EXTENT OF USE OF COWDUNG GAS AS A HOUSEHOLD FUEL IN COIMBATORE DISTRICT

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I INTRODUCTION

Agriculture in India is not only a way of life but also a way of making a living. About half of the country's national income is derived from the agricultural and allied activities which are the main activities of the rural India.

In rural India where more than 83 per cent of the people live on agriculture the need for improving the animal husbandry is important since it is an integral part of a sound system of diversified agriculture. Among the several schemes of animal husbandry importance has been given for cattle improvement since the cow is a biological mechanism of great versetality and its waste products are of great economic value as manure and fuel.

The census of 1970 has calculated that the cattle strength in India is 17.6 crores and the amount of fresh dung available from the animals is estimated at over 120 crores tonnes per year. But Khanna (1975) states that over 50 per cent of the available total dung is now dried and burnt as fuel. This is a serious loss to the development of the rural areas as it affects its growth of economy.

Upliftment of the rural economy through Khadi and Village Industries Commission is the major objective of India's

Planning Commission. Hence the gobar gas scheme had been included in the Khadi and Village Industries Commission as one of the means. The uniqueness of the gobar gas scheme lies in the fact that it develops a plant to utilise the animal waste which is otherwise burnt as fuel, in an efficient way to produce methane gas simultaneously with high quality manure both of which are in acute short supply.

Though the work on gobar gas was started in 1939, the interest of the people has increased in using the gas for domestic purposes recently when the social and economic benefits of the gobar gas plant came to light.

But still the high cost of installation of gas plants is a draw back for its popularity. So to cut down the burden of the people in installation, the Ministry of Agriculture has agreed to sanction twenty five percent of the cost of the gas plant through Khadi and Village Industries Commission. The remaining seventy five percent can be obtained as loan from Nationalised Banks.

Though the Government has taken many steps, interest in installation of the gas plants has spread only recently in Tamil Nadu. But the extent of use of the gas is not yet known. Hence the investigator is interested in finding out the extent of use of cowdung gas as a household fuel. So as a preliminary start Coimbatore district has been chosen to conduct the study.

It is hoped that the results of the study will provide sufficient publicity to motivate more and more farmers to avail of this opportunity of producing their fuel at home and improving their fertilisers.

II REVIEW OF LITERATURE

The review of literature is discussed under the following headings:

A. Sources Of Heat Energy

B. Cowdung Gas As A Fuel

C. History Of Gas Plant

D. Uses Of Cowdung Gas Plant

E. Difficulties Encountered In Popularising The Gas Plant Scheme

F. Role Of Various Institutions In Installation Of Gas Plant

and G. Studies Conducted On Cowdung Gas Plants.

A. Sources of Heat Energy:

Energy as defined by Compton's Pictured Encyclopaedia (1956) the ability to do work such as producing motion, heat or chemical change in matter. Mukherjee (1970) classifies energy sources as:

(a) Primary sources of energy or commercial energy which comprise coal, lignite, natural gas and oil, nuclear energy, geothermal energy from hot springs and hydro-electric power.

(b) Secondary sources of energy, include coke, gasoline, diesel oil, kerosene, fuel oil and thermal electricity from coal.

(c) Non-Commercial fuels which are bagasse, fire wood, charcoal, lumber-mill wastes-straw, paddy husk and vegetable and wood wastes.

According to Earle (1956) forms of energy are mechanical, chemical, electrical, heat, radiant and atomic.

Avery (1956) opines the chief sources of heat usable by a man are chemical reaction which include the burning of fuels, electrical and mechanical energy.

Fuels are also another sources of heat. Soundararaj (1963) and the Encyclopaedia Britanica (1968) define fuel as material used to produce heat by Combustion in air. Stowell et al define fuel as the substance which produce heat when the various elements of which it composed combine chemically with oxygen in the air to burn and give heat with the exception of hydrogen gas.

Binne and Boxall (1974) opine that the most common fuels used in home to-day are solid fuels that are wood, coal, the liquid fuel which includes gasoline, kerosene furnace oil and gaseous fuel such as the natural and artificial gas, cowdung, fire wood, charcoal and kerosene are considered to be the domestic fuels used in our country.

1. <u>Solid Fuels:</u>

Solid fuels are those which are used in solid state. Wood, charcoal and coal are the solid fuels used commonly;

2. <u>Liquid Fuels:</u>

Fuel used in a liquid state is known as liquid fuel. According to Osborn (1929) liquid fuels contain impurities mixed with carbon compound obtained from vegetable oil, animal oil or petroleum which is a natural mixture of hydrocarbon obtained from the earth.

3. <u>Gaseous Fuels:</u>

Osborn (1929) explains that gaseous fuels contain uncombined gases like hydrogen, nitrogen and oxygen. They leave no ash on burning, but are converted entirely to carbon-di-oxide and water. According to Mack <u>et al</u> (1956) several gases are commonly employed as sources of heat, light and power including producer gas, coal gas, water gas and natural gas.

Mack <u>et al</u> (1956) state that producer gas is used not only as a fuel but also as a source for nitrogen and hydrogen used making ammonia by Haber process. Binnie and Boxell (1974) state that coal gas is a mixture of hydrogen, nitrogen and carbon monoxide and is now more widely used as a domestic fuel for cooking heating etc. According to Partington (1957) and Weaver and Foster (1960) water g s is a mixture of carbon monoxide and hydrogen and burns with a pale blue non luminous flame. Natural gas as the ideal fuel gas where it is available for use in homes, can be located economically at the source of supply as stated by Encyclopaedia Britanica (1968).

