SOME MANAGEMENT ASPECTS OF THE ORDINARY CHULA AND SMOKELESS CHULA AS COOKING DEVICES.

By

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TABLE OF CONTENTS

LIST OF TABLES.

LIST OF FIGURES

LIST OF APPENDICES

I. INTRODUCTION.

In a home, the homemaker carries out various activities such as: buying, storing, cooking and serving food; household cleaning; laundering; entertaining guests and caring for the children and the other members of the family. Among these activities, cooking occupies an important place, since it is concerned with providing nutritious and tasty food to the members of the family and food is basic to health and happiness.

The homemaker spends 70 per cent of her working time in the kitchen, which is the centre of cooking activities.[1] However, the kitchens of most homes in India are smoky, dark and cumbersome to work in. As Raju (1957)[2] says, "Indian kitchens are very often suffocating chambers of pungent smoke violently irritating to the eyes, nose and lungs and also to the temper of the housewife". Therefore cooking is considered as drudgery by some homemakers. In order to make cooking pleasant, easy and efficient, saving in terms of energy, time and money, the kitchen should be so constructed and organised, that physical and mental strain involved in cooking is minimum.

A good kitchen should facilitate the efficient carrying out of functions such as: cleaning and cooking of food; storing of food, fuel and utensils and washing of utensils. In order to carry on these activities smoothly, proper space, facilities and equipment need to be provided. The equipment in the kitchen should include cook-

ing utensils, tools, cleaning equipments, containers for foods, grinding devices and 'chula'* or 'adupu'.

Most of the activities in the kitchen revolve around the chula. An efficient chula should be smokeless, consume minimum fuel and easy to operate. The chulas commonly used in Coimbatore area and most other parts of Madras, Andhra Pradesh, Kerala and Mysore States are made of different materials, such as, mud, baked pottery, bricks and cement and have one, two or three pot seats. There are many defects in these chulas, such as: absence of a properly channelled exit for smoke, high fuel consumption and difficulty in controlling and maintaining a steady flame. The average Indian cannot go for gas or electricity for cooking purposes, as his per capita income is only Rs.291.5.[3]

However, as Guruswamy (1957)[4] comments, "It is strange that until sometime past, the ovens which occupy a key position in our family life had not been given due investigation". Therefore attempts need to be made to develop efficient chulas, with which charcoal or firewood can be used as fuel. Some such efforts have been made during recent years by Rural Extension Centres, Gram Sevikas Training Centres, Community Development Programmes, the Khadi Gramodyog Commission and certain individuals. Con-

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* Chula is the Hindi equivalent for the Tamil word 'adupu', which means, the cooking fireplace. Throughout this study the word 'chula' has been used to indicate the cooking fireplace.

sequently, smokeless chulas of different types, as mentioned by Ramdas (1957)[5], such as Raju chula, Mysore type, Etawah type, Magan chula, Bah type, Hill type, Pratapgarh type, Bakshi-ka-Talab type, have been developed and promoted. The designers of each of these have pointed out the several advantages of their particular smokeless chula, over the ordinary chula.

These advantages have not yet been established by scientific experiments, nor have they been popularised adequately to be adopted for use by larger sections of people. This study is therefore an effort to compare the ordinary chula, commonly used in Coimbatore District, with a well-known type of smokeless chula, namely, 'the portable Magan chula' made by the pottery section of the Gandhiniketan Ashram, T.Kallupatti. The points of comparison are: the amounts of fuel and time consumed for cooking a standardised lunch, ease of working and the time taken to clean the utensils after cooking. It is hoped that the findings of this study will go a long way towards the popularisation of the inexpensive, but efficient portable Magan chula type of smokeless chulas.

II. REVIEW OF LITERATURE.

a) The Principles of Combustion as Related to Fuels.

All the fuels are combustible and have a kindling temperature. Combustion is defined by Deming(1952)[6] as, "oxidation that is so rapid and vigorous that light and easily evident heat are emitted". Black and Conant (1956)[7] state that, "the substance catches fire at a temperature known as kindling temperature". According to Deming (1952)[6], the kindling temperature depends upon the following:- (i) the nature of the material, (ii) the fineness and subdivision of the material, (iii) concentration of oxygen, and (iv) the rate at which fresh oxygen is supplied.

i) The Nature of the Material:- The kindling temperature for substances which are volatile is lower than the substances which are not volatile. For example, the kindling temperature for phosphorus and gasoline is much lower than that of wood and coke.

ii) The Fineness of the Subdivision of the Material:- A finely divided material such as powdered magnesium, presents more surface for exposure to oxygen in the air and gets oxidised more rapidly. Therefore it gets kindled at a lower temperature than a coarsely divided material such as a slab of magnesium.

iii) Concentration of Oxygen:- All combustible materials catch fire at a low temperature when the oxygen content in the air supplied to them is at a higher concentration

than when lower.

iv) The Rate at Which Fresh Oxygen is Supplied:- Black and Conant (1954)[7] explain that in order to maintain combustion, a continuous supply of fresh oxygen is essential. If the oxygen supply is insufficient, incomplete combustion will result. Carbon monoxide and particles of carbon which are the products of incomplete combustion, will escape into the atmosphere in the form of smoke.

The heat that is liberated from any fuel is maximum when combustion is complete. Therefore complete combustion should be achieved in order to obtain the maximum fuel value and to avoid smoke. For combustion to be complete, it is necessary that the design of the heating plant is such that a continuous supply of fresh oxygen is maintained.

b) The Types of Ordinary Chulas in Use.

In South India, the chulas used are made of various materials such as mud, baked clay, stones, bricks and cement. The designs are generally as follows:

i) The One Pot Seated Chula. The one pot seated chula as shown in Figure 1 usually consists of a solid bottom and a 7 inches high semi-cylindrical wall forming a pot seat, 5½ inches in diameter with a 4 inches wide opening at the front, called the 'mouth' of the chula. It has three spherical projections of one inch height on the top edge to hold the utensil, as well as to permit the

ORDINARY CHULAS

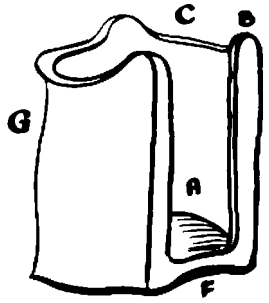

FIGURE .1

THE ONE POT SEATED

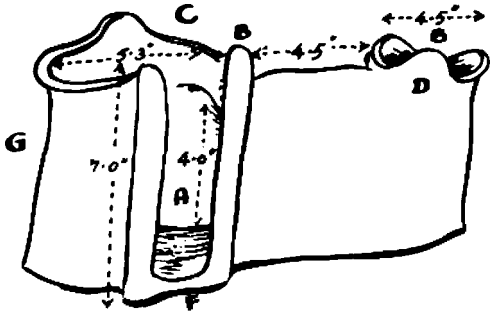

FIGURE . 2

THE TWO POT SEATED

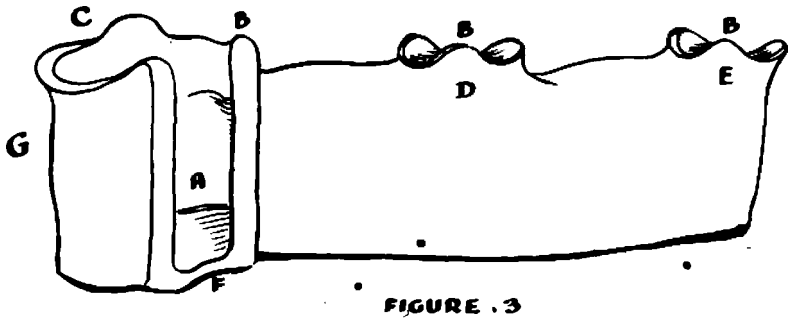

FIGURE . 3

THE THREE POT SEATED

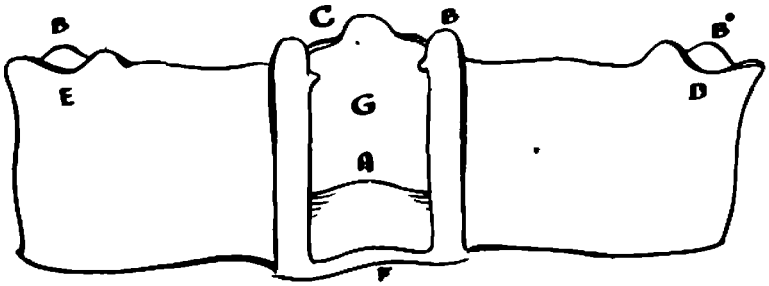

FIGURE . 4

THE THREE POT SEATED

A. MOUTH

B. PROJECTION

C. FIRST POT SEAT

D. SECOND POT SEAT

E. THIRD POT SEAT

F. FLOOR OF THE CHULA

G. SEMI CYLINDRICAL CHULA

flames to pass out of the chula, to surround the utensil.

ii) The Two Pot Seated Chula. The two pot seated chula as shown in Figure 2 is a one pot seated chula, with one of its side walls, usually the right wall, branched to provide another pot seat usually 4.5 inches in diameter, which also has three projections to support the second utensil placed on it.

iii) The Three Pot Seated Chula. The three pot seated chula as shown in Figure 3 is again the two pot seated chula where a third pot seat is provided by branching the side wall of the first pot seat or the second pot seat.

e) Working of the Ordinary Chula.

The fuel used for the ordinary chula is mostly firewood which is placed at the mouth of the chula and lighted. The utensils with the cooking media are placed on the projections of the pot seats. The flames emerge out and partly escape into the air through the space between the bottoms of the utensils and the pot seats and partly surround and heat the utensils and the food placed in them. In the case of the two pot seated chula, the flames pass through the connection between the first pot seat and the second pot seat and reach the second pot seat to heat the second utensil placed on it. Likewise, in the three pot seated chula, the third utensil gets heated by the flames which pass through the connection between the second pot seat and the third pot seat.

d) The Disadvantages of the Ordinary Chula.

