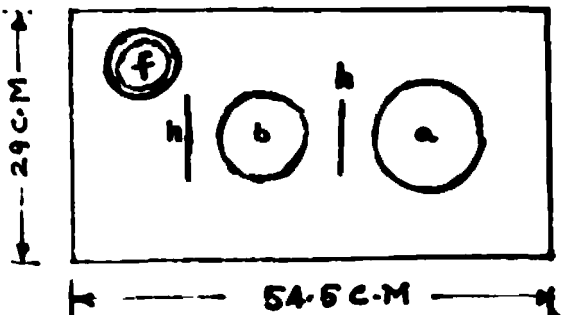
SECTION



ELEVATION

INDEX

7.6 10.72 8 13 C.M 10



PLAN

- a. FIRST POT SEAT
- b. SECOND POT SEAT
- c. FUEL FEEDING MOUTH
- d. FLUE
- e. CHIMNEY
- f. CHIMNEY BASE
- g. COWL
- h. DAMPERS
- l. BAFFLE WALL

FIGURE 8 b





FIGURE-9
SAMADHAN CHULA

FIGURE-10
RATU CHULA



variations were that it had three pot seats, height was more and the placement of the pot seats was not in a straight line. The plain dampers were used.

3. The Raju 'Chula'

The 'Raju Chula' is shown in figure 10. The construction of Raju 'Chula' is in the same line as that of BKI 'Chula' except for the following differences; the height is less, third pot seat is larger specially provided to utilize the heat from escaping gases to heat water. The bottom of the 'Chula' is slightly raised from working place to facilitate the placing of firewood in an inclined position to permit the air circulation.

On these lines three 'chulas' were constructed in a room against a wall in a line, facing in the same direction to minimise variations due to air currents, temperature and humidity.

The diameter of the first pot seat was kept identical in all the 'chulas' that is 13 cms. so as to have this factor constant. The dimensions for the respective features were proportionately computed.

The constructional details of three 'chulas' are given in Table III.

TABLE III
THE CONSTRUCTIONAL FEATURES OF THE THREE CHULAS

	Samadhan	BKT	Raju
1. Inside capacity (mls)	3500	7000	6800
2. Length (cm.)	76.0	54.5	65.25
3. Height (cm.)	23.0	20.5	15.25
4. Breadth (cm.)	53.5	29.0	48.00
5. Diameter of first pot-seat (cm.)	13.0	13.0	13.0
6. Diameter of second pot-seat (cm.)	10.16	10.72	12.7
7. Diameter of third pot-seat (cm.)	9.5	Nil	22.0
8. Distance between the first and second pot-seat (cm.)	10.16	7.6	7.6
9. Diameter of chimney base (cm.)	10.00	10.00	10.00
10. Height of chimney (cm.)	230.0	230.0	230.0
11. Number of dampers	2 plain	1 plain 1 perforated	1
12. Number of baffle walls	2 at second and third. pot. seat	1 at Second pot seat	-
13. Number of grates	1	Nil	11
14. Provision for hot-water	Nil	Nil	Present.

The inner capacities of the 'chulas' given in Table III were measured by filling the entire fire place and flue with puffed rice up to the brim noting the volume of puffed rice in millilitres.

D) Comparison of three Selected 'chulas'.

The comparison of the performances of the three 'chulas' involved.

1. Selection of the material and equipment,
2. Standardisation of the procedure.

1. Selection of the material and equipment.

In order to maintain the caloric value released in these experiments, firwood was obtained from a single 'neem' tree in the campus. The 'neem' tree was chosen as Sharma (1959)¹⁴ has reported that it is commonly used for fuel. The logs were cut into pieces of 18" x 3" approximately, dried in the sun for two months and stored in a dry place. The remaining firewood chips were collected and stored to be used for starting the fire.

The equipment used in the study consisted of three sets of aluminium pots, each set having three pots identical in size, shape, and weight. Details of their dimensions and weights are given in Appendix II.

The pots used in a set were so selected as to be adequate to cook one meal that supplied for a family. (three to five persons) 500 to 600 gm. of cereals and 220 gm. of pulses in accordance with the allowances recommended by Aykroyd (1963)⁵⁴. Each pot was provided with a lid, with provision for inserting the thermometer.

The other equipment used in this study consisted of, a pair of scales with two firewood and residual charcoal.

A set of standard measuring cups, graduated in millilitres for measuring water, and a measuring cylinder of 50 ml. capacity for measuring kerosene.

A time-piece and a stop-watch recording the timings, and four thermometers with the range 0° C to 150° to register the temperature of water were procured.

Soft red soil and ash were sifted, mixed in equal quantities and used for cleaning utensils. Five grams lot of coconut fibre were made into bundles for scrubbing purposes.

Soft water (Siravani) was used throughout the study as it can be measured correctly, constant in its quality, and temperature can be determined easily. Appendix III.

2. Standardisation of procedure:

The experiments were always started with the 'chulas' at room temperature at the same time in the morning. The initial temperature was observed and noted.

a) Heating of water: The water was heated in the clean and dry pots. The pot on the first pot seat was filled with 1500 ml. of water, on the second pot seat with 1650 ml. litre and on third pot seat with 3500 ml. of water.

b) Measurement of Firewood: Before starting the experiment six pieces of firewood weighing around 900 grams each, were weighed and used for cooking. At the end of the experiment, the pieces of firewood remaining were withdrawn.

the burning ends dislodged and extinguished by using sand. The remaining stumps were weighed. The difference between the initial and final weight gave the weight of firewood consumed. The live pieces of cinders were collected from the inside of the smokeless 'chula' by means of tongs leaving the ash inside, put into a metal container, and covered loosely to put out the fire, and weighed after 25 minutes, as cinders could be further used as household fuel. The firewood equivalent of the cinders was estimated by using the 'Conversion table' used by National Council of Applied Economic Research (1959)².

G. Lighting the 'chulas': For standardisation of the lighting of 'chula' three logs of firewood and 50 gms. of chips were placed in the fuel feeding mouth and 12 millilitre of kerosene was poured on them. The chips were, lit with a match stick, and 90 seconds after lighting the fire, the utensils were kept on the pot-seats.

In order to maintain a steady flame throughout the experiment periodical pushing and rearranging of firewood inwards was done.

H. Cleaning the Utensils: For washing one moistened coconut bundle dipped in 20 grams of the cleaning mixture was used to scrub each set of pots. The pots were scrubbed first inside, and then outside specially at the bottom. The scrubbing was continued until the utensil was free from spot and these rinsed with water. The utensils over each 'chula' were washed separately.

Before starting the experiments, all the necessary equipments and materials were kept ready near the smokeless 'chulas'.

a) Sequence: Sequence of activities involved were

- i) Allotment of the pots for pot-seats.
- ii) Filling the pots with specified volumes of water
- iii) Lighting of 'chulas'
- iv) Heating water
- v) Measurement of firewood
- vi) Cleaning the utensils.

i) First pot-seat was a capacity 1500 ml. and second pot seat 1650 suitable for cereals which are usually cooked in larger amounts in Indian families.

ii) Pots were filled with water.

iii) The Samadhan 'chula' was lighted first. Five minutes after the lighting of the BKT 'chula' the Raju chula was lighted and 90 seconds after lighting each 'chula' pots for the first, second and third pot seats were placed successfully, and the time noted after, all the three pots were kept in their places.

iv) The time taken for the water at the first pot seat to start boiling, and the temperature of water at the time in the other pot seats were noted for the three 'chulas'.

v) Immediately after waves the firewood and the live cinders were taken out and extinguished as per the standardised procedure, and their weights noted.

vi) The utensils were cleaned according to the standardised procedure.

Time taken for the water to come to boil on the first pot-seat of the three 'chulas' is summarised in Table IV.