The Gobar gas is of recent discovery. Devadas (1970) pointes out that Cow-dung gas is obtained by fermenting cowdung in specially constructed plants. Desai and Biswas (1945) and Surendr (1975) point out that by an anerobic fermentation, cattle dung can be used to produce fuel as well as manure.

B. <u>Cowdung Gas as a Fuel:</u>

Rao (1961) says anerobic fermentation of animal waste is known to result in quite appreciable quantities of combustible gas, the main calorific constituents of which are mu hane and hydrogen. The calorific value of bio gas is influenced largely by its methane content.

Indian Council of Agriculture Research Hand book (1964) states that cellulosic substances like animal dungs, plant residues etc are decomposed anaerobically and they produce large volumes of combustible gases.

Patel (1975) mentions due to unaerobic fermentation of cowdung containing cellulose, a mixture of 50-60 per cent methane and carbon-di-oxide is produced which can be very conveniently used as fuel in rural areas.

Bio gas burns with a smokeless flame and has a calorific value of 5000 K.Cal/cubic metre(550 BTU c.ft) as opined by Subramanium and Ganesh (1974).

Khanna (1975) points out that the gas obtained from the gas plant is used for cooking and the blue flame iof the gas is hot and smokeless. Acharya (1957) explains the composition of the gas as, methane 58.4 per cent, hydrogen 6.6 per cent, Carbon di oxide 31.8 per cent and other residual gas 3.2 percent.

Vimuktananda (1961) states the composition of the cowdung gas as methane 68 per cent, carbon-di-oxide 31 per cent and nitrogen 1 per cent. Dagli (1974) mentions that the gas contains 60 per cent methane, 30 per cent carbon-di-oxide and 10 per cent hydrogen.

C. History of Gas Plant:

The developmental history of gas plant in abroad as narrated by Acharya (1957) is given below.

The stress of war and the need to tap all available sources of fuel supply gave fillip to investigation on the subject in several countries.

The production of combustible gas from decaying organic wastes in mashes and swamps (Marsh-gas-or'will-o'-the wisp') has been known for a long time. The combustible gas was known to contain methane (Volta, 1778, vide Laurie, 1941). Pasteur 1884 presented a paper by Gayon on the production of methane from farm yard manure to the Academic des Sciences of France (Martin - Leake and Howard 1952).

Ducellier and Isman (1950) conducted experiments in Algiers (N. Africa) on the production of fuel gas from different kinds of farm wastes, which were later continued at Grignon (France) by Mignotte (1951). In 1920, there were about thousand farm installations for gas production in operation in France (Martin - Leake and Howard 1952).

Rosenberg (1952) gives an account of investigation carried out by Hieserich in Germany and of a special conference held at Ludwigsberg in 1947 to discuss the subject. As a result of the conference, a large sized mechanized biological gas plant was set up at Allerhop in the Luneberg Heath area.

Quershi (1975) states, Bio-gas industry in Pakistan is of recent one.

Indias

The history of gas plant in India as given by Srinivasan (1973) is as follows:

In India, with the commissioning of sewage purification station at Dadar, Bombay in 1937, the anerobic sludge digester started working.

Desai, scientists of the Imperial Agricultural Research Institute (IARI) who visited the sewage purification station at Dadar started this work in 1938-1939 and the results were published in 1945-1946.

In 1951, Patel designed a plant and he named the plant as Gramalaxmi Gas Plant. In 1952, Gupta started work on gobar gas at Khadipratisthan, Sodepur, Calcutta. In 1952-53, Imperial Agricultural Research Institute renewed plants activity and built two plans side by side having gas holders as covers on the digester.

Towards the end of 1960, the manufacture of methane gas from cow-dung and other waste products was included in the schedule of village industries financed by the Khadi and village Industries Commission.

In 1962, Katwal, and his assistant Borkar set up an experimental digester and did some laboratory work to show that when urine was added to the cattle dung it fermented rapidly and give more gas per unit of cattle dung.

Joshi started this work in 1962-63 and the digester was identical to the apparatus used by Desai at Imperial Agricultural Research Institute,

The work shop on Bio-gas Technology and utilisation sponsored by the United Nations Economic and Social Commission for Asia and Pacific in collaboration with UNIDO and the National Committee on Science and Technology Government of India held at New Delhi suggested the construction of experimental bio-gas plants on Proto-type scale and the following type of digesters were developed and their standard drawings proposed.

1. Single Stage Digester
2. Two Stage Digester
3. Batch feed Digester
4. Digester for cold climatic areas.

D. Uses of Cowdung Gas Plant:

The various uses of cow-dung gas plant as listed out by Patel (1964) are the following.

(1) Gives good calorific value
(2) Cheapness of fuel
(3) High nitrogen content of the manure and
(4) Other benefits such as the promoting of hygenic and sanitary condition in the cooking area and around the home.

1. Good Calorific Value of the Gas:

Patel (1964) states that the gas has a calorific value of 350 BTU (British Thermal Units) per cubic feet. According to Pai (1974), the heat efficiency of the dung cakes burnt in usual manner is more than 11 per cent while gas burnt in properly designed burners has a heat efficiency of 60 per cent.