When the design and working of the ordinary chulas are examined in relation to the principles of combustion, many defects are evident as listed below:-

i) Smoke nuisance,

ii) Fuel wastage,

iii) Escape of heat into the kitchen,

and iv) Accumulation of ash.

i) Smoke Nuisance:- In the ordinary chula, combustion is not complete because the amount of air supplied is insufficient and hence the concentration of oxygen available is limited. Therefore much smoke is produced. The design of the ordinary chula is such that there is no proper exit for the smoke. Therefore, smoke, instead of being channelled off into the outside atmosphere, gets accumulated in the kitchen and blackens the sides of the utensil, the walls and ceilings of the kitchen. As pointed out by Devadas (1960)[8], smoke is not a desirable product because it is injurious to the eyes and causes discomfort to the homemaker. The smoke obstructs even the illumination and ventilation of the kitchen.

ii) Fuel Wastage:- As mentioned earlier due to incomplete combustion of the fuel, unburnt carbon particles and carbon monoxide escape in the forms of smoke and soot, from the ordinary chula. Therefore the fuel is not utilised fully, resulting in large wastages.

iii) Escape of Heat into the Kitchen:- Due to the project-

ions on the pot seats in the ordinary chula, much space is left between the bottom of the utensil and the flames. The heat from the flames escapes into the room through these spaces in the form of convection currents and radiation, warming the kitchen unnecessarily and making it uncomfortable in an already hot climate. This also accentuates the fuel wastage, since the amount of heat escaping into the kitchen has not been utilised for heating the utensil.

iv) Accumulation of Ash:- Another defect inherent in the design of the ordinary chula is, that the ash gets collected in the place meant for the live coal, settles down as a covering layer on the burning fuel, thereby cutting off the contact between the fire and the air, that is the oxygen content. As has already been pointed out, oxygen is necessary to maintain combustion and in its absence the combustion becomes interrupted. In order to start combustion again, blowing air by means of a blow pipe is commonly resorted to. Such blowing habit leads to weakening of lungs and consequently diseases of the respiratory tract.

e) Earlier Attempts to Avoid Smoke.

Wood and Collentwood (1945)[9] postulate, that the forerunner of the fireplace might have been the fire which the American Indians had in their teepees.* The teepee

*The teepee was a tent in which the American Indians lived. They did their cooking also inside the teepee.

had a hole at its peak for the smoke to pass out. Harcum (1921)[10] describes the Roman Kitchen as having the hearth built of masonry, which had above it, a window as smoke outlet. In spite of the window, smoke and soot continued to accumulate in the kitchen, making it far from satisfactory. Raju (1957)[2] describes the attempts made in India for the removal of smoke from the kitchen by providing an arch and flue over the chula. These constructions increased not only the building costs without solving the problem, but also presented some new problems, such as, the soot forming spongy masses on the arches and falling into the cooking utensils, the long narrow flue harbouring insects, which drop into the cooking utensils and the difficulties in cleaning.

f) The History of the Smokeless Chula in India.

Raju (1957)[2] reports that in 1946, The Hyderabad Engineering Research Laboratories had undertaken research to make the ordinary chula "more scientific, efficient and economical". Following carefully the experiments in the direction of controlled combustion carried out by The Hyderabad Engineering Research Laboratories, the pottery section of the All India Village Industries Association, Maganwadi* proceeded by various experiments

*Maganwadi near Wardha, the headquarters of The All India Village Industries Association, got the name from the late Maganlal Gandhi, Gandhiji's nephew, who was very much devoted to village industries.

to evolve a smokeless chula (Kumarappa 1948)[11]. This smokeless chula came to be known as 'Magan Chula' having been developed at Maganwadi. Since then various other workers have designed different patterns of smokeless chulas as enumerated by Ramdas (1958)[5].

g) Different parts of the Smokeless Chula and its Distinguishing Features.

Figure 4 presents the section through the smokeless chula. The different parts of the smokeless chula are: The pot seats A and B; the fuel feeding mouth C; the combustion chamber D; the ash pit E; the grating F which supports the fire wood and lets the ashes pass through it to get collected in the ash pit and also serve as the additional inlet for fresh air, as the air can come in through the ash pit and grating, into the combustion chamber; the chimney base G; the chimney H through which the smoke escapes into the outside atmosphere; the gradient J, which is provided in the connection between the pot seats A and B in order to reduce the volume of the space in the second pot seat and thereby improve the utilisation of heat there; the baffle wall K provided in the pot seat B, which regulates the passing of flames in the direction of the gradient.

The distinguishing features of the smokeless chula are the following:-

PARTS OF THE SMOKELESS CHULA

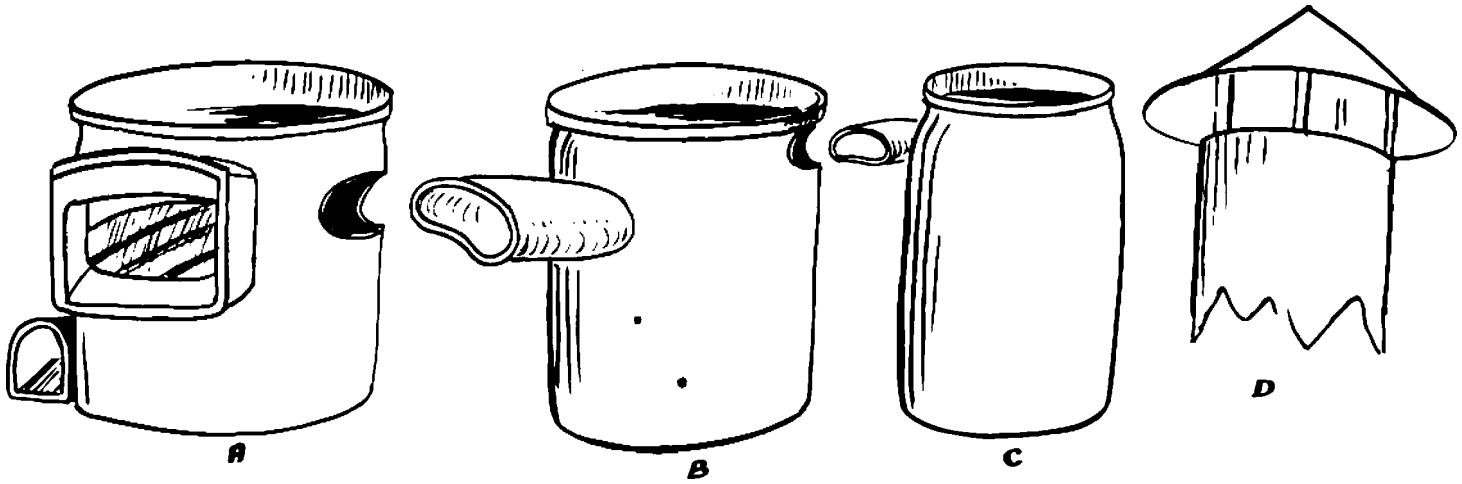

FIGURE.5

A. FIRST POT SEAT

B. SECOND POT SEAT

C. CHIMNEY BASE

D. CHIMNEY ABOVE THE ROOF

i) Absence of smoke nuisance,

ii) Fuel saving,

iii) Absence of radiation of heat into the kitchen,

and iv) Provision for ash removal.

i) Absence of Smoke Nuisance:- As the smoke coming out of the last pot seat passes out into the atmosphere through the chimney base and the chimney which serves as the smoke outlet, there is no smoke nuisance in the kitchen.

ii) Fuel Saving:- The construction of the baffle wall and the gradient in the flue passage and the consequent modification in the volumes of the space for combustion in the second pot seat, facilitate more complete combustion than in the case of the ordinary chula. Further they aid in better distribution and utilisation of the heat evolved, thus leading to a great saving of fuel.

iii) Absence of Radiation of Heat into the Kitchen:- As the smokeless chula does not have projections on the pot seats, the utensils fit tightly, leaving no space between the bottoms and the pot seats for the flames to escape out of the chula (Figure 6C). Thus combustion being carried out in a more enclosed space, the wasteful radiation of heat into the kitchen is avoided.

iv) Provision of Ash Removal:- In the case of the smokeless chula, ash pit is provided which facilitates the collection and easy removal of ash. As the ash does not

form a layer on the burning logs, more complete combustion is also effected by ensuring better contact between the burning logs and the oxygen in the air supplied, than in the case of the ordinary chula.

b) Previous Studies Conducted with the Smokeless Chula.

Ramdas (1958)[5] describes the experiments carried out with different smokeless chulas at The Extension cum Training Centre, Bakshi-ka-Talab, Lucknow, under the auspices of the Planning Research and Action Institute (P.R.A.I.) with the object of comparing their merits. The smokeless chulas included in that study were, Raju type, Mysore type, Etawah type, Magan chula, Bulandshah type, Bah (Agra) type, Pratapgarh type, Hill type, three Bakshi-ka-Talab chulas namely A-C type, 1-3 type and L-shaped type and Desi chula (ordinary chula). While the common feature of all these smokeless chulas is the chimney base with its smoke outlet; they varied in their dimensions, number of pot seats and their alignment and the other aspects, such as the gradient between the pot seats, dampers and baffle walls. Appendix I gives the special features of some of the smokeless chulas included in the study, as described by Ramdas (1958)[5].

The series of experiments conducted by P.R.A.I. were to note (i) the time taken and firewood consumed for boiling 1000 cc of water and cooking varying quantities of rice and pulse, and (ii) the time taken to consume

12 chhataks* of fuel and the consequent rise in temperature of definite quantities of water on the different pot seats.

The results of these experiments indicated that the B.K.T - A type smokeless chula was the most satisfactory of all the chulas used in the experiment, being completely smokeless and consuming the least amounts of time and fuel. A further detailed study of the special constructional and functional features of B.K.T - A type smokeless chula seems to be needed.

The report of another experiment carried out at The Etawah Pilot Project is given by Barkat Narasin (1954)[12]. The experiment was carried on, to find out the correct specifications for a smokeless chula, which will give maximum efficiency with minimum fuel consumption. As a result of that experiment a chula whose dimensions are given in Appendix I, with two pot seats, was found to be sufficient for an average village home. It was also found that fixing the flue pipe at right angles to the out let of the second pot seat and having the floor of the second pot seat gradually sloping upward from the first pot seat, were advantageous.

i) Importance of Fuel Saving.

In 1956, The National Council of Economic Research was requested by the Ministry of Commerce and Industry,

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*One chhatak is equal to two ounces.