TABLE IV

TIME TAKEN FOR WATER TO START BULLING AT FIRST POT SEAT
OF THE THREE CHULAS

Replicates.	Time taken in minutes			Analysis of mean difference
	Sanadhan (S)	BKT (B)	Raju (R)	
1.	42	35	43	S.B. = 8.5 ^{**}
2.	41	33	41	R.S. = 0.5
3.	41	32	40	R.B. = 8.00 ^{**}
4.	40	30	38	
Mean	41.0	32.5	40.5	

D.01 = 4.01

D.05 = 2.76

From Table IV it is to be noted (41.0) that the average time taken to boil (41.0) water maximum in case of Saaadhan 'chula' and minimum in case of BKT (32.5 minutes.) The differences between the Saaadhan 'chula' and BKT 'chula', Raju 'chula' and BKT 'chula' were significant at one percent level whereas the difference between the saadhan 'chula' and Raju 'chula' was not significant as shown in Appendix IV.

TABLE V

FUEL CONSUMED IN BOILING WATER AT FIRST POT SEAT ON
SAMADHAN 'BKT' AND 'RAJU' CHULA

Replicates	Weight in (grams)			Analysis of Mean Difference
	Samadhan	BKT	Raju	
1.	925	800	1050	R-B = 0.17 ^{xx}
2.	875	820	1000	R-S = 0.08 ^{xx}
3.	880	790	957	S-B = 0.09 ^{xx}
4.	890	790	973	
Mean	892.5	800.00	987.5	

$$D_{0.01} = 0.005$$

$$D_{0.05} = 0.003$$

Table V indicates that the average fuel consumed was lowest in case of BKT 'chula' among the three and maximum in case of Raju 'chula'. The difference in fuel consumed was significant between the Raju and BKT, Raju and Samadhan and Samadhan and BKT at one per cent level as shown on Appendix V.

It is interesting to note that fuel consumption was not directly proportional to the time consumption in boiling. Saving of significant time and fuel may be attributed to the constructional features of BKT. Hence BKT was selected as "REFERENCE CHULA".

IV TESTING DIFFERENT VARIABLES WITH THE REFERENCE 'CHULA'

In order to determine the criteria for the development of an Improved 'chula' the Reference 'chula' was used to test the different variables such as:

1. Height of chimney,
2. Use of grate,
3. Use of baffle wall,
4. Size of the first pot seat,
- and 5. Height of the 'chula';

The experiments were conducted on the Reference 'chula' by boiling water at the first pot-seat, as the basis for comparison. Each experiment was repeated four times, varying one aspect at a time, keeping the other factors, constant.

All the processes, lighting, use of pot seat, quantity of water, in sequence were, as per the standardised procedure. The data recorded and the performance of the Reference 'chula' was assessed in terms of the time taken to boil water in the first pot-seat, fuel consumed and temperature of water reached in the second pot-seat.

Results and Discussion

1. Height of Chimney:

The heights of the chimney varied to be 230 cms. 320 cms. and 410 cms. respectively. As mentioned by Rao (1962)¹¹ and Raju (1953)⁸ there is no specific chimney height but chimney should go two feet ^{above} the roof. Singer (1961)²⁸ proposes the chimney height of 4 meters. In this study, effect of varying the heights is presented are shown in Table VI.

TABLE VI
EFFECT OF VARYING THE CHIMNEY HEIGHT ON THE PERFORMANCE
OF THE REFERENCE 'CHULA'

Variables in Chimney ht. (in cm.)	Time taken in minutes in First Pot seat	Fuel consumed in grams	Temperature reached in Second pot seat °C
230 (a)	31.75	820	74
320 (b)	26.25	735.5	77
410 (c)	27.5	760.5	78

Analysis of

Mean	..	DO.01	=	3.08	DO.01	=	.014
Difference		DO.05	=	2.14	DO.05	=	.012
		a-b	=	5.50**	a-b	=	.03**
		a-c	=	4.25**	a-c	=	.06**
		c-b	=	0.25	c-b	=	.03*

The results presented in Table VI indicate that at the chimney height of 320 cms. the time taken was the lowest

and highest at 230 cms. The difference in time taken to boil water in the first pot-seat was significant between the heights 230 cms. and 320 cms., 230 cms. and 410 cms. but not significant between 410 cms. and 320 cms. Regarding the fuel consumption the difference at height 320 cms. was the lowest among the three heights. The difference in fuel consumption at the heights 230 cms. and 320 cms., 230 cms. and 410 cms. and 410 cms. and 320 cms. were all significant at one percent level. Details of data are given in Appendix VI.

Thus the chimney height between 320 and 410 cms. may be considered as suitable.

2. Use of Grate.

Comparison was made on the Reference 'chula' with and without grate in the fire place under the first pot-seat. When the grate was used in the 'chula' blowing was needed only once for heating water as against four times in 'chula' without grate. The average time required to start fire was 90 seconds in the former as compared to the 210 seconds in the latter. Thus the use of the grate facilitated the lighting of the smokeless 'chula', probably because the grate permitted free movement of the air circulation, as against the restricted circulation in its absence.

3. Use of Baffle Wall.

The Reference 'chula' was tested with and without baffle wall at the second pot-seat keeping all the other features constant. The results obtained are given in Table VII.

TABLE VII
EFFECT OF BAFFLE WALL ON THE PERFORMANCE OF THE
REFERENCE 'CHULA'

Variables	Time taken in minutes in First pot-seat	Fuel-weight in grams.	Time taken in minutes in Second pot seat
With Baffle wall	31.75	820	34.75
Without baffle wall	31.75	820	40.5
F. Value	Mean difference is 0		227.1**

Table VII indicates that the time taken to boil water on the second pot-seat was 34.75 minutes with the baffle wall, and 40.5 minutes without the baffle wall. The difference in the time taken was statistically significant at one percent level (Appendix VII.) The data also shows that baffle wall does not in any way affect the fuel consumption and time taken to boil water at first pot-seat. The presence of the baffle wall appeared to direct the flame more advantageously towards the second pot-seat, as noted by Ramdas (1958)¹⁰. Thus in the same amount of fuel used, heat is better utilized in the second pot-seat with the baffle wall.

4. Size of the First Pot Seat.

Two variables for the diameter of the first pot-seat 15 cms. and 13 cms. were tried in the reference 'Chula'. The results obtained are presented in Table VIII.

TABLE VIII

EFFECT OF THE DIAMETER OF FIRST POT SEAT ON THE PERFORMANCE OF THE REFERENCE 'CHULA'

Variables in diameter	Time taken in Minutes	Fuel consumed in Grams	Temperature Reached in Second pot seat
15 cms.	22	551.25	63.25
13 cms.	29	827.5	75.00
F. Value	24.5**	170.3**	-

Table VIII indicates that the first pot-seat with 15 cm. diameter took significantly more time and consumed more fuel to boil water when compared to the 13 cm. diameter level. With regard to the temperature of water at second pot seat, it can be seen that at larger the diameter of the first pot seat, the lesser was the heat provided to the water on the second pot seat, and temperature 63.25°C. as against 75°C when the diameter of first pot seat being 13 cms. However this would have been due to the longer time the pot was kept on the pot seat while the water in first pot seat was brought to boil. However for household cooking 13 cms. diameter appeared suitable because of the size of pots needed for cooking. Larger diameters are bound to be of use for larger families. Details of data are in Appendix VIII.

5. Height of the 'Chula'.

The results obtained with regard to the variation in

the heights of 'chula' are given in Table IX.