Thus it will be clear that the same amount of dung can produce 43 per cent more manure and 20 per cent more heat when put through the plant.

2. Cheapness of Fuel:

Wandrekar (1964) has calculated the net savings in the cost of fuel by using cowdung gas for cooking purposes. The cost of the production of the gas according to Patel (1964) is about Rs.3.00 per 1000 c.ft. in the gobar gas plant.

Hazra (1974) states the advantage of gas plant as, if the fuel value to be Rs.2 per day, the cost of installing a gas plant is recovered within three to four years.

3. Nitrogen content:

Harikirat Singh (1958) points out that the plant takes only the gas out of cowdung but returns the same that could be utilised for manurial crops.

The IARI (1963) points out that the Cowdung after the removal of heat constituents in the form of gas actually is a manure of high nitrogen content. The cowdung in the form of manure obtained from gobar gas plant contains 1.5 per cent nitrogen while the farm yard manure contains only 1 per cent Nitrogen in its dry matter says Patel (1964).

According to Patel (1975) the bio-gas plant is essentially a converter of fermentable material into gas and residue.

The main advantages according to him are

(a) saving of dung for manure which would otherwise be burnt in the forms of dung cakes

(b) Saving in dry matter as well as nutrients of manure due to fermentation in condition that is more and better quality of manure from cattle dung.

According to Ramachandra Rao (1975) the manure from the gobar gas can be used in various ways. It can be used directly by mixing with irrigation water. The Nitrogen content in the fresh slurry is over 2 per cent and mixes very well with the soil. The slurry can also be used for fermenting the compost.

4. <u>Other uses</u>:

Harikirat Singh (1958) opines that the cowdung gas helps to maintain the sanitary aspects relating to complete stoppage and spread of pathogenic organisms from dried and fresh dung around the village.

According to Pimplikar (1961) and Chittaranjan Prasad (1966) the gas can be utilised to generate mechanical and electrical energy by using it in gas lamps provided with mantles and internal combustion engine which can be utilised for running pumps for irrigation purposes.

Chawla (1974) opines the advantages of gobar gas plant as (a) The conversion of dung into gas yields a fuel which is more than 6 times as efficient (b) the nuisance of smoke, the cause of eye and heart disease among rural folk is eliminated (c) there is no dung slurry for flies and mosquitoes to breed in (d) the removal of heat constituents make the residue actually richer than the original dung and (e) less smoke and the vessels are not blackened.

Krishnakumar (1974) points that gobar gas can be used in several ways. It could be directly burnt to give thermal energy or converted to other energy form which are easier to control. It can also be used directly to run internal combustion engines with a dual fuel system.

Roychoudhry (1974) mentions the outstanding features of the gas plant as

(a) there is no need to keep the hearth burning all the time as has to be done with coal or wood fuel in the rural areas.

(b) The gas is a free byproduct.

(c) The manure obtained can be used in sandy soil or in Soil with high iron and aluminium content, to which addition of chemical fertiliser is always risky.

Gandhalekar (1975) states the main advantages as

(a) increased soil fertility due to additional organic manure which would otherwise be wasted by burning

(b) reduced pressure on forests on fuel wood

(c) the reduced illness and saving in lost man hours and

(d) it helps to solve the problem of increasing population by satisfying urban amenities in villages.

Kuchhal (1975) opines that after separating carbon-di-oxide, Nitrogen and Hydrogen sulphide, bio-gas may be compressed, at the pressure of 2500 pounds. Two cylinders (ten inch by 3 feet) will provide necessary fuel for standard size car to run about 80 miles.

Surendr (1975) opines that being a fully digested manure, all weed seeds in it are destroyed, thereby saving weeding costs after application in fields. The Nitrogen content of this sludge ranges from 1.5 to 2 per cent. This Nitrogen could help to produce twenty two tonnes of additional food grains each year in each village.

E. <u>Difficulties Encountered In Popularising the Cowdung Gas Plant Scheme:</u>

The Cowdung gas has problems in using besides the very and outstanding features. The problems as pointed out by Surendr (1975) as follows:

1. In rural areas building gobar gas plants was a problem. Houses are clustered in most villages. This makes it difficult to construct small private plant on a little available space in a house which is normally taken by a primitive cattle shed. The present social and economic structure of villages make it difficult to run a community gas plant.

2. The gas has to be distributed over a large areas which necessitates booster pumps.

3. Expensive gas metres will have to be installed to check the daily and monthly consumption of each family for accounting purposes.

4. The distribution of gas manure and profits from the sale of these items are involved problems.

5. Besides at the moment, the high initial costs of the plant put it beyond the reach of the marginal farmers and landless labourer who form over 50 per cent of an average village population.

6. There is difficulty in storing the daily generated gas due to high pressure.

7. The ignorance of the villagers needs the necessity of demonstrating the gas plants to show them the benefits of gobar gas energy and the utilisation of dung and waste materials which could improve the sanitation and health in villages.

8. The high water requirements of a gas plant make it imperative to have a source of water close to the plant or a means of conveying water easily from a distant source.

9. The fabrication of the holder requires technical skill. If holders are produced centrally, problem crop-up in transporting them to the site. The mild steel gas holder, if it is unchecked, after constant submersion in slurry, gets corroded. This results in replacing the gas holder which is of high cost.