Government of India, to study the problem of domestic fuel supplies, as their consumption contributes about 60 per cent of the total energy consumption in India (Lokanathan 1959)[13]. Table I gives the domestic fuel consumption in urban and rural areas in million tons of coal equivalent.*

TABLE I.

DOMESTIC FUEL CONSUMPTION IN URBAN AND RURAL AREAS IN MILLION TONS OF COAL EQUIVALENT.

Fuel.	Urban.	Rural.	Total.
Coal.	20	-	2.0
Electricity.	0.2	-	0.2
Kerosene.	0.3	-	0.3
Dung.	4.0	35.0	39.0
Firewood.	13.5	42.0	55.5
Total.	20.0	77.0	97.0

From the figures in Table I, it can be seen that firewood constitutes the major proportion of the domestic fuels, both in rural and urban areas and dung comes next. The amount of dung burnt as fuel in India will produce, if used as a manure, about nine million tons of food grains every year. A larger proportion of dung is used in rural areas than in urban areas. The widespread use of dung as fuel has many disadvantages. It deprives the soil of valuable and inexpensive natural nutrients. Therefore, The National Council of Economic Research

*One ton of coal equivalent of a fuel refers to the amount of energy as liberated by a ton of coal.

recommended that cow-dung consumption as domestic fuel should be discouraged.

In the case of firewood also the loss is great. Master (1959)[14] states that "with the rapid increase of population and industries, the demand for land and forest products increased so rapidly that forests were cleared at a fast pace and the land stripped naked. One could even see the resultant effects of soil erosion with deep gullies and crevices, the silting of valuable reservoirs and river mouths, drying up of perennial sources of water.... the large scale destruction of forests affected adversely, even the rainfall in many parts of the country".

The use of firewood and dung in large amounts is not desirable in the interests of national economy. In order to save firewood and dung, The Council of Economic Research suggests the substitution of firewood and dung in the city by commercial fuels, such as kerosene and gas and the replacement of dung by firewood in the countryside, until such time as increased productivity enables the villages also to use commercial fuels.

This suggestion to provide the countryside with firewood in order to replace completely the dung used for fuel can be implemented in two ways:

(1) To cut down more trees, accelerating de-forestation with all its disadvantages, which undoubtedly will not be a desirable solution,

and (2) To find methods and devices to use only minimum amounts of firewood by individual households, since whatever quantities of firewood are saved by the individual households, will constitute a positive saving to the whole community. Introduction of the smokeless chula on a nationwide basis will result in significant firewood saving.

III. EXPERIMENTAL PROCEDURE.

The experimental procedure in this study consisted of:-

(a) Selection of equipments and materials,

(b) Standardisation of methods,

and (c) Conducting the experiments.

(a) Selection of Equipments and Materials.

The equipments and materials involved in this study were (i) chulas, (ii) utensils, (iii) measuring devices, (iv) food materials, (v) firewood, and (vi) cleaning materials.

(i) Chulas.

1) Ordinary Chulas: The ordinary chula selected for this study, shown in Figure 2 was made of baked clay. It consisted of a seven inches high semi cylindrical wall, with an opening of 3.8 inches in the front for feeding firewood and three projections of one inch height on the upper rim to support the utensil. The second pot seat, 4.5 inches in diameter with three projections to support the second utensil, was formed by the branching of the right wall of the first pot seat whose diameter was 5.5 inches.

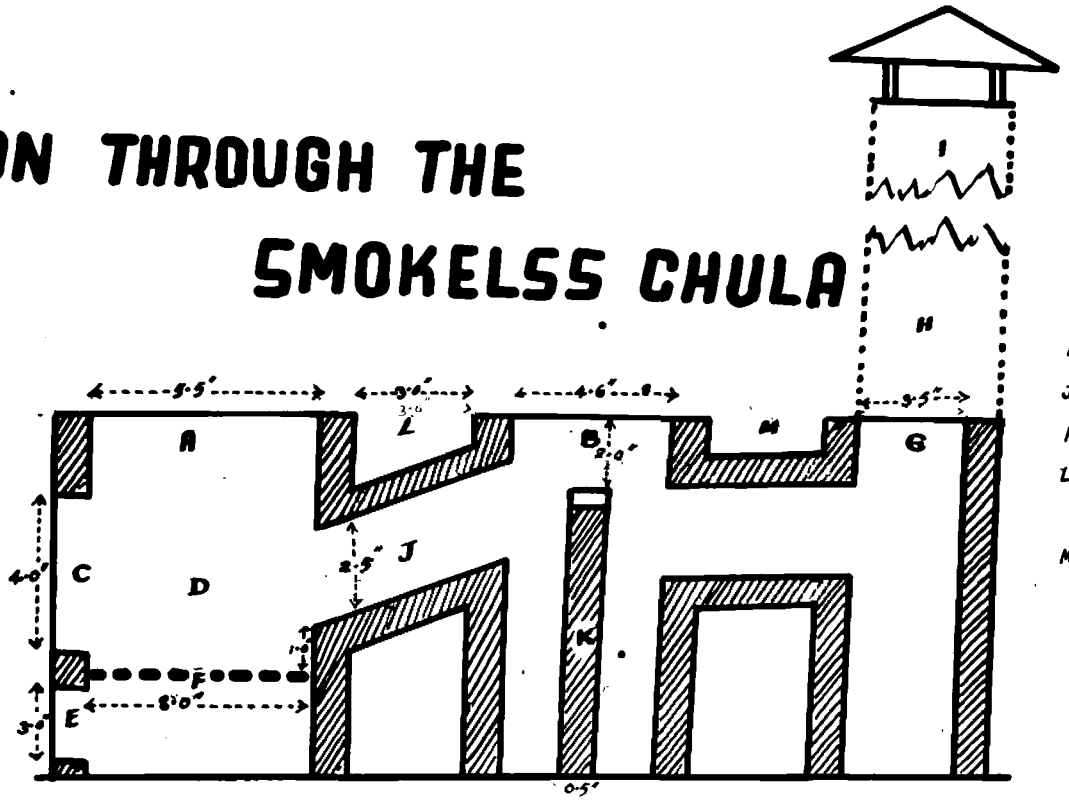
2) Smokeless Chula: The smokeless chula selected was the 'portable Magan Chula' with the dimensions given in Figure 4. This chula was made of baked clay, obtained from the pottery section of Gandhiniketan

Ashram, T.Kallupatti, Madurai District. In this model the different parts of the chula, namely the pot seats, chimney base and the smoke outlet pipes are separate as shown in Figure 5. These parts were assembled in the space allotted for the chula in the experimental kitchen.

Both the ordinary and smokeless chulas were kept side by side in the kitchen, facing east, at a distance of 10 inches from each other and plastered with a mixture of cement and lime as shown in Figure 6.

(ii) Utensils. Two identical sets of brass utensils which were tinned inside, each consisting of three utensils as shown in Figure 7, were selected for cooking the standardised preparations. In each set, the utensils were marked A, B, C and were used to cook the selected food preparations namely beans, rice and dhal respectively. They were as identical as possible with regard to the material of which they were made, size, shape, surface, area and weight. The exact dimensions of the utensils are given in Table II.

SECTION THROUGH THE SMOKELSS CHULA



A,B. POT SEATS.
C. FUEL FEEDING MOUTH.
D. COMBUSTION CHAMBER.
E. ASH PIT.
F. GRATING.
G. CHIMNEY BASE.
H. CHIMNEY UNDER THE ROOF.
I. CHIMNEY ABOVE THE ROOF.
J. GRADIENT IN FLUE PASSAGE.
K. BAFFLE WALL.
L. CONNECTION BETWEEN THE TWO POT SEATS.
M. CONNECTION BETWEEN THE SECOND POT SEAT AND THE CHIMNEY BASE.

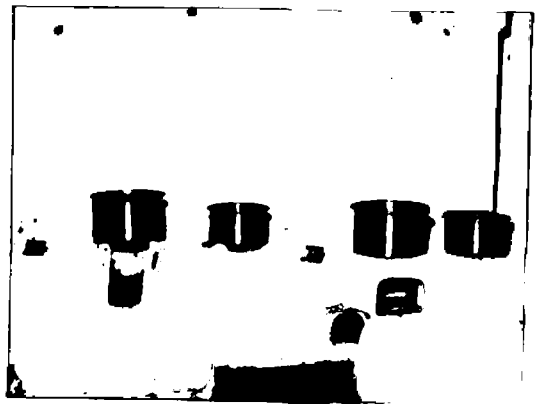
Scale 1 cm. 1·0"

FIGURE 4

INSTALLED CHULAS IN THE EXPERIMENTAL KITCHEN

a) THE CHULAS AS INSTALLED

b) THE CHULAS WITH FIREWOOD



c) THE CHULAS WITH THE UTENSILS. NOTE THE DIFFERENCE IN FITTINGS OF THE BOTTOMS OF THE UTENSILS.

I ORDINARY CHULA

II SMOKELESS CHULA

FIGURE 6.

UTENSILS USED FOR COOKING FOODS

SET-I

SET-II

FIGURE 7

TABLE II.

THE DIMENSIONS OF THE UTENSILS.USED
TO COOK BEANS, RICE AND DHAL.

Utensils.	Diameter in Inches.		Height in Inches.		Weight in Ounces.		Capacity in cups.*	
	Set I.	Set II.	Set I.	Set II.	Set I.	Set II.	Set I.	Set II.
A	6.20	6.20	2.80	2.80	11.00	11.50	6½	6½
B	7.20	7.20	3.70	3.60	21.00	20.75	7-1/8	7½
C	5.80	5.90	4.70	4.70	38.00	37.75	13	13½

* One cup is equal to eight ounces by volume.

(iii) Measuring Devices: The following measuring devices were selected for use in this study:-

1) For Weighing: For weighing rice, beans, green gram dhal, tamarind, firewood, charcoal and wood chips, a balance with five pounds capacity was selected.

2) For Measuring Volume: For measuring volume of water and ash a measuring cup was used. A measuring cylinder graduated up to 100 cc for measuring the kerosene utilised for igniting the chula was also used.

3) For Measuring Time: For measuring time, a stop watch and a time piece were used.