TABLE IX

EFFECT OF THE HEIGHT OF CHULA ON THE PERFORMANCE OF
THE REFERENCE CHULA

Variables in Heights (in cms.)	Time Taken in minutes	Fuel consumed in grams	Temperature Reached in Second pot seat
16.5 (a)	39.5	821.25	71.25
20.5 (b)	31.75	780.75	72.5
24.5 (c)	46.5	838.75	73.6
Variation in mean	DO.01 = 3.28	DO.01 = 28.45	
of Difference	DO.05 = 2.28	DO.05 = 10.74	
	C-a = 7**	a-b = 40.50**	
	a-b = 14.75**	a-b = 53.00**	
	a-b = 7.75**	a-b = 17.50**	

Table IX indicates that the time taken and the fuel consumed is the lowest at the 'chula' height 20.5. The time taken to boil water is significantly less at the 20.5 cm. height than at 24.5 cm. and that at 16.5 cm. The difference in time taken is significant at the height of 'chula' 24.5 and 20.5 cm. With regard to fuel consumption the difference is highly significant at the heights 16.5 cm. and 20.5 cm; and 24.5 cm. and 20.5 cm. whereas between 24.5 and 16.5 cm. at 5 percent level. This may be attributed to the proper air circulation at the 'chula' height 20.5 cm. than at other two heights - Appendix IX.

From the results of these series of experiments on testing the variables with Reference 'chula', the optimum dimensions for an Improved 'chula' were

Height of chimney = 320 cm.

Diameter of the first
pot seat = 13 cms.

Height of the chula 20.5cms.

Baffle wall at the second pot seat and grate at the first pot seat are necessary.

V. DEVELOPING THE IMPROVED 'CHULA'

On the basis of the results obtained with the Reference 'chula' of the performances which were tested with several variables, the Improved 'chula' was designed to include the constructional features given in Table X.

TABLE X
PARTICULARS OF THE CONSTRUCTION IMPROVED AND REFERENCE
'CHULA'

S.No.	Constructional features.	Improved chula	Reference chula
1.	Length (cm.)	68.5	54.5
2.	Height (cm.)	20.5	20.5
3.	Breadth (cm.)	30.5	29.0
4.	Diameter of first pot seat (cm.)	13.0, 13.0	13.0
5.	Diameter of second pot-seat (cm)	13.0	10.72
6.	Diameter of Chimney base (cm.)	7.6	7.6
7.	Distance between first and second pot-seat (cm.)	10.0	7.6
8.	Distance between second pot-seat and chimney base (cm.)	7.6	7.6
9.	Height of chimney (cm.)	320	320
10.	Dampers	1 plain	1 plain 1 perforated
11.	Baffle wall	1	1
12.	Grate	1	-
13.	Shutter for fuel feeding mouth	1	-
14.	Ash outlet	1	-
15.	Hotwater device	Attached	-

From Table I it may be noted that the dimension of the Improved and the Reference 'chula' were identical in height of 'chula' dimension of the first pot-seat, diameter of chimney base, distance between second pot seat and chimney base, and chimney height as shown in Figure (11).

The special features of the Improved 'chula' are:-

Two level first pot seat (a) 13 cm. and 15 cm. specially constructed for backing 'chappatti' as it allows more surface of tava to be exposed to the flames and even the distribution of heat. Figure (12)

The second pot-seat (b) had the same diameter as for the first pot-seat

Ash outlet (i) (7.5 cm. x 7.5 cm.) opening was made in the side wall near the grate to make removal of ash convenient and to aid in ventilation

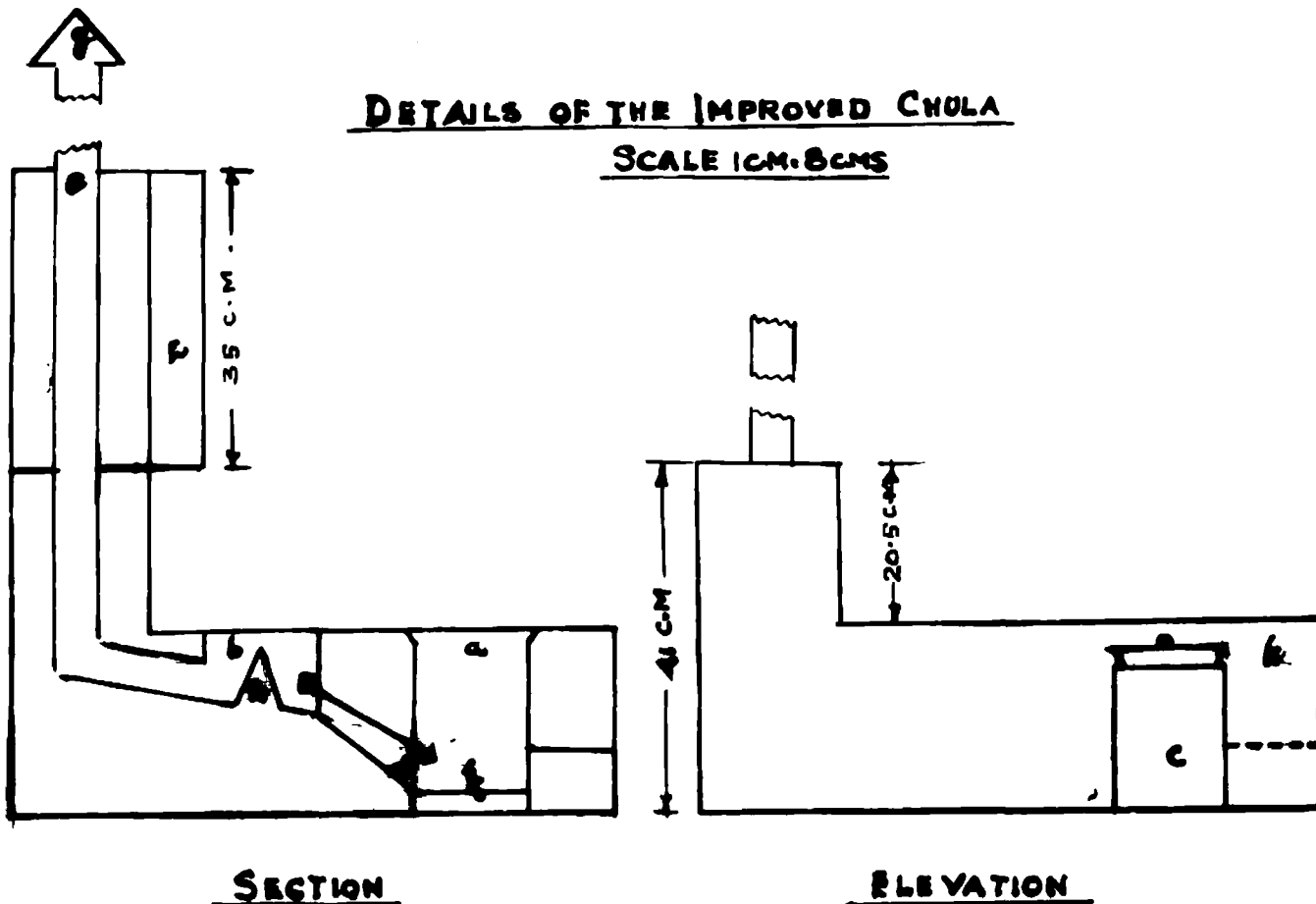
Shutter: A square metal sheet (k) was used to close the fuel feeding mouth which could be adjusted to the desired height, to regulate the supply of air and thus the speed of combustion as required, and to help the house maker to adjust cooking according to the convenience.

Grate: To keep the wood in an inclined position, to supply air from below and to have room for ash, grate (i) was fixed 4 cm. above the base.

Doors were avoided to minimise the required accessories of 'chula' to avoid complication in construction.