Shah (1974) and Patel (1975) opine the problems as

(1) The mal-nutrition of the cattle which has been the major constant affecting the quality as well as quantity of the dung in turn can upset the viability of the gobar gas units.

(2) Methane gas cannot be transported economically in small quantities as produced in domestic gobar gas plants.

(3) Gobar gas contains about 45 per cent of carbon-di-oxide which result in the deposition of carbon in engine and burners run with the gobar gas.

(4) Cattle dung is a very slow fermenter because it is poor in favourable nutrients which pass on the urine. But there is no arrangement of modern cattle sheds under which both cowdung and urine could be collected with ease.

According to Idnani (1969), Chawla (1973) and Patel (1975) the problem is as the day temperature goes down the gas production falls when the digester temperature reaches 10°C (50°F) the production of gas almost ceases.

f. <u>Role of Various Institutions In Installation Of Gas Plants:</u>

a. <u>Role of various Banks:</u>

Efforts in assisting gobar gas plants made by banks as stated by Kakatkar (1975) are summarised below.

Bank of Baroda: It has decided to give 100 per cent loan to the famrer to meet the entire cost.

Bank of India: In this scheme, the marginal contribution from the beneficiaries has been reduced from 25 per cent to 10 per cent and so far the bank had set the target of financing about 1500 plants.

Canara Bank: It has granted a sum of Rs.6.25 lakhs for installation of gobar gas plants all over the country basing on the satisfactory.

The Indian Bank: It is implementing the gobar gas plant scheme in collaboration with the Tamil Nadu Khadi and Village Industries Board. The scheme is being operated in the entire Tamil Nadu area. Individual farmers are financed to install gobar gas plants of various sizes depending upon the number of cattle owned. The financial aid is in the form of medium term loans, not exceeding Rs.3,800 per borrower repayable in 2 years.

Indian Overseas Bank: It has been given a tentative target of financing the setting up of 500 gober gas units during the year 1975.

Punjab National Bank: Loans have been sanctioned for installation of 1200 plants so far and about Rs.20 lakhs have been disbursed.

Syndicate Bank: The bank has made an effort to obtain cement and steel on a priority basis from the government so that the same could be made available to the persons who have borrowed for setting up gober gas plants.

United Bank of India: The Bank has sanctioned assistance for 9 plants until 1975.

b. Role of Khadi and Village Industries Commission:

The assistance can be obtained from the commission as reported by the Khadi and Village Industries Commissions Report (1975) are Technical guidance and Financial assistance.

Technical guidance: As regards technical guidance for construction of gas plant it falls into three categories.

(i) Scrutinising the proposals and according approval for financial assistance

(ii) Surveying the site for location of gas plant.

(iii) Supervising the construction of gas plant and ensuring satisfactory operation.

Financial assistance: As regards financial assistance it falls into 2 categories.

(i) Capital assistance for institutions and co-operative societies.

(ii) Capital assistance to individuals.

c. Role of educational Institutions:

(i) Tamil Nadu Agricultural University:

The Tamil Nadu Agricultural University has now come out with a cowdung gas plant made of steel which can be easily transported and installed even in crowded cities.

The transportable cowdung gas plant constructed with 18 gauge m.s.sheet consists of a cubical tank of dimension 4' x 4' x 4' with a capacity of 400 gallons. The cost of this plant is only Rs.1,500/- including the stand. The unit is handy and can be transported any where easily. Cowdung from a head of cattle is just enough to meet the daily requirements of gas for a family of five. There will be no mosquito nuisance and corrosion problem (Hindu, January 30,1976).

It is hoped that this mobile gas plant will increase the number of installation of gobar gas plants in future.

(ii) Sri Parasakthi College,Courtallam:

Propagation of gobar gas scheme by the students of Sri Parasakthi College in the villages has drawn surprisingly favourable response. The college had conducted Training Course in the Construction of Gobar gas plant which was attended by fourteen candidates (6 men and 8 women). Among them eight were graduates. These trained Supervisors have so far constructed nearly 50 gas plants at various places in Tamil Nadu. (Gobar Gas Plant, pamphlet issued by Sri Parasakthi College, Courtallam, Bhagirathi, 1974).

G. <u>Studies Conducted on Cowdung Gas Plants:</u>

Studies conducted by Acharya (1957) reveals, the dung loses about 27-28 per cent of dry matter and yields about 105 cubic feet of gas per pound of fresh bullock dung added or about 8 cubic feet of gas per pound of dry matter in the added dung. He again stresses that dilution of dung with water (1:10, 1:1½) to 2 level of 7-9 per cent solids was found to increase the rate of gas production. The rapidity of gas production increases with increasing proportion of the freshly added dung.

The study conducted by Kamalaveni (1962) reveals the following characteristics of cattle dung gas while using over fire wood.

(a) A saving of 28 per cent of time for cooking meals for a family of three was noted.

(b) There was a saving of 63 per cent of time taken for scrubing the utensils while washing them after they were used for cooking.

(c) The foods cooked using cattle dung gas were acceptable to the same extent as those cooked with fire wood as the fuel.