4) For Measuring Temperature: For measuring the room temperature and water temperature, a Centigrade thermometer (0°C - 110°C) was used.

(iv) Foods Selected for Cooking:

1) Foods and their Quantities: Rice, green gram dhal and french beans were selected for cooking in this study because, meals in South India generally consist of a cereal, a pulse and a vegetable. The quantities of these foods taken for cooking were calculated on the basis of a day's requirements for a family of three adults, taken from Health Bulletin - 23 (1962)[15] as shown in Table III.

TABLE XII.

QUANTITIES OF FOODS REQUIRED FOR A FAMILY OF THREE ADULTS FOR A DAY.

Foods.	Amount in Ounces. Individual.	Total.
Cereals:		
Rice.	20	42
Ragi.	7	
Wheat flour.	15	
Pulses:		
Green gram dhal.	6	9
Red gram dhal.	3	
Green leafy vegetables:		
Cabbage.	9	12
Coriander leaves.	3	
Root vegetables:		
Carrot.	9	9
Other vegetables:		
French beans.	9	9
Fruits:		
Papaya.	9	9
Sugar and jaggery:		
Sugar.	4	6
Jaggery.	2	
Vegetable oil and ghee:		
Gingelly oil.	4	6
Ghee.	2	
Fish and meat:		
Fish.	9	9
Egg: Egg.	3 whole.	3 whole.

All the foods included in the menu were those commonly used by the average middle class families. The days menu was then planned as shown in Table IV, utilising the quantities given in Table XII.

TABLE IV.

THE DAYS MENU FOR A FAMILY OF THREE ADULTS.

Meal.	Menu and foods used in ounces.	
Breakfast:		
	Ragiputtu:	
	Ragi.	7
	Jaggery.	2
	Eggs.	3
	Coffee:	
	Sugar.	2
	Milk.	8
Lunch:		
	Rice.	14
	Green gram dhal.	6
	Ghee.	2
	Beans (Poriyal).	9
	Carrot (Salad).	9
	Coriander (chutney).	3
	Milk (curds).	14
	Pappaya.	9
Tea:		
	Kichidi:	
	Redgram dhal.	3
	Rice.	6
	Tea:	
	Milk.	8
	Sugar.	2
Dinner:		
	Chapathi:	
	Wheat flour.	15
	Cabbage (Poriyal).	9
	Fish.	9

From the days menu given in Table IV the lunch was selected as the typical meal for the cooking experiments in this study. Among the items listed for the lunch, rice, green gram dhal and french beans were selected as the other foods namely ghee, carrot, salad, coriander leaves chutney, curds and pappaya did not require cooking. The quantities of the foods so selected for cooking were:

Parboiled rice.	14 Ounces.
French beans.	9 Ounces.
Green gram dhal.	6 Ounces.

2) Purchase and Storage of Foods: It was estimated that 40 meals would be cooked for standardisation and experimentation. The quantities of foods selected were calculated accordingly, purchased in one lot, cleaned and stored in dry tin containers. The amounts of rice and dhal thus stored were 10 and 4½ Madras measures* respectively.

As french beans could not be stored for any length of time, 18 ounces-the amount required for cooking on both the chulas for a day-were bought on each day of experimentation.

(v) Firewood: Krishna and Ramaswamy (1932)[16] report that calorific value of woods depend upon their chemical composition and the quality and nature of deposits of

* One Madras measure is equal to eight cups.

During the preliminary experiments, three logs of firewood of approximately 1½ feet in length and 1½ inches in thickness were found to give a fairly steady flame when compared with two logs or four logs of similar size. Logs of the same size were selected, since the amount of surface of the firewood exposed to oxygen in the air makes a difference in kindling temperature and in the rate of burning as mentioned on page 4 . The three logs were weighed and the initial weight noted. The logs were then placed with their tips crossed together. The crossed position allowed good circulation of air, as the space between the logs was greater than that when the logs were placed next to or over each other. Two ounces of wood chips were then placed over the crossing of the logs, seven millilitres of kerosene poured over them and lighted with a match stick to start the fire. Two minutes after starting the fire, the utensils were kept on the pot seats and cooking was carried out according to the standardised procedure.

(ii) Extinguishing the Fire:- In order to calculate the amount of firewood used, the burning logs had to be extinguished, after the completion of cooking. For that purpose, the procedure standardised was as follows: After the utensils were removed from the pot seats on completion of cooking, the burning logs were taken out and pushed into a small heap of sand which was constant

for all the experiments, to extinguish the fire. The live charcoal pieces left in the chula were also taken out, put in a small aluminium utensil and covered to be extinguished. After an hour, the logs were removed from the sand shaken to remove the pieces of charcoal sticking to their ends. These charcoal pieces were added to the utensil in which the live charcoal had been left earlier. The remaining logs and the charcoal so collected were weighed separately and the weights of the logs and the charcoal were noted. The amount of firewood consumed was obtained by subtracting the final weight of the logs from the initial weight.

(iii) Cooking of Beans:- Beans is a good source of vitamin C, containing four milligrams of it per ounce (Aykroyd 1956)[15]. Therefore any method used for cooking of beans should be such that will help to retain the vitamin C. As pointed out by Fitch and Francis (1955)[17] the cooking water and time should be kept minimum to avoid the loss of vitamin C.

For cooking green vegetables Halliday and Noble (1939)[18] describe two general methods, which help to maintain their colour. The first one is the open kettle method, where the vegetable is dropped into boiling salted water, which is taken in quantities adequate to cover all parts of the vegetable completely. The boiling is continued until the vegetable becomes tender, preferably without a lid, to allow the volatile acids to pass

off in steam. The second and more recent method is pressure cooking. In this study the open kettle method was used for cooking the beans.

A seriesof preliminary experiments were conducted with both the chulas for determining the amounts of water to be added to, the time to be allowed for cooking the beans and the pot seats on which to be cooked. Nine ounces of beans were cut into ½ inch pieces and cooking on the second pot seat of each chula was tried first but it took a long time to cook and consequently, they lost colour. Hence cooking them on the first pot seat was adopted.

Experiments were conducted cooking beans with 1½, 1 and ¾ cups of water over the ordinary chula. It was observed that the amounts of time taken for cooking* were 17, 19 and 20 minutes respectively. In the case of the smokeless chula when 1½ cups of water were used the cooking time was 18 minutes, when 1 cup was used it was 19 minutes and when ¾ cup was used it was 20 minutes. When the cooked beans were examined it was observed that the samples cooked with ¾ cup of water for 20 minutes in both instances were most satisfactorily cooked, on the first pot seat.

With these findings the procedure standardised for cooking beans on both chulas was as follows: Beans were washed and cut into ½ inch pieces. In Utensil A, ¾ cup

*The time taken for cooking means the amount of time taken after the water resumed boiling with beans.

of water was placed on the first pot seat. When the water started boiling the cut beans were added. When the water resumed boiling along with beans, the time was noted and after twenty minutes of boiling, utensil A was removed with cooked beans from the fire.

(iv) Cooking of rice:- Parboiled rice is a good source of vitamin B_1 and nicotonic acid, having 60 milligrams and 1.1 milligrams of each respectively in one ounce. Hence any cooking method should be such that the loss of these nutrients is avoided. Aykroyd (1941-42)[19] states, "the losses on cooking depend to a great extent on whether cooking water is discarded or not."

Sweetman and Mackellar (1954)[20] recommend using only the amount of water which will be absorbed so that none will be left to be discarded and the maximum amounts of nutrients will be preserved. Therefore in this study rice was cooked with just sufficient water.

A series of experiments were conducted to arrive at the amount of water to be added and time to be allowed for cooking 14 ounces of rice. From the starting time until the beans were cooked and removed, utensil B with water for cooking rice was placed on the second pot seat. When the utensil A with cooked beans was removed from the first pot seat, utensil B was transferred to the first pot seat. Using 7, 6, 6½ and 6¼ cups of water for cooking rice on the ordinary chula experiments were conducted and it was observed that the amounts of time taken for

cooking were 33, 35, 38 and 40 minutes respectively. Similarly in the case of the smokeless chula 6, 5½ and 5¼ cups of water were used and the amounts of time taken for cooking were observed to be 45, 43 and 39 minutes respectively. When the cooked samples were examined the sample cooked on the ordinary chula for 40 minutes using 6¼ cups of water and the sample cooked on the smokeless chula for 43 minutes using 5½ cups of water were found to be most satisfactory. The difference in the amounts of water needed may be due to the rapid evaporation in the case of the ordinary chula as compared to the smokeless chula.

In the case of the ordinary chula, after 40 minutes, boiling on the first pot seat, utensil B with rice almost cooked, was retransferred to the second pot seat and kept there till the dhal got cooked in utensil C on the first pot seat.

In the case of the smokeless chula after 43 minutes boiling, the cooked rice was removed from the first pot seat along with the cooked dhal from the second pot seat.

Thus the standardised method of cooking rice used in this study was as follows:-

The utensils B of set I with 6¼ cups of water and of set II with 5½ cups of water were placed on the second pot seats of the ordinary chula and smokeless chula respectively. When beans were removed from the first pot seats, the utensils for rice were transferred to the first

pot seat from the second pot seat. The water was brought to boil. In the meantime rice was washed, drained and added to the boiling water. When the water resumed boiling with the rice, the time was noted. In the case of the ordinary chula after 40 minutes of boiling, utensil B with rice was retransfered to the second pot seat and kept there till the dhal in utensil C was cooked on the first pot seat. Then both utensils B and C were removed from the fire. In the case of the smokeless chula, after 45 minutes of boiling, utensil B with rice from the first pot seat was removed along with the cooked dhal in utensil C from the second pot seat.

(v) Cooking of dhal:- The customary method of boiling dhal with necessary amount of water was employed to cook six ounces of green gram dhal. To arrive at the correct amount of water to be added and the amount of time to be alloved for cooking, a series of experiments was conducted. In the case of the ordinary chula, until the utensil B with rice was retransferred to the second pot seat, utensil C for cooking dhal was kept on the second pot seat. When the utensil B with rice was retransferred to the second pot seat, utensil C was transferred to the first pot seat. While the water was being boiled, dhal was washed, drained in a colander and added to the water when it started boiling, noting the time. Experiments were conducted using 2½, 2, 1¾ and 1½ cups of water and the amounts of cooking time were observed to be 22, 20, 15 and 17 minutes respectively.

when the samples were examined, the product cooked with two cups of water for 20 minutes was found to be the most satisfactory one.