The provision for Hot water simultaneously during cooking was the very special feature of the Improved 'chula'. Taking into consideration the need for hot water in a home,

DETAILS OF THE IMPROVED CHOLA
SCALE 1CM:8CMS

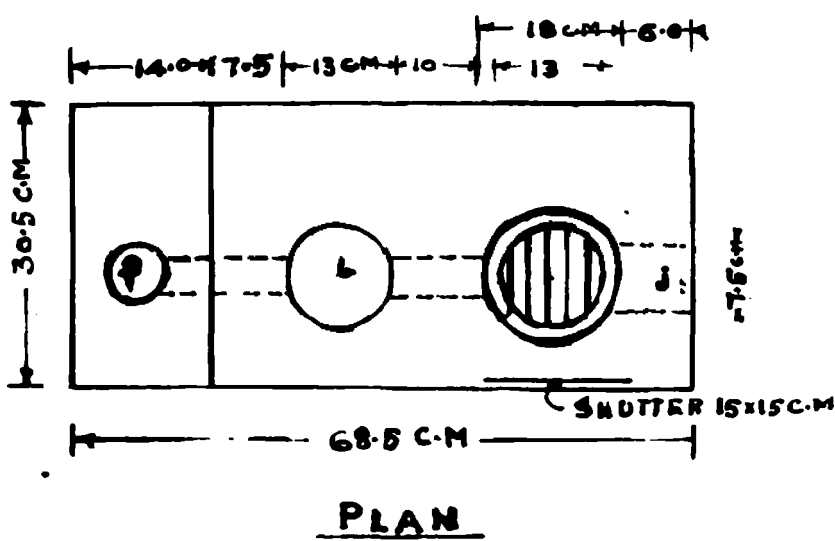


SECTION

ELEVATION

INDEX

- a. FIRST POT SEAT
- b. SECOND POT SEAT
- c. FUEL FEEDING MOUTH
- d. FLUE
- e. CHIMNEY . . .
- f. CHIMNEY BASE
- g. COWL
- h. BAFFLE WALL
- i. GRATE
- j. ASH OUTLET
- k. SHUTTER
- l. HOT WATER DEVICE



PLAN

FIGURE



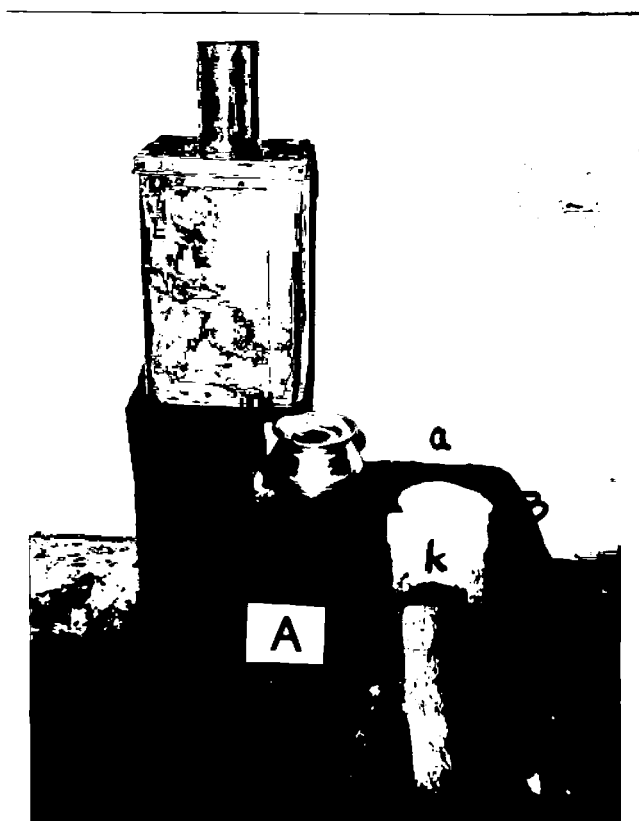


FIGURE - 11
THE IMPROVED CHULA

FIGURE - 12.
TWO LEVEL POTS SEAT

and the best utilization of the escaping hot gases from 'chula' a container was fixed around the chimney so that convection currents passing through the chimney would be used to heat water. It was placed 25 cm. above the surface of the 'chula'. Humphrey (1950)⁶⁶ and Reddick ()⁶⁷ state that constant supply of hot water is essential for labour saving home, through effective cleaning and washing of house hold equipment and clothes. Boil water is useful for sterilisation of feeding equipment and drinking. The need for hot water for bathing purposes in cold North or mountain regions is known to all.

Suggestions for success of Chula:

Construction:

1. Measurement must be carefully followed.
 2. Finishing to be done when the 'chula' is wet
- Device is to be held by a platform,
 Inner passage should be smooth,
 No leakage in the chimney,
 and Chimney should be straightly erected.

Use:

- Pot-seats always to be closed by pots,
 Water to be present in the device,
 Fuel & feeding mouth to be kept shut,
 Cleaned when cold, and brushed with mixture,
 fresh cowdung, soil and water,
 and Chimney should be cleaned periodically.

VI EVALUATION OF THE PERFORMANCE OF THE IMPROVED

'CHULA'

The performance was tested with reference to

- A) Heating water,
- B) Cooking four preparations.

a) Heating water:

Water was brought to boil on the Improved and the Reference 'chulas' according to the standardisation procedure and results obtained are mentioned Table XI.

TABLE XI

COMPARISON FOR THE PERFORMANCES OF THE IMPROVED AND THE REFERENCE 'CHULA'

Type of chula	Time taken in minutes	Fuel consumed Kg.	Temperature on Second pot-seat.
Improved chula	31.5	.31	89.25
Reference chula	29.5	0.320	74.5
F. Value	7 *	—	56.4 **

Table XI indicates that the time taken to boil water in the Improved 'chula' was higher that is, 31.5 minutes as against 29.5 minutes in Reference 'chula'. The difference on fuel consumption was .01 kg. less in the Improved 'chula' when compared to the Reference 'chula'. So far as temperature reached in the second pot seat is concerned, it was 89.25 °C in case of the Improved 'chula' as against 74.5 °C in case of

the Reference 'chula' which may be attributed to the constructional features of the Improved 'chula' which enables the water to receive more heat and 'chula' as a whole proves to be more efficient. (Appendix K)

When the heat utilized by water was calculated, it was found that the heat received in the Improved 'chula' is higher that is 295 calories per gram of fire wood as against 217 calories in the Reference 'chula'. Thus it is proved that Improved 'chula' excels the performance of the Reference 'chula'.

B) Cooking Experiments:

This includes

1. Selection of items to be cooked,
 2. Purchase of food,
 3. Standardisation of equipment and cooking procedure
 4. Recording observation,
- and
5. Judging the palatability.

1) Selection of the Items to be Cooked.

The selection of the items of food preparation was based on the common diets and prevailing methods of cooking in Indian homes, such as boiling, simmering, baking and frying, Aykroyd (1965)⁵⁴. The items selected for cooking experiment were 'Porridge' 'Cholan' 'Chapatti' 'Sundal' and 'Kootu' as in Appendix XI, XII, XIII, XIV respectively.

Cholan was selected as it is the staple food cereal next to rice in India. Radhakrishnarao (1956)⁶⁸ records

the consumption of cholan is 13.8 ozs. per G.U per day it is consumed in the form of 'Roti', 'Kali' and 'Porridge'. 'Porridge' is commonly made of ragi rice, wheat flour and cholan flour which is a simple preparation common in India and requires simmering method of cooking, Gopalan (1958)⁶⁹. In the survey conducted, the smokeless 'chula' was referred as unsuitable for making 'Chappaties'. It was selected as a representation of pan baking as adai, Dosa, used all over India; Khoala, (1963)⁷⁰. Pulses are used in the form of 'Sundal' in many parts of India and involved the method of boiling as per Gopalan (1956)⁶⁹.

A leafy vegetable was included, as it is used in all the regions being in expensive and easily available and of high nutritive value. Cooking greens in minimum amount of water is the best method according to the recipe by ICMR (1959)⁵⁴ was selected.

2) Purchase of Foods:

The total quantities required to cook of 20 standardized preparations, was calculated on the basis of the meals selected as shown in Appendix III.

3) Standardisation of Equipment and Cooking Procedure.