The experiments conducted by Tej Narain and Ramamurthy (1964) at Gram Sevika Training Centre At Rajendranakar show that 13 cubic feet of gas per hour is required for cooking food for six persons. The study revealed that to satisfy the gas requirements for cooking for a family of six a gas holder with a diameter of five feet, a height of 4 feet, located at a distance of about 33 feet, supplied with about 15 pounds of cowdung per day was necessary.

Studies conducted by Pathak et al (1965) on the effect of recirculation of the gas through the fermenting medium reveals that the gas production was nearby doubled (187-353 litres)

The study conducted by Raji and Sathyavathy (1968) reveals, (a) A saving of 18 per cent of time was noted for cooking the three items namely rice, dhal and vegetable. A saving of 11.3 per cent, 19 percent and 23 per cent time was noted for cooking rice, dhal and vegetable individually.
(b) When compared with kerosene, there was a saving of 3[illegible].3 per cent of the cost in using gas for cooking the three food items.
(c) The nitrogen content of the slurry and cowdung in the

dry state was found to be 2.55 per cent and 3.18 per cent respectively.

(d) The flow of gas was found to be continuous and adequate. On an average 91 c.ft. of gas was needed to cook the wholeday menu for a family of 6 members. The gas obtained from 250 pounds of cowdung per day was found to meet the requirements of cooking for a family of 6 members.

(e) The annual monetary returns from the cowdung gas plant amounted to Rs.247.40 (Rs.58.40 from the slurry and Rs.189.00 from the fuel).

Chawla (1973) opines that scientists at Imperial Agricultural Research Institute has worked on the practical problems of the farmer in making the gas plant workable round the year without being affected by low temperature in winter.

Physical studies:

One of village model gas plants installed in the Division of soil science and Agriculture was covered all around with alkathene cloth which was fixed on the wooden frame fitted around the gas plant and the entire fittings were made airtight. A double door was erected for entering this enclose and two thermometres, one inside, and the other outside the enclosure, were fixed for recording the temperature of the inner enclose as well as the outer atmosphere. By this arrangement the outer cool was cut off from coming in contact with the gas plant. This was conducted for four months in both the gas plants. The result of this study showed that the rate of gas production was greatly stimulated which went to the extent of 50 per cent increased gas production as compared to the uncovered one.

Chemical studies:

Urine fraction of animal excreta resulted in stimulation of bacterial activity and utimately increased gas production during winter months.

In this case the experiment was conducted by the addition of 1 per cent wheat straw or bajra leaves finely powdered in combination with 1 per cent urea to dung at fortnightly. There was increased bacterial activity due to the addition of these easily decomposable materials in combination with a very small amount of urea which means that addition of urea accelerated the decomposition of added wheat straw or bajra leaves. There was increased gas production to the extent of 30 - 50 per cent during winter months as compared to control.

Study conducted in Ratlam district of Madhya Pradesh in 1972-73 to assess the benefits obtained from cowdung gas plant as quoted by Misra (1975) reveals

a) The gas obtained from the plant is used for cooking purposes only.

(b) The manure obtained from the plant is almost double in humus as compared to farm yard manure, contains 2.5 per cent nitrogen and it increases the field productivity of various crops like wheat, cotton, jowar, maize and grams.

(c) The gas plant manure in fully fermented and has no weeds and cost of weeding is minimised.

According to Patel (1975) a field study conducted by the Institute of Co-operative Management, Ahemadabad, reveals

(a) 50 per cent of the respondent farmers had 200 cubic feet per day gas plants.

(b) The maximum incremental benefit due to better quality of manure and additional manure income of a gas plant with an input of 45 kg per day dung plus excreta having 9 kg dry matter in such input would be about Rs.125 per year.

III EXPERIMENTAL PROCEDURE

The procedure for this study 'Extent of use of cowdung gas as a household fuel' included the following phases.

A. Household Survey

B. Determining the Utilisation of Gas in a Hostel Kitchen

and C. Cooking Experiments.

A. <u>Household Survey:</u>

To understand the extent of use of cowdung gas as a household fuel a survey was conducted in selected households in Coimbatore District where cowdung gas plants has been installed. The survey was conducted following the steps given below.

1. Selecting the area to be surveyed.
2. Locating the households with cowdung gas plants.
3. Selecting the method of study.
4. Conducting the survey.
5. Consolidation and presentation of data.

1. <u>Selecting the area to be surveyed:</u>

All the Taluks in Coimbatore District (Figure 1) namely Avinasi, Bhavani, Coimbatore, Dharapuram, Erode, Gobichettipalayam, Palladam, Pollachi and Udumalpet were

FIGURE I
MAP SHOWING THE TALUKS IN COIMBATORE DISTRICT

selected because these places could be visited in person, if necessary by the investigator.

2. <u>Locating the Houses with Cowdung Gas Plants</u>:

Various sources such as the Khadi and Village Industries Board in Coimbatore, Tirupur and Erode and Co-operative Agricultural Society, Tudiyalur were visited by the investigator and addresses where these gas plants had been installed with their co-operation, were collected. Thus one hundred and twenty five addresses were gathered.

3. <u>Selecting the method of study</u>:

Interview method was selected to gather the required information on gas plants since Yang (1966) suggests that it is the best suited method to get first hand information. The schedule was prepared in Tamil so as to make it easy for the respondents to understand better. The validity of the schedule was assessed by pretesting. Appendix I gives the modified schedule used for the study. The schedule thus prepared called for information about the gas plant regarding the date and year of construction, capacity of the gas plant, size of the gas holder, amount spent on construction, number of cattle available, size and price of the gas burners, uses of cowdung gas and suggestions if any for improvement in future.