In the case of the smokeless chula utensil C was kept on the second pot seat itself till it was cooked and removed. Using 2½, 2, 1½ and 1¼ cups of water experiments were conducted cooking dhal. It was observed that the amounts of cooking time were 28, 25, 22 and 23 minutes respectively. When the samples were examined, the product obtained, when 1¼ cups of water were used and cooking time was 23 minutes, was found to be the most satisfactory. As the dhal and rice were cooked simultaneously over the second and first pot seats, both were removed together.

With these findings, the procedure standardised for cooking was as follows:-

In the case of the ordinary chula until the utensil B with rice was retransferred to the second pot seat, utensil C with two cups of water for cooking dhal was kept on the second pot seat. When the utensil B was re-transferred to the second pot seat, utensil C was trans-ferred to first pot seat. When the water boiled, the washed and drained dhal was added and the dhal was allowed to be cooked for 20 minutes and then removed from fire along with utensil B with rice from the second pot seat.

In the case of the smokeless chula the dhal was cooked on the second pot seat itself. One and half cups

of water were brought to boil and the washed and drained dhal was added to it, noting the time. After 25 minutes the utensil C with cooked dhal was removed from the fire along with utensil B with cooked rice.

The following table explains the position of the utensils A, B and C during cooking of beans, rice and dhal over the ordinary and smokeless chulas.

TABLE V.

THE POSITION OF THE UTENSILS A, B, C DURING THE COOKING OF BEANS, RICE AND DHAL OVER THE ORDINARY AND SMOKELESS CHULAS.

Types of chula.	Steps in cooking.	Utensil on the first pot seat.	Utensil on the second pot seat.
Ordinary chula.	When the cooking was started.	Utensil A for beans.	Utensil B for rice.
	After beans were cooked and removed.	Utensil B for rice.	Utensil C for dhal.
	From when rice was almost cooked till the end of cooking.	Utensil C for dhal.	Utensil B for rice.
Smokeless chula.	When the cooking was started.	Utensil A for beans.	Utensil B for rice.
	After the beans were cooked and removed till the end of cooking.	Utensil B for rice.	Utensil C for dhal.

As can be seen in Table V the number of steps in cooking involved with the use of ordinary chula was three while it was only two in the case of the smokeless chula.

It may be pointed out that the utensils were not covered during cooking, because open cooking is preferred in the case of beans to allow the volatile acids to pass

off, and in the case of rice and dhal, water boiled over during cooking, if kept covered.

The cooked rice, dhal and beans were not seasoned in this study, since the objective of comparing the time taken with both chulas could be achieved even without seasoning, which in any case would have introduced another variable in the study.

(vi) Judging the Palatability of Cooked Foods:- Whatever may be the equipment used, and method of cooking employed, the cooked product should be palatable. Therefore it was considered necessary to judge the palatability of the cooked rice, dhal and beans in this study.

Mason (1939)[21] classifies the methods of testing the palatability of foods as 'subjective' and 'objective'. By the subjective methods, the quality is determined largely through sense organs and is affected by the opinions of the judges who taste the foods. By the objective methods the quality can be determined by means of various measuring devices, such as colour comparators to compare the colour of two products and photographs to compare fluffiness. Generally speaking, such mechanical devices for measuring a given quality of food are expensive and take time to perfect.

The subjective methods are satisfactory when the purpose is to detect the differences in quality and when the differences in quality are obvious as in this study. For subjective tests, score cards are developed for the

use of the judges to rate the products. Scoring consists of evaluating on a pre-established numerical basis, single or combinations of quality factors of a food product.

1. Score Cards:- There are many varieties of score cards for different foods and different purposes. In this study, a descriptive score card was developed and used, where each quality to be tested is graded, not in terms of numerical values, but by adjectives as suggested by Mason (1939)[21]. While computing the results, a numerical value was assigned to each of the adjectives. The score card developed in this study, given in Appendix II, was on a five point scale, and the adjectives describing the quality were given in a form of check list to make the mechanics of scoring as easy as possible for the judges who are busy with other work. The following characteristics were to be adjudged, using this score card:

Rice	-	Appearance. Smell. Texture. Taste.
Dhal	-	Texture. Smell. Taste.
Beans	-	Texture. Colour. Smell. Taste.

2. Judges:- The desirable number of judges depends to some extent upon the purpose of scoring. Love (1955)[22] expresses, "A small panel of high sensitivity and ability

to differentiate perceptions may be preferable to a large panel of less sensitivity". Hence, a panel of three experienced judges were requested to score the foods.

3. Methods of Judging:- As proper environment and good lighting are two of the conditions necessary for sound scoring, a well lighted room where the environment was conducive for concentration was selected for carrying out the scoring. The cooked rice, dhal and beans were served immediately after cooking was completed on uniform white porcelain quarter plates, one item in each, in identical quantities. On each plate, one teaspoon was placed. Foods were served as the judges were arriving, to avoid exposure to air, and to maintain the warmness of foods. Judges were seated comfortably and at a considerable distance from each other, so that facial expressions of one judge would not influence the judgement of others. As recommended by Love (1955)[22], each judge was given a glass of water and was requested to rinse the mouth before tasting each sample, to remove the flavour of one sample before the second was tasted.

(vii) <u>Washing the Utensils After Cooking</u>:- The amounts of soot accumulated and deposited on the utensils used for cooking over the ordinary chula and the smokeless chula were found to differ from each other. In the case of the utensils placed on the ordinary chula, the de-

position of soot was much greater than that on the utensils placed on the smokeless chula, in which case, only a thin layer of soot was seen on the bottom of the utensils. In order to find out the difference in the amounts of time involved in washing the two sets of utensils after cooking, the following procedure was adopted.

After some preliminary experiments, the amounts of the cleaning materials used for cleaning utensils after cooking were standardised as given in Table VI.

TABLE VI.

AMOUNTS OF CLEANING MATERIALS USED FOR CLEANING UTENSILS AFTER COOKING.

Utensils.	Ash in cups.	Tamarind in Ounces.	Coconut fibre bits.	Water in gallons.
Utensils used on the ordinary chula.	1/3	1/2	2	1½
Utensils used on the smokeless chula.	¼	¼	2	1½

The ash used in the case of the utensils from the smokeless chula was less than the amount used for utensils from the ordinary chula because the soot deposited on the utensils from the smokeless chula was much less.

Method:- The utensils were emptied of the cooked contents and placed in the sink. A cup of water was sprinkled on them. Using part of the ash they were scrubbed with the aid of the coconut fibre to remove the soot. Then ash and tamarind were applied and the utensils were scrubbed

for the second time till they became bright and clean. Finally they were rinsed thoroughly with water. This procedure was followed for both the sets of utensils using fresh amounts of cleaning materials for each set. The time taken for the first scrubbing, for applying tamarind and ash for the second scrubbing, and for the final rinsing was standardised for each set after a series of preliminary experiments, as given in Table VII.

TABLE VII.

THE STANDARDISED AMOUNTS OF TIME TO WASH THE TWO SETS OF UTENSILS AFTER COOKING.

	Time in Minutes.	
	Utensils used on the ordinary chula.	Utensils used on the smokeless chula.
First scrubbing.	15	2
Applying tamarind and ash.	1½	1½
Second scrubbing.	5	2½
Rinsing with water.	2½	2
Total.	24	8

The total time taken differed from each other, as the utensils used on smokeless chula collected much less soot than in the case of the utensils used on the ordinary chula and hence needed much less time in scrubbing.

(c) Conducting the Experiments.

(1) Preliminary Preparation: Two batches of food ingredients each batch consisting of nine ounces of fresh french beans, 15 ounces of rice and six ounces of green gram dhal were taken for cooking on each chula.

water and placed in a colander to be drained. When the water in utensil B began to boil, the rice from the colander was added. The time was noted, when the water in utensil B resumed boiling along with the rice, forty minutes after which the utensil was re-transferred to the second pot seat and utensil C was placed on the first pot seat. While the rice was getting cooked on the second pot seat, the dhal was washed with two cups of water and placed in a colander. When the water in utensil C began to boil, the washed dhal from the colander was added. When the water with the dhal resumed boiling in utensil C, the time was noted and 20 minutes afterwards, both the utensils B and C were removed from the fire, noting the final time $t_2(0)$*. At this stage, the cooking of the foods was complete and the amounts $W_2(0)$** and $W_3(0)$*** of firewood and charcoal left behind respectively were calculated as described on page .

The time consumed for cooking was then calculated by subtracting the initial time $t_1(0)$ from the final time $t_2(0)$.

(ii) Cooking on Smokeless Chula: To the utensils A, B, C of the Set II three-quarter cup, five and three-quarter cups and one and a half cups of water were added

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*$t_2(0)$ is the starting time of cooking on the ordinary chula.

**$W_2(0)$ is the weight of firewood left behind after cooking in the ordinary chula.

***$W_3(0)$ is the weight of charcoal left behind after cooking the ordinary chula.

respectively. The initial weight $W_1(S)^*$ of the firewood was noted. The beans were washed, drained in a colander and cut into half inch pieces just before lighting the smokeless chula.

The smokeless chula was lighted in the same manner as the ordinary chula, 15 minutes after starting the ordinary chula, in order to coincide with the time of completion of cooking, for both the chulas. After two minutes of lighting, the utensils A and B were kept on the first and second pot seats respectively and the time of starting, that is the initial time, $t_1(S)^{**}$ was noted.

When the water in utensil A started boiling, the cut pieces of beans were added. When the water with the beans started boiling again, the time was noted, and after 20 minutes, when the beans were completely cooked, utensil A was removed from the chula. Utensil B was transferred from the second pot seat to the first pot seat and utensil C was placed on the second pot seat. Rice was washed as in the case of the ordinary chula, and when the water in utensil B started boiling, the washed, drained rice was added, and the time noted. The dhal was also washed as in the case of the ordinary chula and added to utensil C when the water in it started boil-

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*$W_1(S)$ is the initial weight of firewood used in the smokeless chula.