Additional utensils needed for cooking experiments were carefully selected as to be identical in all dimensions. Details are given in Appendix II.

In order to standardize the size of cholan 'Chappatti' a special rolling board was devised (Figure 12). It was



FIGURE- 13
SPECIAL ROLLING BOARD



- A. CIRCULAR DEPRESSION**
B. ROLLING PIN
C. CLEATS



22 cm. in dimension. A circular depression of 15.1 cm. diameter was made at the centre. On either sides of this circular depression cloths were fixed, .4 cm. thick (Fig.12). A Cellophane sheet was cut in a circular shape and kept on the depression over which the chappatti dough was rolled to avoid sticking and facilitate the removal of 'Chappatti' from the rolling board.

Cooking over the Reference 'chula' and Improved 'chula' were planned to be carried on simultaneously. Taking into consideration the recipes, the attention and the time needed, the frequency of the use of the utensils, the desirable temperature at which a particular recipe was to be cooked, the sequence of the order of cooking each item was determined, as shown in Table XII.

TABLE XII
ROTATION OF SEQUENCES USED

Replicates	First pot seat . . .	
	Improved 'chula'	Reference 'chula'
1.	'Sundal' 'Chappati'	Chappati Sundal
2.	'Chappti' 'Sundal'	Sundal Chappati
3.	'Sundal' 'Chappati'	Chappati Sundal
4.	'Chappati' 'Sundal'	Sundal Chappati

Table XII indicates that two sequences were followed over the 'chulas' with the difference of four minutes to start and order of preparation in second pot was kept the same - 'porridge' first 'kootu' next. Throughout the cooking experiment, each set of utensils was rotated in their use on both the 'chulas' in order to equalise any difference that may be existing in the utensils. The device as was filled with 10.5 litre of water before starting. Cooking was commenced every day at 8 a.m. so that the completion of cooking over both the 'chulas' coincided the termination at the time convenient for the panel of judges for scoring.

Utensils were washed according to standardised procedure and the time of cleaning the pots was noted.

4. Recording of Observations.

During the experiment the activities as blowing and flame, adjusting of wood to maintain flame, tapping of wood, turning of 'chappatti', and avoiding escape of smoke and flame coming out from fuel feeding mouth were carried out.

Foods were prepared and the following data collected:

- a) Time of cooking taken for each preparation
 - b) Number of times of blowing, adjusting wood, tapping of wood and to avoid escape of smoke and flame.
 - c) Temperature reached by 10.5 litre of water in the device soon after the cooking was over.
- and
- d) Time taken to clean utensils

5 Judging the Palatability:

Sweetman and Mackeller (1954)⁷¹ defined palatability as the relative acceptability or appeal of a food.

'Cholan Porridge', 'Sundal', 'Cholan Chappati' and 'Kootu' were appraised for palatability for comparison of the Improved and the Reference 'chula'. Score cards were developed for each of the preparation in relation to appearance, colour, doneness, taste, texture or consistancy and smell fo the foods cooked using both the smokeless 'chulas' . Samples of score-cards are given in Appendix XV, XVI, XVII XVIII.

Four judges of standards specified by Low (1955)^{7c} with previous experience of scoring foods, of the same education and training constituted the tasting panel. (Appendix XIX). All the judges, were familiar with 'Chappatis' and its qualities.

A small portion of 'Porridge', 'Sundal' and 'Kootu' cooked over the Improved 'chula' was served on a porcelain plate marked 'A', and the other series cooked over Reference 'chula' were marked 'B'. One Chappati was cut into six equal pieces in the triangle shape so that each piece would be a representative portions and sides of the Chapati. The order was reversed.

12 IMPROVED 'CHULA'S:-

The results obtained with the Improved 'chula' and the Reference 'chula' in terms of cooking 'Porridge', 'Sundal', 'Chappati', 'Kootu' and heating water in four replicates are analysed and discussed under

1. Time Management and attention required in maintaining fire
2. Money management
- and 3. Palatability of foods cooked

1. Time Management:

The management is discussed in relation to (a) cooking and heating water (b) cleaning the utensils (c) attention required.

a) Time for cooking and heating water:

The total time taken to cook 'Porridge', 'Sundal', 'Cholan', 'Chappati', 'Kootu' and to heat 10.5. litres of water on the Improved 'chula' and the Reference 'Chula' is given in Table XIII.

TABLE XIII

TOTAL TIME TAKEN FOR COOKING 'PORRIDGE', 'SUNDAL',
'CHAPPATI', 'KOOTU' AND HEATING WATER ON THE IMPROVED
AND THE REFERENCE 'CHULA'

No.	Items	Pot-seat	Time taken in Minutes		Difference
			Improved chula	Reference Chula	
1.	'Sundal'	First	40.5	42.0	
2.	'Porridge'	Second	22.0	26.0	
3.	'Chappati'	First	22.5	23.0	
4.	'Kootu'	Second	41.0	47.0	
5.		Total	125.0	138.0	
		On each Chula	63.0	69.0	
		For handling the utensils	0.75	0.75	
		Total time taken on each 'chula'	63.75	69.75	
5.	Time taken for Heating water		00.00	34.00	
	Total Time		63.75	103.75	40.0
					38.55 %

From Table XIII, it can be noted that each item of preparation cooked on the Improved 'chula' takes less time than on the Reference 'chula'. The total difference amounts for 40 minutes that is 38.55 per cent which is found significant at one percent level when analysed statistically, as shown in Appendix XX

The reason for significant saving of time can be attributed to the higher amount of heat available that is 89.25°C in second pot seat of the Improved 'chula' as against 74.5°C temperature available in second pot-seat of the Reference 'chula' as shown in Table XI. The higher temperature of the second pot-seat of the Improved 'chula' may be attributed to the construction of passage sloping towards first pot seat linking first and second pot seat which made easy for the flames to reach the second pot-seat. Another reason may be the height of the baffle wall which was 3.5 cm. higher in the Improved 'chula' than in the Reference 'chula' (5 cm.). The third reason may be that the grate used in the case of the Improved 'chula' which permits the ash to be removed greater ventilation to aid combustion.

No extra time was taken over the Improved 'chula' to heat water as hot water was the by-product of the cooking process. But in case of Reference 'chula' water had to be heated directly in a similar container which needed the extra time of 34 minutes to heat water upto 60°C .

b) Time Taken To Clean Utensils:

The pots and the water device used over the Improved and the Reference 'chula' were cleaned separately using the standard procedure given in Table XIV.

TABLE XIV
TOTAL TIME TAKEN TO CLEAN UTENSILS

Replicates	Time taken in Minutes		Saving of Time in Minutes (B - A)	Percentage of time saved
	Improved 'chula'	Reference 'chula'		
1	5.20	7.30		
2	5.15	7.30		
3	5.18	7.35		
4	5.20	7.35		
Average	5.18	7.32	2.14	29.23

$F=3060$ - significant at one percent level.

Table XIV indicates the time taken to clean utensils used over the Improved 'chula' was 29.23 percent less than the time taken for cleaning utensils used over the Reference 'chula.' However the difference of 2.14 in total time minutes when statistically analysed, was significant, although it meant considered saving ^{of} energy and time, as shown in Appendix XXI.

Attentions required in Maintaining Fires

Differences in the number of special tasks performed during the use of the Improved 'chula' and the Reference 'chula' such as blowing, adjusting wood, tapping wood, are given in Table XXI.

TABLE XV

ATTENTION REQUIRED DURING COOKING FOUR PREPARATIONS OVER THE 'IMPROVED' AND THE 'REFERENCE CHULA'.

Activity	Average No. of Times Attended		
	Improved 'chula'	Reference 'chula'	Difference
Blowing	0.5	2.5	2.0
Adjusting of Wood	4.25	13.25	9.0
Tapping of Wood	4.0	4.75	0.75

Table XV indicates the difference in attention required during cooking over the Improved and the 'reference chula'. The attention required is less for the Improved 'Chula' because better ventilation.