4. <u>Conducting the Survey</u>:

The investigator visited in person twenty houses among the addresses collected. Rapport was created and the required informations were gathered using the schedule. Wherever it was not possible to go in person it was decided to send the schedules by post. The investigator posted schedules to the remaining addresses since it was not possible to have personal contact with all the families selected. Out of the 105 sent only sixty schedules were returned with all the informations called for. Thus a total of eighty schedules were considered for the study.

5. Consolidation and Presentation of data:

The collected data were consolidated and presented in Chapter V.

6. Determining the utilisation of Gas in a Hostel Kitchen:

This phase of the study was included in the present investigation since a 300 cft gas plant had already been constructed in the Sri Avinashilingam Home Science College campus (Sathyavathi, 1967) and data on utilisation of this gas connected to the kitchen were not available. Figure 2 shows the cowdung gas plant constructed at the campus.

The deputy warden was contacted and requested to render the necessary assistance to carry out the study. The items cooked using cowdung gas and durations of cooking per day were recorded everyday, for one month.

FIGURE 2

COW DUNG GAS PLANT

C. Cooking Experiments:

The cooking experiments were designed to compare the efficiency of gobar gas produced with that of indane cooking gas, which is a popular fuel in the middle income families, in terms of time taken for cooking a standardised meal and the palatability of the cooked products.

The burners selected for gobar gas (figure 3) consisted of a hollow ring with orifices for the passage of gas and four projections to serve as rests for the utensil. This was obtained from Khadi and Village Industries Board, Coimbatore. The planet make of indane gas (figure 4) burner used had the same diameter of that in the gobar gas burner.

The procedure involved the following steps.

1. Selection of cooking utensils and accessory items.
2. Selection of recipes tobe cooked.
3. Standardisation of the procedure.
4. Preparing the selected recipes.

and 5. Judging palatability of the cooked foods.

1. Selection of cooking utensils and accessory items:

Aluminium utensils were selected for cooking. Ehrenhranz and Inman (1973) opine that aluminium is a good conductor of heat and hence can be used to make cooking utensils. Studies reveal that it is widely used in household equipment(Kale, 1972).

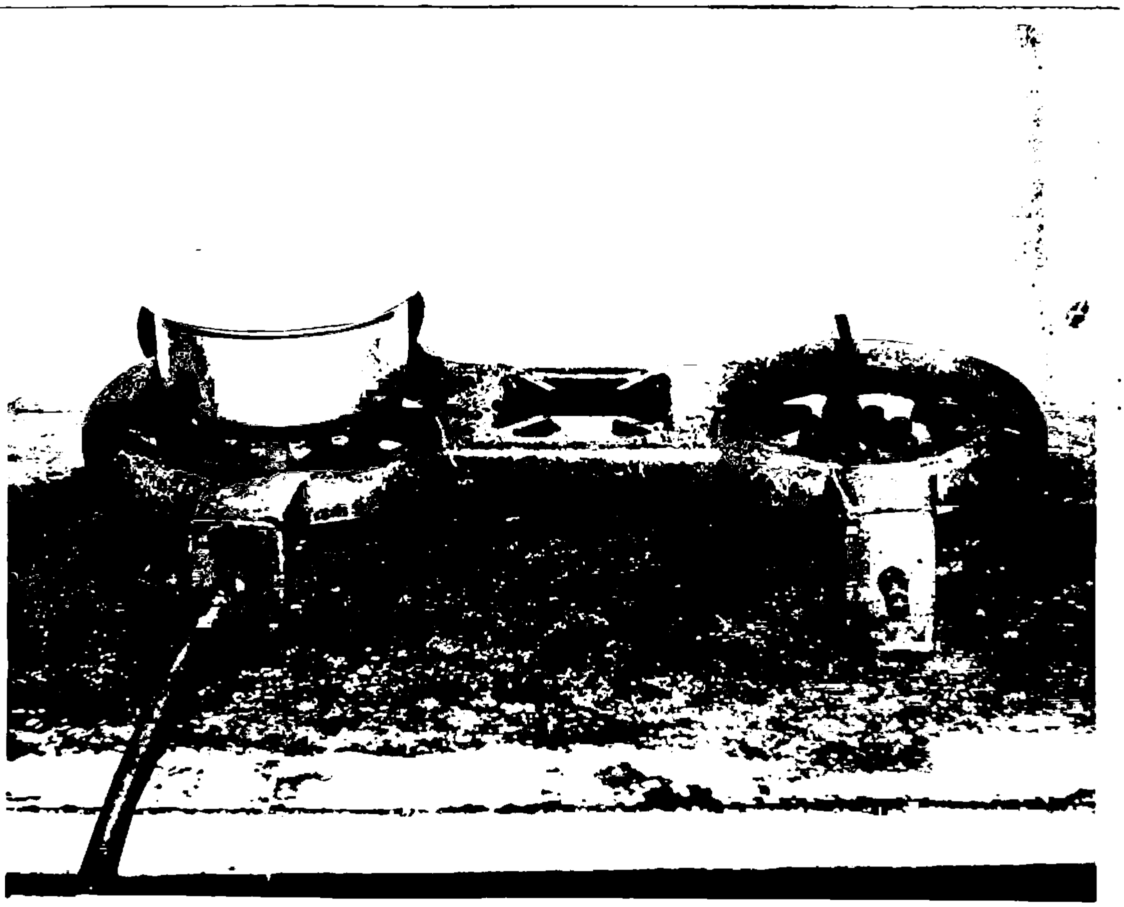


FIGURE 3

COWDUNG GAS BURNER
(Double-Delux Economy Size)