**$t_1(S)$ is the starting time of cooking on the smokeless chula.

ing and the time noted. Forty three minutes after the water started boiling with rice, both the utensils B and C containing rice and dhal were removed from the first and second pot seats respectively noting the final time $t_2(S)$*. The logs and charcoal were put off and their weights $W_2(S)$** and $W_3(S)$*** respectively were noted as in the case of the ordinary chula. The amounts of time and firewood consumed were also calculated as in the case of the ordinary chula.

(iii) Judging the palatability of the Cooked Foods: The foods cooked on the ordinary chula and the smokeless chula were served to the judges for tasting as described on page 40.

(iv) Washing the Utensils After Cooking: After tasting was over, the foods were removed from the utensils and the utensils were washed using the standardised amounts of cleaning materials and procedure, as described on page . The time consumed for washing each set of utensils was noted.

(vi) The Availability of Heat from the Different Pot Seats: In the above experiments, it was observed that in the case of the smokeless chula, dhal got cooked

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* $t_2(S)$ is the time of completion of cooking on the smokeless chula.

** $W_2(S)$ is the weight of firewood left behind after the cooking on the smokeless chula.

*** $W_3(S)$ is the weight of charcoal left after the cooking in the smokeless chula.

completely while it was on the second pot seat, whereas in the case of the ordinary chula, even the water for dhal did not boil. Therefore this experiment was carried out to find out the actual amounts of heat available at the first and second pot seats in both the chulas.

Two clean utensils of almost identical dimensions, shape and weight made of the same material (brass) were taken. In each of them 10 cups of water was placed. A thermometer was hung with its mercury bulb immersed in water, in each utensil. The initial temperature of the water was noted before starting the chula.

Three pounds of firewood were taken, consisting of three logs of approximately equal size and the chula was lighted as described on page 29. The two utensils were placed on the first and second pot seats respectively.

At the end of every three minutes, the temperature of the water in both the utensils was noted. The three minutes interval was selected in order to get a fairly large number of readings to indicate the trend of the rapidity of water getting heated.

The experiment was repeated three times on each chula alternating the time of cooking every day; that is, on the first day, the smokeless chula was used in the morning and the ordinary chula was used in the afternoon. On the next day, the order was reversed, using the ordinary chula in the morning and the smokeless chula in the afternoon. This alternation was effected in

order to minimise the changes due to climatic conditions.

The heat available at each pot seat was calculated by adding the heat gained by the utensil and the heat gained by the water in the utensil, when its temperature was raised from the initial value to the final value.

Edser (1950)[25] points out that if the mass of the utensil is m_1, the specific heat of the material of the utensil is s_1, and the increase in temperature is t_1; then the heat gained by the utensil is $m_1 s_1 t_1$. Similarly if the mass of water in the utensil is M_1, its specific heat S_1 and the increase in temperature T_1; then the heat gained by the water is $M_1 S_1 T_1$. Then the heat available at that pot seat will be -

$$m_1 s_1 t_1 + M_1 S_1 T_1$$

In this case as the increase in temperature for both utensil and water in it is the same, the above formula may be written as -

$$(m_1 s_1 + M_1 S_1)t$$

where t is the increase in temperature of both the utensil and the water. As the specific heat of water is one, the formula can be simplified as $(m_1 s_1 + M_1)t$.

The above procedure is adopted to calculate the heat available at each pot seat separately.

IV. RESULTS AND DISCUSSION

The results and discussion in the following pages include the total time consumed and fuel consumed for cooking beans, rice and dhal, time consumed for washing the utensils after cooking, palatability of the cooked foods and the heat availability at different pot seats of both the chulas, by which the suitability of the ordinary and smokeless chulas as cooking devices was studied.

(a) Time Consumed for Cooking.

From the readings of the experiments recorded in Appendix IIA the total time taken for cooking beans, rice and dhal over both the ordinary chula and the smokeless chula is given in Table VIII.

TABLE VIII.

TOTAL TIME TAKEN FOR COOKING BEANS, RICE AND DHAL OVER THE TWO CHULAS.

Replicates.	Time in Minutes.		
	Ordinary chula.	Smokeless chula.	Difference.
1	98.00	84.00	14.00
2	101.00	87.00	14.00
3	97.00	83.00	14.00
4	99.50	85.00	14.50
Average.	98.37	84.75	14.12

These figures given in Table VIII were statistically analysed to find the F ratio. (F is a ratio of the variance between the experimental variables and within replicates.) (Snedecor 1946)[24]. If F, the probability of

TABLE XI.

ANALYSIS OF VARIANCE FOR THE FUEL CONSUMED FOR COOKING OVER THE TWO CHULAS IN FOUR REPLICATES.

Source of variation.	Sum of squares.	Degree of freedom.	Mean square.	
Between chulas.	441.6424	1	441.6424	$F = 299.80$
Within replicates.	8.8184	6	1.4697	$P < .01$

Thus the statistical appraisal revealed that the difference was very significant as indicated in Table XI.

The saving of firewood in the case of the smokeless chula was 14.67 ounces which amounted to 30.74 per cent of the fuel consumed by the ordinary chula. This saving of the firewood may be attributed to the more efficient utilisation of heat in the smokeless chula than in the ordinary chula. Two possible factors which might have facilitated the effective utilisation of heat are: (i) Great availability of heat due to the minimisation of loss of heat due to radiation caused by the projections on the pot seats and (ii) Better distribution of heat between the pot seats. Although the heat available at the first pot seat of the ordinary chula was higher than that available at the first pot seat of the smokeless chula, the heat available at the second pot seat of the smokeless chula was much higher than that available at the second pot seat of the ordinary chula as shown on page 61 . Child and Niles (1937)[25] have shown that when once water starts boiling the amount of heat required

to maintain the boiling point is much lower than that required to bring it to boiling. Therefore the application of large quantities of heat, after boiling has commenced, is superfluous, the heat being unutilised resulting in wastage of fuel. Such application besides being wasteful in terms of fuel, may lead to the boiling over of the foods because of the enhanced rate of boiling. In the case of the smokeless chula, though less heat was available at the first pot seat as compared to that of the ordinary chula, that amount of heat was adequate to bring the water to boiling point and maintain it boiling for the completion of the cooking of rice. This principle explains also the cooking of the dhal completed on the second pot seat itself on the smokeless chula.

Thus the distribution of the amount of available heat between the two pot seats of the smokeless chula was more favourable for cooking rice and dhal than that of the ordinary chula.

Cost of the Firewood: On an average the firewood utilised to cook the standardised meal, was 48.36 ounces in the case of the ordinary chula and 33.50 ounces in the case of the smokeless chula resulting in a saving of 14.87 ounces as shown in Table X. Assuming that three meals a day are cooked for a family the saving per month would be -

14.87 x 3 x 30 = 83.59 pounds (in 30 days).

Calculating at the rate of 4.37 Naye Paise per pound

UTENSILS WITH SMOKE AFTER THE COMPLETION
OF COOKING ON BOTH CHULAS

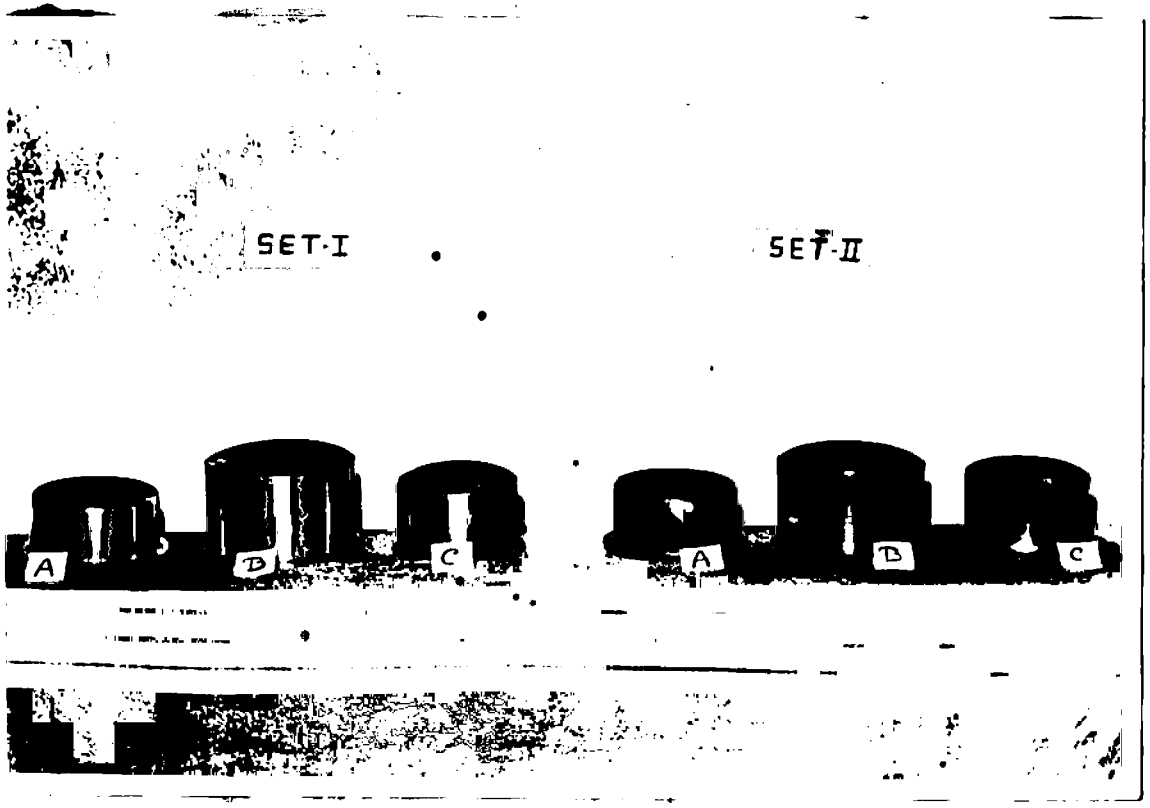

FIGURE 8

SET I .. UTENSILS USED ON SMOKELESS CHULA

SET II .. UTENSILS USED ON ORDINARY CHULA

TABLE XII.

TIME CONSUMED IN WASHING THE UTENSILS.