Adjusting of wood and tapping were done to dislodge the cinders from burning fire and to maintain a constant flame, and in case of the Improved 'chula' shutter fixed to the fuel feeding mouth helped in even burning requiring less adjustment.

2. Money Management:

Money management is discussed here in terms of saving through fuel consumption.

Data regarding the fuel consumed for cooking 'Porridge', 'Sundal', 'Chappati' and Kootu' and heating 10.5 litre of water over the Improved and the Reference 'chula' are presented in Table XVI.

TABLE XVI
FUEL CONSUMED FOR COOKING FOUR PREPARATIONS AND
HEATING.

Replicates	Total		Difference	Saving of firewood in per- centage
	Fuel consumed in Kg. Improved chula (A)	Reference chula (B)		
1	1.32	1.94		
2	1.14	1.72		
3	1.34	1.74		
4	1.19	1.82		
Mean	1.24	1.30	.56	45

$F = 11.10 **$

From Table XVI it can be seen that the saving of fuel use of the Improved 'chula' was 45 percent, which was statistically significant at one percent level, as in Appendix XXI

This saving was primarily due to the use of hot water device which helped to utilize the heat of flue gases whereas in case of the Reference 'chula' water has to be heated directly by consuming extra fuel.

Calculated in terms of money the saving of money was 3.5 Rs. per being 45 per cent over that of the Reference 'chula' for preparing simple four preparations. As Kamalaveni (1962)²¹ states that the larger the amount of

foods cooked greater is the time spent on cooking. In joint families or big households, the use of 'chula' would result in great saving of fuel and cost.

As Sanyal (1964)⁷³ has reported, at present a total of 100 millions tons of firewood is being used in our country. Hence a saving of 45 per cent of fuel over the best of the smokeless 'chula' would add substantially towards the national saving.

3. Palatability of Cooked Food:

The total scores obtained for the 'porridge', 'sundal', 'cholam chappatti' and 'kootu' are given in Table XVII.

TABLE XVII

TOTAL SCORE OBTAINED FOR FOUR PREPARATIONS OVER THE IMPROVED AND THE REFERENCE CHULA

Preparation	Total score		Differences
	Improved 'chula'	Reference 'chula'	
Cholam Porridge	21.54	17.60	3.94
Sundal	22.09	15.72	06.32
Cholam Chappatti	22.29	14.75	07.54
Kootu	21.42	17.97	3.45

Data presented in Table XVII indicates that the total score is higher in case of the Improved 'chula' than the Reference 'chula'. The difference in the total score obtained over the Improved and the Reference the 'chula' is

the lowest in case of 'cholam porridge' and the highest in case of cholam 'Chappatti'. Level of significance is shown in Table XVIII.

TABLE XVIII

LEVEL OF SIGNIFICANCE FOR THE PALATABILITY OF PORRIDGE,
SUNDAL, CHAPPATTI AND KOOTU

	Appear- ence	Colour	Doness	Taste	Texture	Smell
Porridge	-	-	*	*	**	-
Sundal	**	**	**	**	**	**
Chapatti	**	**	**	**	**	**
Kootu	**	*	*	**	-	**

** Significant at one per cent level

* Significant at five per cent level.

- No significant difference.

Table XVIII, it is seen that the difference in palatability is significant at one percent level in case of 'sundal' and 'chapatti'. In case of 'porridge' the doneness and taste are significant at five percent level and texture at one percent level. In case of 'kootu' appearance, taste and smell are highly significant. Our Improved 'chula' than the Reference 'chula' other qualities being significant - at five per cent level. (Appendix XIII). The doneness, taste consistency of 'porridge' were significantly better in case of the Improved 'chula' than the Reference 'chula', which may be attributed to the temperature 89.25°C in case of the Improved 'chula' as

against 74.5°C. At this temperature, a smooth consistency due to uniform gelatinization is attained in case of the Improved 'chula'. As stressed by Sweetman and Mackellar (1957)⁷² and Stanley and Cline (1950)⁷⁵. (Appendix XXIII) For 'sundal' difference between quality of appearance, colour, doneness taste, texture and smell were significant. The reason may be attributed to the high and constant temperature which is responsible for the proper doneness of 'sundal'. (XXIV)-Appendix.

The difference between score for appearance, doneness, taste, colour, texture and smell were found to be significantly better at one percent level for the Improved 'chula'. The bigger pot-seat made for baking 'cholan', 'Chappatti' had helped in even distribution of heat. It needed constant rotating of 'Tava' on pot-seat for even baking of 'Chappatti'. As Stanley and Cline (1950)⁷⁵ point out slow roasting causes the large proportion of starch to be changed into dextrin to develop flavour. (Appendix XXV).

In case of 'Kootu' appearance, doneness, taste, colour and smell were significantly better which may be attributed to the time taken to cook 'Kootu' which was less over the Improved 'chula' than over the 'Reference 'chula' which is the important factor in maintaining the colour of the greens as stressed by Devdas (1958)⁷⁵. (APPENDIX XXVI)

VII SUMMARY AND CONCLUSION

1. The advantages and disadvantages of smokeless 'chula' were elicited from 25 rural home makers from two different states of Maharashtra and Madras.
2. Constructional feature of the most successful of the existing smokeless 'chula' were appraised from available literature and three 'chulas' namely 'BKT', 'Raju' and 'Samadhan' were tested. The 'BKT' 'chula' was selected as a Reference 'chula' because of its maximum saving of time and minimum of fuel consumption.
3. Variables such as height of the chimney, use of grate, use of baffle wall, size of the first pot seat and height of the 'chula' were tested with the Reference 'chula' and optimum conditions for satisfactory functioning were determined.
4. An improved 'chula' was developed with a special hot water device and tested against Reference 'chula'. The performance was tested in terms of time management, fuel consumed while cooking four simple selected preparations namely 'Porridge' 'sundal', 'cholan chapatti' and 'kootu' cooked over it, and then palatability.
5. The finding of the experiments proved that the Improved 'chula' was superior to Reference 'chula'

Time saved in terms of cooking was 33.5 percent, and cleaning utensils was 29 percent;

and Fuel saved was 45 percent which would directly result in saving of fuel cost.

Average palatability of the four preparations were superior to those cooked over the Reference 'chula'.

6. The use of Improved 'chula' may be promoted successfully through:

Construction of smokeless 'chula' to be undertaken by Housing Co-operative Societies placing these 'chula' in the market;

Demonstrations of correct technique of construction and use, through the extension workers such as Gram Sevikas and Mukya Sevikas.

Convincing the home makers of the superiority of using smokeless 'chula' and by relating the importance of smokeless 'chulas' in the bettering of home life, while teaching its use.

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A P P E N D I X E S

APPENDIX I

SRI AVINASHILINGAM HOME SCIENCE COLLEGE, COIMBATORE.
INTERVIEW SCHEDULED ON SMOKELESS CHULA

BY

Smt. ASHA B. NINKAR.