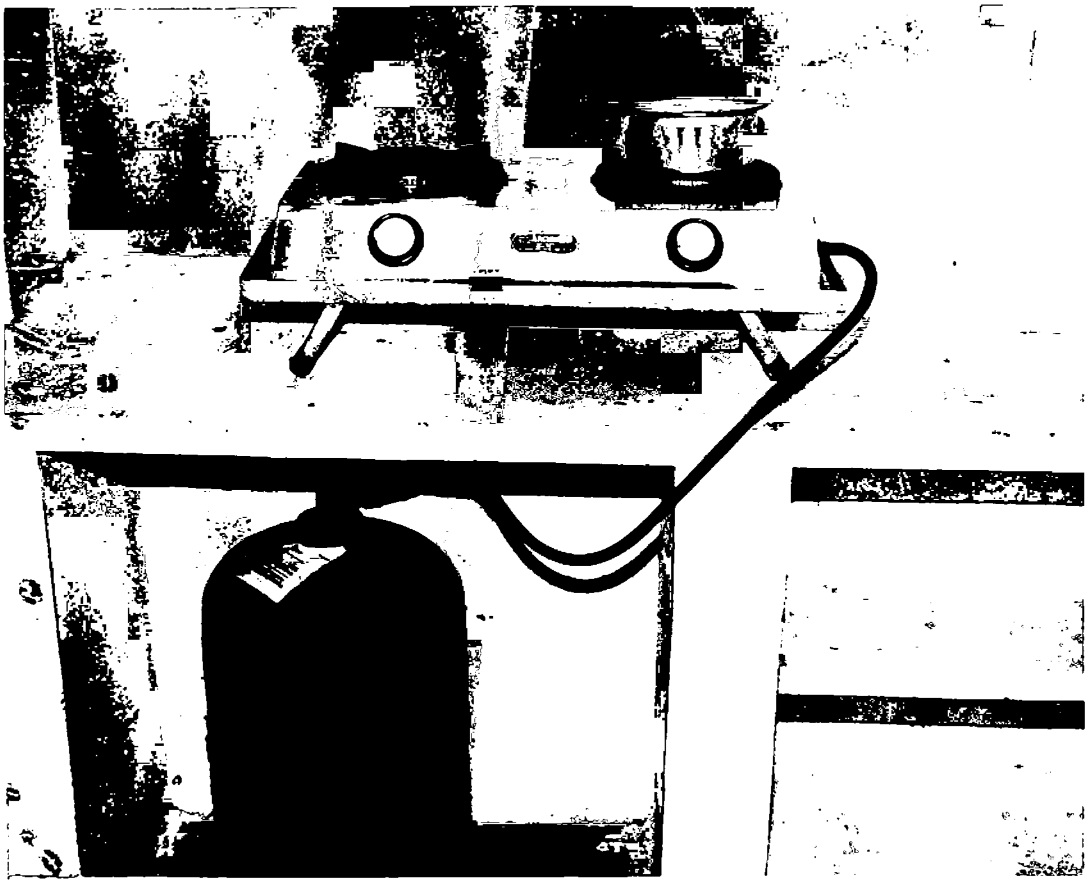


FIGURE 4

INDANE GAS BURNER

Two sets of identical cooking utensils were selected to be used, over the two fuels.

The accessory items included, containers for storage of provisions, measuring devices and serving plates used for the palatability tests.

A set of standard measuring cups and spoons specified by the standardization and Terminology Committee of the Home Science Association of India were used for measuring liquids condiments and spices. The five hundred grams capacity dietetics scale was used to weigh solid food stuffs. The stop watch was used to record the time.

2. <u>Selection of recipes to be cooked:</u>

A lunch for a family of four members (sedentary work man and woman, children of six and nine years) was selected which was planned to supply the recommended daily allowances of nutrients by the Indian Council of Medical Research 1969. (Appendix II).

The following are the items included in the menu.

Rice

Onion sambar

Cabbage poriyal

Raw plantain curry

Curds.

Since the preparation of the lunch may not involve all the cooking methods, the following recipes each representing one of the four cooking methods namely boiling, steaming, roasting and frying which were frequently adopted in South Indian households were also selected.

Items	Method employed
Coffee	Boiling water and milk
Rice pittu	Steaming
Potato chips	Frying
Greengram	Roasting

3. <u>Standardisation of the procedure:</u>

a. <u>Purchasing food stuffs:</u>

The non perishable food stuffs such as rice, dhals, oil, condiments and spices were purchased as one lot from the consumer co-operative society to ensure the quality of the food stuffs used for the experiment. Perishable food stuffs such as Potato, cabbage and raw plantain were purchased daily.

b. <u>Measuring fuels and calculating fuel cost:</u>

The amount of cowdung gas used for cooking was measured by the size of the burner used for cooking. In this study Double Delux economy size burner (16 c.ft/Hour of gas) was used. By using this the amount of fuel consumed ~~and the cost of fuel consumed~~ and the cost of fuel were calculated.