Replicates.	Time in Minutes. Ordinary chula.	Smokeless chula.	Difference.
1	23.75	8.00	15.75
2	24.00	7.75	16.25
3	24.50	8.00	16.50
4	24.00	8.00	16.00
Average.	24.06	7.94	16.12

These figures in Table XII were statistically analysed and Table XIII shows the analysis of variance applied to them.

TABLE XIII.

ANALYSIS OF VARIANCE OF THE TIME CONSUMED IN WASHING THE UTENSILS IN FOUR REPLICATES.

Source of variation.	Sum of squares.	Degree of freedom.	Mean square.	
Between chulas.	519.7088	1	519.7088	F = 9069
Within replicates.	0.3438	6	0.0573	P < .01

The analysis of variance indicates that the F ratio is very significant as is shown in Table XIII. The time saved through the use of the smokeless chula was 16.12 minutes on an average and this amounted to 66.80 per cent of the time consumed for washing the utensils used on the ordinary chula.

(d) Palatability of the Foods Cooked.

The scores awarded by the panel of judges to the beans, rice and dhal are given in Appendix IV and summarised in Table XIV.

TABLE XIV.

AVERAGE SCORES AWARDED TO THE FOODS COOKED ON THE ORDINARY AND SMOKELESS CHULAS.

Food.	Qualities.	Scores. Ordinary chula.	Scores. Smokeless chula.
Rice.			
	Appearance.	3.91	4.00
	Smell.	4.91	5.00
	Texture.	4.00	4.58
	Taste.	4.16	4.49
	Total.	16.18	18.07
Dhal.			
	Texture.	3.58	4.58
	Smell.	4.83	5.00
	Taste.	3.83	4.58
	Total.	12.24	14.16
Beans.			
	Texture.	4.25	4.25
	Colour.	4.00	4.00
	Smell.	5.00	5.00
	Taste.	4.25	4.25
	Total.	17.50	17.50

The figures in Table XIV show that the qualities of the products cooked over the smokeless chula are superior to those of the products cooked over the ordinary chula.

Table XV gives the summary of the levels of significance of the difference between the various qualities of the foods cooked over the ordinary chula and the smokeless chula.

TABLE XV.

A SUMMARY OF THE LEVELS OF SIGNIFICANCE OF THE DIFFERENCES BETWEEN SCORES OF THE VARIOUS QUALITIES OF THE FOODS.

Quality.	Difference between the scores of: Individual qualities. F	Level of significance.	Total qualities. F	Level of significance.
Rice.			26.72	Very significant.
Appearance.	0.097	Not significant.		
Smell.	1.10	Not significant		
Texture.	7.637	Significant.		
Taste.	35.01	Very significant.		
Dhal.			32.85	Very significant.
Texture.	19.5			
Smell.	0.913	Not significant		
Taste.	34.26	Very significant		
Beans.				
Texture.	Calculation of significance level does not arise as there is no difference in the scores obtained by the various qualities of beans cooked over ordinary chula and smokeless chula.			
Colour.				
Smell.				
Taste.				

As revealed by the statistical appraisal and indicated in Table XV the difference between the scores for texture of rice cooked on both the chulas is significant. The difference between the scores for taste of rice cooked on both chulas is very significant. In the case of the texture and taste of dhal the differences are found to be very significant.

When the scores of the total qualities of foods cooked on the two chulas were analysed statistically it was found that the differences are very significant in the case of rice as well as dhal. In the case of beans the analysis of significance level did not arise as there was no difference between the scores obtained by beans cooked over both

the chulas.

The reasons for the superior quality obtained by the rice and dhal when cooked over the smokeless chula, may be attributed to the suitability of slow heating for cooking starches and proteins as pointed out by Todhunter (1958)[26]. In the case of starches, slow heating also helps to develop a pleasing flavour and a slightly sweet taste due to the partial conversion of starch to sugar. In the case of proteins, the higher the temperature of cooking the harder they become due to coagulation. Therefore use of low temperatures is generally recommended for cooking proteins.

(e) Heat Availability at Different Pot Seats of the Ordinary Chula and the Smokeless Chula.

The detailed record of all readings involved in the experiment on heat availability at different pot seats of the chulas is given in Appendices V and VI. The amounts of time taken for 10 cups of water to be boiled at different pot seats of the ordinary and smokeless chulas are given in Table XVI.

TABLE XVI.

TABLE SHOWING THE TIME AT WHICH THE WATER BOILED ON THE FIRST AND SECOND POT SEATS OF THE ORDINARY CHULA AND THE SMOKELESS CHULA.

Replicates.	Time in Minutes.			
	Ordinary chula.		Smokeless chula.	
	First pot seat.	Second pot seat.	First pot seat.	Second pot seat.
1	20.50	Never boiled.	28.75	54.00
2	20.00	Never boiled.	29.50	55.00
3	19.50	Never boiled.	30.00	54.25
Average.	20.00		29.75	54.41

From Table XVI it is seen that the temperature of the water on the second pot seat of the ordinary chula did not boil and from Appendix V it is seen that the temperature did not rise by above 3.5°C even at the end of one hour.

As to the actual amount of heat available, Table XVII, gives the total B.T.U.* available at the different pot seats at the end of eighteen minutes.**

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* B.T.U. (British Thermal Unit is the quantity of heat required to raise one pound of water through one degree Fahrenheit.

** Eighteenth minutes was taken as the upper limit because the time at which water boiled on the first pot seat being 19.5 minutes in one of the replicates, falls in the seventh class interval which is from the 19th minute till the end of the 21st minute. Therefore the last completed class interval is the sixth class interval - from fifteenth to eighteenth minute. Therefore eighteenth minutes was taken as the upper limit.

TABLE XVII.

TABLE SHOWING THE NUMBER OF B.T.U. AVAILABLE AT THE FIRST AND SECOND POT SEATS OF THE ORDINARY CHULA AND THE SMOKELESS CHULA.

Replicates.	Heat in B.T.U.					
	Ordinary chula.		Smokeless chula.		Total.	
	First pot seat.	Second pot seat.	First pot seat.	Second pot seat.	Ordinary chula.	Smokeless chula.
1	547.94	6.90	396.22	183.96	554.84	580.18
2	541.45	9.20	400.84	193.17	550.65	594.01
3	571.36	6.90	394.44	183.96	578.26	578.40
Average.	553.58	7.66	397.16	187.03	561.25	577.51

From the Table XVII, it can be seen that the actual amount of heat available is the greatest at the first pot seat of the ordinary chula being 553.58 B.T.U. on an average. The amount of heat available at the first pot seat of the smokeless chula is only 7.66 B.T.U. as contrasted with the 187.03 B.T.U. available at the corresponding second pot seat of the smokeless chula.

As mentioned on page the higher amount of the heat available at the second pot seat of the smokeless chula than at the second pot seat of the ordinary chulahad been responsible for the saving of time and fuel effected in the case of the former.

(f) Other Observations.

Table XVIII gives the amounts of charcoal collected from the ordinary and smokeless chulas as described on page .

TABLE XVIII.

CHARCOAL LEFT AFTER COOKING IN THE ORDINARY AND SMOKELESS CHULAS.

Replicates.	Charcoal in Ounces.		
	Ordinary chula.	Smokeless chula.	Difference.
1	4.00	1.50	2.50
2	4.25	1.50	2.75
3	4.50	1.00	3.50
4	5.00	2.00	3.00
Average.	4.44	1.50	2.94

From Table XVIII it is seen that the average amount of charcoal left in the case of the ordinary chula was 4.44 ounces and 1.5 ounces in the case of the smokeless chula. The excess of charcoal left in the case of the ordinary chula may be due to two factors. Firstly, the firewood consumed in the case of the ordinary chula was 14.86 ounces more than that in the smokeless chula. Therefore, the amount of charcoal left might have been larger. Secondly, the incomplete combustion in the ordinary chula would have resulted in a large amount of charcoal left unburnt.

The smoke coming out of the ordinary chula, accumulated in the kitchen causing irritation to the eyes and nose, whereas no smoke was found escaping out of the smokeless chula into the kitchen.

In the case of the smokeless chula, as the flames were not surrounding the utensils, the hotness felt by the hands while removing the utensils was less than in the case of the ordinary chula, in which case, much care had to be exercised in order to avoid the flames scorching the hands.

The rice cooked in the smokeless chula had the grains relatively bigger and loosely packed in comparison to the rice cooked on the ordinary chula. The charring of foods at the bottom of the utensils during cooking was greater in the case of the foods cooked over the smokeless chula.

V. SUMMARY AND CONCLUSION.

1. The ordinary chula which is commonly used for cooking in most homes in India has defects such as the absence of a properly channelled smoke exit and soot accumulation around the utensils. In order to remedy these defects, attempts are being made to evolve more efficient and inexpensive types of smokeless chulas. However scientific evidence available regarding the various advantages claimed by the designers of these chulas is negligible. This study on some management aspects of the ordinary chula and smokeless chula in terms of their efficiency as cooking devices was therefore undertaken.

2. A baked clay two pot seat ordinary chula and a portable Magan smokeless chula were selected for the study.

3. Rice, dhal and beans were cooked on the chulas and the amount of time taken for cooking, fuel consumed, the time taken for cleaning the utensils after cooking and the quality of the foods cooked were compared.

4. The amount of time saved in cooking the three foods by the use of the smokeless chula averaged 14.12 minutes and amounted to 14.23 per cent of the time taken over the ordinary chula.

5. The amount of fuel saved by the use of the smokeless chula was 14.87 ounces and this amounted to 30.74 per cent of the amount of fuel consumed by the ordinary chula.

6. The amount of time saved in washing utensils by using smokeless chula was 16.12 minutes which amounted to 66.8 per cent of the amount of time taken in washing the utensils used over the ordinary chula.

7. From the analysis of variance of the scores awarded by the tasting panel to the cooked foods it was revealed that the quality of rice and dhal cooked over the smokeless chula was very significantly superior to the quality of the rice and dhal cooked over ordinary chula. The difference between the scores of beans cooked over ordinary chula and smokeless chula was not significant.