Name of the family head

Occupation of the family head

Full Address

Composition of the family

Joint/Single

S.No.	Name	Sex	Age	Relation	Occupation	Monthly income	Other particulars.
-------	------	-----	-----	----------	------------	----------------	--------------------

General meal Menus

Morning

Evening

Smokeless

Type of smokeless chula Used

Ordinary/Smokeless/
Stove/Chagri/Electricity/
Gasplant any others

Overall size of the chula used

Length

Bredth

Height

Discription of the Chula		Name	
Pot seats		Diameters	Depth
1st			
2nd			
3rd			
4th			

Chimney	height	Diameter	material	used-
	Curves if any	Location		
	(inside/outside). Any trouble			

Material Used in construction of the Chula
 Mud/mixture of mud, straw, cowdung/Bricks/
 Cement/Any other

Fuel used Wood/Twigs/Cowdung/Coal/
 Any other

Smoke Creates too much smoke/such smoke/slight or
 little smoke/negligible smoke/not at all/

The 'Chula' is used because

- | | |
|---|---------|
| 1. It saves time | ratings |
| 2. It consumes less fuel | |
| 3. It gives no smoke | |
| 4. It increases the efficiency of
the home maker | |
| 5. It does not require fan or blow | |
| 6. It gives hot water at all times | |
| 7. It keeps food hot for a long time | |
| 8. It is easy to operate | |
| 9. It is more safe | |
| 10. Any other reason. | |

The Chula is not used because:

(Ratings)

- (1) It does not function well
- (2) It gives too much smoke
- (3) It consumes much time
- (4) It does not have space for baking chapatis
- (5) It is difficult to construct or repair
- (6) It occupies more space in the kitchen
- (7) It requires fan or blow
- (8) It consumes more fuel
- (9) It has more cooking seats than required
- (10) Any other reason

APPENDIX - II

DETAILS OF THE UTENSILS USED

Utensil	Number	Diameter in cms.	Height in cms.	Weight in Gms.	Capacity in litres.	Use						
	I	II	III	I	II	III						
	Set	Set	Set	Set	Set	Set						
Pot Aluminium*	1	9	9	12	12	280	75	275	1.5	1.5	1.5	For 'Sundal'
Pot Aluminium*	1	10	10	13	13	278	234	210	1.65	1.65	1.65	For 'Por- ridge' kootu
Pot Aluminium	1	16½	16½	14	14	350	349	348	3.5	3.5	3.5	
'Tava Iron'	1	23½	23½	24	-	509	510	510	-	-	-	To bake 'Chappati'

Note: * indicates Set I and II of the utensils used for cooking experiments.

APPENDIX - III

QUANTITIES OF FOODS AND FUEL PURCHASED AND STORED

Foodstuff	Quantities Stored	
Cholan	28.0	Kilogram
Bengal Gram	7.0	"
Green Gram Dhal	4.0	"
Jaggery	3.0	
Salt	0.5	"
Firewood	20	maunds
Fire wood chips	20	Kilogram
Kerosene	3	Litre
Ash	0.5	Kilo
Red Soil	0.5	Kilo
Coconut Fibre	200	Gms.

In order to keep the quality of the food stuffs constant, dry provisions were purchased in one lot, cleaned, stored in the metal containers with close fitting lids, and labelled. Vegetables required were bought daily.

APPENDIX -IV

ANALYSIS OF VARIANCE FOR THE TIME TAKEN TO BOIL WATER AT FIRST
POT-SEAT ON 'SAMADHAN', 'BKT', AND
'RAJU' CHULA

Sources of variation	df	Sum of squares	Mean square	F.value
Between sets	2	182	91	29.25 **
Within sets	9	23	2.56	
Total	11	210		

APPENDIX V

ANALYSIS OF VARIANCE FOR THE FUEL CONSUMED TO BOIL WATER AT
FIRST POT-SEAT ON 'SAMADHAN', 'BKT', AND 'RAJU' CHULA.

Sources of Variation	df	Sum of Squares	Mean Square	F.value
Between sets	2	0.074	0.037	64.91 **
Within sets	9	0.0052	0.00057	
Total	11	0.0792		

APPENDIX VI

**EFFECTS OF VARYING CHIMNEY HEIGHTS ON THE PERFORMANCE OF
THE REFERENCE CHULA**

Variables Heights in cm.	Replicates				Mean	Analysis of Mean Difference
	1 Time Taken	2 in	3 Minutes	4 in		
220 (a)	32	32	33	30	31.75	Do.01=3.08
320 (b)	28	27	24	26	26.25	Do.05=2.14 a - b=5.50 **
410 (c)	29	27	27	27	27.5	a - c=4.25 ** c - b=0.25
Fuel Consumed in Grams						
250 (a)	840	800	850	790	820.0	Do.05=. . =.02 Do.01=. . =.04 a - b=.08 **
320 (b)	744	738	735	713	735.5	a - c=.06 **
410 (c)	768	760	765	749	760.5	c - b=.05 **
Temperature Reached °C in Second Pot-Seat						
250 (a)	75	75	75	75	74	
320 (b)	75	77	78	78	77	
410 (c)	76	77	79	80	78	

APPENDIX VII a

**EFFECT OF BAFFLE WALL ON THE PERFORMANCE OF THE REFERENCE
GHULA**

Variables	Replicates				Mean	F. Value
	1	2	3	4		

Time Taken in minutes in
First Pot-seat.

With Baffle wall	32	32	33	30	31.75	
Without Baffle wall	32	32	32	31	31.75	

Fuel consumed in Grams

With Baffle wall	840	800	850	790	820	Mean difference being Zero F
Without Baffle wall	850	820	800	810	820	

Time taken in Minutes in Second Pot-seat

With Baffle wall	35	35	35	34	34.75	.227.1 **
Without Baffle wall	40	41	41	40	40.5	

** Significant at one percent level

APPENDIX - VII 9

ANALYSIS OF VARIANCE OF THE EFFECT OF BAFFLE WALL ON THE
PERFORMANCE OF THE REFERENCE CHULA.

Sources of Variation	df	Sum of Square	Mean Square	F. Value
Between sets	1	65.875	65.875	227.1 **
Within Sets	6	1.75	0.29	
Total	7	67.625		

** Significant at one percent level.

APPENDIX VIII

EFFECT OF THE DIAMETER OF FIRST POT-SEAT ON THE PERFORMANCE OF THE REFERENCE 'CHULA'

Variables	Replicates				Mean	F. Value
	1	2	3	4		

Time Taken in Minutes

Diameter 15 cm	23	20	25	20	22	24.5**
Diameter 12.5 cm.	29	27	30	30	29	

Fuel consumed in Grams

Diameter 15 cm.	550	500	550	525	531.25	170.3 **
Diameter 12.7 cm.	870	800	850	790	827.5	

Temperature Reached in Second Pot-seat

Diameter 15 cm.	65	60	64	64	63.25	
Diameter 12.5 cm.	78	76	73	73	75.00	

	Sources of variation	sum of squares	Df.	mean square	F value
Time Taken	Between Sets	98	1	98	24.5**
	Within Sets	24	6	4	
Fuel consumed	Between Sets	175328.125	1	175328.125	170.3
	Within Sets	6193.75	6	1032.29	

APPENDIX IX

**EFFECT OF VARYING THE HEIGHT OF THE CHULA ON THE PERFORMANCE
OF THE REFERENCE CHULA**

REPLICATE

Height of Chula in Cm.	Time Taken in minutes				mean	Variation in mean Difference.
	1	2	3	4		
16.5 (a)	41	41	38	38	39.5	Do.01 = 3.28 Do.05 = 2.28
20.5 (b)	32	32	33	30	31.75	c - a = 7 ** c - b = 14.75 **
24.5 (c)	48	45	46	47	46.5	a - b = 7.75

Fuel Consumed in Grams

16.5 (a)	820	810	825	830	821.25	Do.01 = 28.45 Do.05 = 10.74 a - b = 40.50**
20.5 (b)	780	780	785	778	780.75	c - b = 58.00 **
24.55 (c)	845	830	835	945	838.75	c - a = 17.50 *

Temperature Reached in Second Jet-vent.

16.5 (a)	70	71	72	72	71.25
20.5 (b)	73	73	72	72	72.5
24.55 (c)	74	75	73	72	73.6

* Significant at five percent level.

** Significant at one percent level.

APPENDIX K

**COMPARISON FOR THE PERFORMANCE OF THE IMPROVED AND
REFERENCE CHULA**

Chula	Time taken in minutes				Mean	F Value
	1	2	3	4		
Improved chula	32	33	31	30	31.5	7*
Reference chula	30	29	30	29	29.5	

Fuel consumed in kilograms

Improved chula	.81	.81	.81	.81	.81
Reference chula	.82	.82	.82	.82	.82

**Temperature reached in
second pot seat**

Improved chula	90	90	88	89	89.25	337.51**
Reference chula	73	74	75	76	74.75	

APPENDIX - XII

RECIPE FOR CHOLAM 'PORRIDGE'

No. of servings : 3.

Time of cooking : 22 minutes.

Ingredients	Amount
Cholam flour	85.2 Gms.
Water	750 ml.
Jaggery (powdered)	75 Gms.

Method:

1. Boil 500 ml. of water.
2. Make a paste of cholam flour with 250 ml. of cold water.
3. Add the paste slowly to the boiling water stirring all the time to avoid lumps.
4. Cook for nine minutes.
5. Add jaggery.
6. Cook for four minutes.
7. Remove from the fire and serve hot:

APPENDIX - XIII

RECIPE FOR SUNDAL

No. of Servings: 3

Cooking time: 41 minutes

Ingredients	Amount
Bengal gram	171 Gms.
Water	130 ml.
Salt	4 Gms.
Grated Coconut	15 Gms.

Method:

1. Soak bengal gram in one litre of water for eight hours.
2. Boil 130 ml. water in the pot.
3. When the water is brought to boil, add the soaked gram
Cover and cook it for 34 minutes.
4. Add salt and grated coconut and mix well
5. Remove from the fire after 3 minutes.

APPENDIX - ~~XIII~~

RECIPE FOR CHOLAM 'CHAPPATI'

No. of servings : 3.

Time of baking : 22 minutes.

Ingredients	Amount
Cholam flour	600 Gms.
Water	500 ml.
Salt	2 Gms.

Method:

1. Heat water to 55°C.
2. Add salt and hot water to the sifted flour and make a dough.
3. Divide into 6 equal parts.
4. Take one part, knead it for 3 minutes and then roll it on the rolling board to fit in the circular depression.
5. Transfer it to 'tava'.
6. Smear water over the 'chappati' after 15 seconds and turn after 70 seconds.
7. Keep on other side for 120 seconds.
8. Bake it on cinders for completion of baking for four minutes, one minute on edges and three minutes on sides.

APPENDIX - XIV

RECIPE FOR 'KOOTU'

No. of servings : 3.

Time of cooking : 41 minutes.

Ingredients	Amount
Amaranth	250 Gms.
Greengram dhal	85.2 Gms.
Water for cooking	750 ml.
Salt	5 Gms.

Method:

1. Boil the water.
2. Clean and wash the dhal, add it to the boiling water and cook.
3. Meanwhile, wash and cut the Amaranth.
4. When dhal is cooked for 26 minutes, add the Amaranth to it.
5. Cook for 8 minutes.
6. Add salt to dhal and keep for two minutes.
7. Remove and serve.

APPENDIX XV
SCORE CARD FOR CHOLAM 'PORRIDGE'

Note: The qualities of the product are listed in the score card. Please taste the samples one by one carefully and tick against the quality that describes the given sample best. Please take sip of water before judging the next sample to remove the taste of previous sample. The judges are requested not to discuss while scoring.

Quality of Product	Description	Samples		Points
		A	B	
Appearance	Excellent			4
	Good			3
	Fair			2
	Poor			1
Colour	Natural			4
	Dark			3
	Light			2
	Very pale			1
Doneness	Well cooked			4
	Overcooked			3
	Undercooked			2
	Uncooked			1
Taste	Excellent			4
	Good			3
	Fair			2
	Poor			1
Consistency	Natural			4
	More thick			3
	Less thick			2
	Watery			1
Smell	Pleasant			4
	Raw			3
	Charred			2
	Burnt			1

Special comments:

Date:

Signature of the Judge.

APPENDIX XVI

SCORE CARD FOR 'SUNDAL'

Note: Under each heading some qualities are given. Please taste the samples one by one carefully and tick against the quality that describes the given sample best. Please take a sip of water before judging the next sample to remove the taste of previous sample. The judges are requested not to discuss while scoring.

Quality of Products	Description	Sample		Points
		A	B	
Appearance	Excellent			4
	Good			3
	Fair			2
	Poor			1
Colour	Brown			4
	Pale brown			3
	Greenish brown			2
	Dark brown			1
Doneness	Well cooked			4
	Overcooked			3
	Undercooked			2
	Uncooked			1
Taste	Excellent			4
	Good			3
	Fair			2
	Poor			1
Texture	Very soft			4
	Soft			3
	Slightly tough			2
	Tough			1
Smell	Pleasant			4
	Smell of raw 'sundal'			3
	Burnt smell			2
	Smoky			1

Special comments:

Date:

Signature of Judge

APPENDIX - XVII

SCORE CARD FOR CHOLAN 'CHAPPATI'

Note: Under each heading some qualities are given. Please taste the samples one by one carefully and tick against the quality that describes the given sample best. Please take a sip of water before judging the next sample to remove the taste of previous sample. The judges are requested not to discuss while scoring.

Quality of Products	Description	Sample		Points
		A	B	
Apperance	Excellent			4
	Good			3
	Fair			2
	Poor			1
Colour	Natural brown			4
	Even spots			3
	Many charred brown spots			2
	Pale dull spots			1
Doneness	Well baked			4
	Over baked			3
	Underbaked			2
	Raw in centre or on the sides			1
Taste	Excellent			4
	Good			3
	Fair			2
	Poor			1
Texture	Soft			4
	Very soft			3
	Tough			2
	Brittle			1
Smell	Pleasant			4
	No smell			3
	Charred smell			2
	Smoky smell			1

Special comments:

Date:

Signature of Judge

APPENDIX - XVIII

SCORE CARD FOR 'KOOTU'

Notes:- Under each heading some qualities are given. Please taste the samples one by one carefully and describe the given sample best. Please take a sip of water before judging the next sample to remove the taste of previous sample. The judges are requested not to discuss while scoring.

Quality of Products	Description	Samples		Points
		A	B	
Appearance	Excellent			4
	Good			3
	Fair			2
	Poor			1
Colour	Natural colour			4
	Slight dark colour			3
	Slight pale colour			2
	Very dark colour			1
Doneness	Greens and dhal Properly cooked			4
	Dhal not properly cooked			3
	Bothe not properly cooked			2
	Greens over cooked			1
Taste	Excellent			4
	Good			3
	Fair			2
	Poor			1
Texture	Soft and smooth			4
	Very soft			3
	Too watery			2
	Slimy			1
Smell	Pleasant			4
	Raw smell			3
	Burnt smell			2
	Smoky smell			1

Special comments:

Date

Signature of the Judge.

APPENDIX - XIX

RESULTS OF TRIANGULAR TEST

Judges	Replicates					Total
	1	2	3	4	5	
1	1	1	1	*	1	4*
2	1	1	1	1	1	5*
3	1	*	1	1	1	4
4	1	*	*	*	1	2
5	1	1	1	1	1	5*
6	1	1	*	*	1	3
7	1	1	1	*	1	4
8	1	1	1	1	1	5*

* Judges who were chosen for pannel.

APPENDIX - XX

ANALYSIS OF VARIANCE FOR THE TOTAL TIME TAKEN FOR FOUR
PREPARATIONS AND HEATING WATER.

.....

Sources of variation	df	Sum of squares	Mean square	f.Value
Between sets	1	3160.125	3160.125	2449.7*
Within sets	6	7.750	1.29	
Total	7	3167.875		

.....

Significant at one percent level

APPENDIX - XVI

ANALYSIS OF VARIANCE FOR THE TIME TAKEN TO CLEAN UTENSILS

Sources of Variation	df	Sum of squares	Mean square	F.value
Between sets	1	9.180	9.180	18360 **
within sets	6	0.003	0.0005	
Total	7	9.183		