8. The experiment conducted to find the actual amounts of heat available at the different pot seats of the chulas revealed that the amount of heat available at the first pot seat of the ordinary chula was higher than that available at the first pot seat of the smokeless chula. The amount of heat available at the second pot seat of the ordinary chula was very low when compared to the amount of heat available at the second pot seat of the smokeless chula.

In conclusion, it can be said that the portable Magan smokeless chula is superior to the ordinary chula as regards the various management aspects studied.

BIBLIOGRAPHY

1. A BETTER HOME FOR THE RURAL FAMILY, Farm Information Unit, Directorate of Extension, Ministry of Food and Agriculture, New Delhi, p. 1.

2. Raju, S.P., SMOKELESS KITCHENS FOR THE MILLIONS, The Christian Literature Society, Madras.3, 1957, pp. 2, 4.

3. INDIA 1960, The Publications Division, Ministry of Information and Broadcasting, Government of India, 1960, p. 183.

4. Gurusamy, R., MAGAN CHOOLA, Gandhiniketan Ashram, T. Kallupatti, Madurai District, 1955, p. 5.

5. Nandas, RURAL HEALTH-REPORTS ON THE EXPERIMENTS WITH VARIOUS DESIGNS OF SMOKELESS CHULA, P.R.A.I., Publication No.146, Planning Research and Action Institute, Planning Department, Uttar Pradesh, 1958, pp. 3-11, 16-18.

6. Deming, H.G., GENERAL CHEMISTRY, John Wiley & Sons, Inc., New York, 1952, pp. 63, 84.

7. Black, N.H., and Conant, J.B., NEW PRACTICAL CHEMISTRY, The Macmillan Company, New York, 1956, p. 425.

8. Devadas, R.P., A SMOKELESS CHULA FOR EVERY HOME, Extension, The Farm and Farm Home Magazine, Vol.1, No.3, 1960, p. 24.

9. Wood, G.C., and Carpenter, H.A., OUR ENVIRONMENT - HOW WE USE AND CONTROL IT, Allyn and Bacon, New York, 1948, p. 219.

10. Harcum, C.C., THE HUMAN KITCHEN, J.H.S., Vol. 13, 1921, p. 507.

11. Kumarappa, J.C., MAGAN CHOOLA, Akhil Bharat Sarva Seva Sangh, Maganwadi, Wardha, 1960, pp. i, ii, 1.

12. Narain, B., SMOKELESS CHULA, Manuel of Health, C.P.A. Series, No.32, Issued by Community Projects Administration, Government of India, 1954, Appendix pp. XIV, XV.

13. Venkatathan, P.S., DOMESTIC FUELS IN INDIA, Asia Publishing House, Bombay, 1959, pp. V, VII, 15.

14. Master, J.A., THE MADRAS STATE FOREST [illegible], Forest Centenary of Forest Administration in the Madras State Souvenir, Madras Forest Department, 1959, p. 9.

15. Aykroyd, W.R., THE NUTRITIVE VALUE OF INDIAN FOODS AND THE PLANNING OF [illegible] DIETS, Health Bulletin No.23, Manager of Publications, Government of India Press, Delhi, 1962, pp. 16, 28, 29, 38, 39.

16. Krishna, [illegible], and [illegible]swamy, [illegible], CHEMICAL VALUE OF SOME INDIAN FOODS, Forest Bulletin No.79, Government of India Central Publication Branch, Calcutta, 1932, pp. 1-4.

17. Fitch, W.E., and Francis, [illegible], FOODS AND PRINCIPLES OF COOKERY, Prentice Hall, Inc., New York, 1959, p. 24[illegible].

18. Halliday, E.G., and Noble, I.A., HOWS AND WHYS OF COOKING, The University of Chicago Press, Chicago, 1959, pp. 4, 5.

19. Aykroyd, W.R., INDIAN DIETS AND THEIR IMPROVEMENT, Reprinted from Nutrition Abstracts and Reviews, Vol. 11, Aberdeen University Press, Aberdeen, 1941-42, pp. 174, 175.

20. Sweetman, M.D., and Mackellar, I., FOOD SELECTION AND PREPARATION, John Wiley & Sons Inc., 1954, p. 522.

21. Mason, E.M., INTRODUCTION TO EXPERIMENTAL COOKERY, McGraw Hill Book Co., Inc., 1939, pp. 30-41.

22. Lowe, B., EXPERIMENTAL COOKERY, Chapman and Hall Ltd., London, 1955, pp. 41, 42.

23. Eaker, E., HEAT FOR ADVANCED STUDENTS, Macmillan & Co., Ltd., London, 1950, p. 123.

24. Snedecor, [illegible]., STATISTICAL METHODS, The Iowa State College Press, Iowa, 1956, pp. 217-219.

25. Child, A.M., and Niles, K.B., FOOD PREPARATION [illegible] FOODS, John Wiley & Sons Inc., New York, 1932, p. 7.

26. Todhunter, E.N., EVERY DAY NUTRITION, Whitcombe and Tombs Ltd., London, 1958, pp. 123-125.

APPENDIX I

SPECIAL FEATURES OF SOME OF THE SMOKELESS CHULAS USED IN PREVIOUS STUDIES

Name of the Chula	No. of pot seats	Diameter of Pot seats in inches: First pot seat	Second pot seat	Third pot seat	Diameter of Chimney pipe in inches	Width of the fuel mouth in inches	Distance in inches between: First & second pot seats	Second & third pot seats	Last pot seat and the Chimney
Study Conducted by Planning Research and Action Institute *									
Maju	3	7	7	12	6	6	3	3	3
Mysore	3	6	6	6	Not given	6	3	3	3
Etawah	2	6	6	-	4	8	3	-	3
Nagan	3	7	7	7	4	6	3	3	3
Bulandshah	2	7	6	-	4	Not given	Not given	Not given	Not given
Bakshi-ka-Talab	2	7	6	-	4	7	3	-	5
Study Conducted by Etawah Pilot Project **									
Etawah	2	6	5	-	4	8	Not given	Not given	Not given

* Dimensions of some of the chulas included in the study as described by Nandas (1958)[5]

** Dimensions of the Etawah smokeless chula as given by Narain (1954)[12]

APPENDIX II.

SCORE CARD FOR RICE, DHAL AND BEANS.

Date:

Scorer:

Kindly judge and tick against one quality which describes the product best under each heading.

		Sample I.	Sample II.
Rice:			
Appearance.	Grains separate.		
	One or two grains sticking together.		
	Grains sticking together in small lumps.		
	Grains sticking together in big lumps.		
	Product pasty.		
Smell.	Smell of well cooked rice.		
	Smell of uncooked rice.		
	Slight foreign smell, such as burnt or smoked.		
	Fairly strong foreign smell.		
	Very strong foreign smell.		
Texture.	Well cooked.		
	Fairly well cooked.		
	Slightly under cooked.		
	Slightly over cooked.		
	Uncooked.		
	Overcooked.		

		Sample I.	Sample II.
	Taste.	Very good.	
		Good.	
		Bland.	
		Bad.	
		Very bad.	
Dhal:			
	Texture.	Well cooked.	
		Fairly well cooked.	
		Just cooked.	
		Slightly undercooked.	
		Slightly overcooked.	
		Uncooked.	
		Overcooked.	
	Smell.	Smell of well cooked dhal.	
		Smell of uncooked dhal.	
		Slight foreign smell, such as burnt or smoked.	
		Fairly strong foreign smell.	
		Very strong foreign smell.	
	Taste.	Very good.	
		Good.	
		Bland.	
		Bad.	
		Very bad.	
Beans:			
	Texture.	Well cooked.	
		Fairly well cooked.	
		Just cooked.	
		Slightly under cooked.	
		Slightly over cooked.	
		Uncooked.	
		Over cooked.	

		Sample I.	Sample II.
Colour.	Natural green.		
	Almost natural green.		
	Fairly greenish.		
	Slightly brownish.		
	Brown.		
Smell.	Smell of well cooked beans.		
	Smell of uncooked beans.		
	Slight foreign smell, such as burnt or smoked.		
	Fairly strong foreign smell.		
	Very strong foreign smell.		
Taste.	Very good.		
	Good.		
	Bland.		
	Bad.		
	Very bad.		

Other comments.

APPENDIX IV

AVERAGE SCORES AWARDED TO THE FOODS COOKED ON THE ORDINARY AND SMOKELESS CHULAS.

Item			Ordinary Chula	Smokeless Chula
1. Rice:	a) Appearance:	Replicate 1	3.66	4.00
		" 2	4.00	4.33
		" 3	4.33	4.00
		" 4	3.66	3.66
		Total	15.65	15.99
	b) Smell:	Replicate 1	5	5
		" 2	5	5
		" 3	5	5
		" 4	4.66	5
		Total	19.66	20
	c) Texture:	Replicate 1	4	4.33
		" 2	4	4.65
		" 3	3.66	4.33
		" 4	4.33	5.00
		Total	15.99	18.32
	d) Taste:	Replicate 1	4.33	4.33
		" 2	4	4.33
		" 3	4.33	4.66
		" 4	4	4.66
		Total	16.66	17.98
2. Dhal:				
	a) Texture:	Replicate 1	3.66	4.33
		" 2	3.33	5
		" 3	4	4.66
		" 4	3.33	4.33
		Total	14.32	18.32
	b) Smell:	Replicate 1	4.33	5
		" 2	5	5
		" 3	5	5
		" 4	5	5
		Total	19.33	20
	c) Taste:	Replicate 1	4	4.66
		" 2	4	4.66
		" 3	3.66	4.66
		" 4	3.66	4.33
		Total	15.32	18.31

APPENDIX IV Contd:-

Item			Ordinary Chula	Smokeless Chula
3. Beans:				
a) Texture:	Replicate	1	4.33	4
	"	2	4	4.66
	"	3	4.66	4.66
	"	4	4	3.66
		Total	16.99	16.98
b) Colour:	Replicate	1	4.66	3.66
	"	2	4	4.33
	"	3	4	4
	"	4	3.33	4
		Total	15.99	15.99
c) Smell:	Replicate	1	5	5
	"	2	5	5
	"	3	5	5
	"	4	5	5
		Total	20	20
d) Taste:	Replicate	1	4.66	4
	"	2	4	4.33
	"	3	4	4.33
	"	4	4.33	4.33
		Total	16.99	16.99