The cost of indane gas used for cooking was calculated by the capacity of the gas cylinder. The capacity of the gas in a cylinder is 1000 cft and it can be used for one hundred and ten hours. This helped to calculate the fuel cost.

c. Lighting fuel:

Each time the burner was lighted, the gas regulator was turned to the fullest supply of gas and the utensil was placed on it. It was found necessary to use at three levels of heat while operating the gas burners, high, medium and low depending on the methods of cooking employed.

Apart from the above items the cooking sequence was standardised for stirring of the food, flame control and for the adjustments of lids.

d. Standardising the procedure for cooking:

Preliminary experiments were conducted with varying quantities of water and time to standardise the methods adopted for cooking. Appendix III gives the preparations thus standardised.

4. Preparing the selected Recipes:

The items were prepared following the standardised procedure described in Appendix III.

Cooking were done simultaneously in both the gas burners. The cooking time was adjusted between 9 - 12 noon to have uniformity in atmospheric condition. Each item was prepared three times to give triplicate values.

5. Judging palatability of the cooked foods:

The acceptability of any food preparation depends on its qualities such as appearance, flavour, texture and taste. Judging the palatability of food preparation is necessary when method of cooking is compared. Judgement of the qualities of food preparation can be accomplished through objective and subjective methods. For this study subjective method was used.

This called for the following steps.

a. Formulation of score card

b. Selection of judges

c. Administering the test.

a. Formulation of score card:

A score card as shown in Appendix IV was formulated to judge the colour, texture, taste, flavour and doneness of the cooked product.

b. Selection of judges:

For the selection of the taste panel the Triangle test described by Amerine et al (1965) was administered to selected post graduate students. A panel of five judges were selected.

e. Administering the test:

The palatability of the cooked food was tested by the selected judges as follows. The samples were served in serving dishes. The judges were requested to taste the cooked products for different qualities and grade them on the scored card according to the directions given.

The data obtained are presented and discussed in Chapter IV.

IV RESULTS AND DISCUSSIONS

The findings of the study are presented under the following main headings:

A. Extent of use of coudung gas plants in Coimbatore District.

B. Utility of the coudung gas in the hostel Kitchen.

and C. Comparison of coudung gas with indane gas.

A. Extent of use of coudung gas plants in Coimbatore District:

The results of the household survey are discussed under the following phases.

1. Background details of the families surveyed.
2. Distribution of gas plants in Coimbatore District.
3. Constructional details of the gas plant.
4. Details regarding the fuels used prior to the construction of the gas plant.
5. Uses of the gas plant among the surveyed families.
6. Benefits derived from the gas plant.

and 7. Problems encountered and suggestions given by the users.

1. Background details of the families surveyed:

Background details of the families include Type, size and income of the households surveyed.

a) Type of the family:

Out of 80 houses surveyed 56 per cent belonged to the nuclear families and 44 per cent belonged to the joint families.

b) Size of the family:

Table I gives the size of the families surveyed.

TABLE I

SIZE OF THE FAMILIES SURVEYED

S.No.	Number of Family members	Number of Families	Percentage
1.	4 - 6	40	50
2.	7 - 9	28	35
3.	10 and above	12	15

The Table shows that the family size ranged from four to ten members among the households. It clearly shows that fifty per cent of the families had four to six members, thirty five per cent of the families had seven to nine and the remaining families had ten and above.

e) Monthly income:

As per Tamil Nadu Housing Board (1974) the middle income ranges between Rs.750-1250 and the high income is above Rs.1250. When analysed on this basis forty two per cent of the families belonged to the middle income group and fifty eight per cent belonged to the high income group.

2. Distribution of gas plants in Coimbatore District:

Table II exhibits the distribution of gas plants in Coimbatore District.

TABLE II

DISTRIBUTION OF GAS PLANTS IN COIMBATORE DISTRICT

S.No.	Taluka	Capacity of the Gas Plants in cft.								
		100	150	200	250	300	350	400	500	Total
1.	Coimbatore	2	2	7	4	4	–	3	–	22
2.	Erode	–	–	8	–	8	1	–	2	19
3.	Dharapuram	–	1	5	1	3	–	–	1	11
4.	Gobichettipalayam	–	1	3	–	3	–	–	1	8
5.	Palladam	–	1	3	–	3	1	–	–	8
6.	Bhavani	–	–	1	–	3	–	–	1	5
7.	Avinashi	–	–	3	–	–	–	–	–	3
8.	Pollachi	–	–	1	–	1	–	–	–	2
9.	Udumalpet	–	–	–	–	2	–	–	–	2
	Total	2	5	31	5	27	2	3	5	80

From the Table it is clear that all the taluka of Coimbatore District had cowdung gas plants. However in Erode and Coimbatore the number is found to be high. This may be due to the interest evinced by the Khadi and Village Industries Board set up in those areas and the co-operation extended by people in those Taluks.

It is also clear that 400 c.ft. and 500 c.ft gas plants are not found to be common due to the investment of larger capital in constructing the same. The prevalence of 100 c.ft. and 150 c.ft. gas plants are also few in number owing to its inability to satisfy the needs of an average family.

3. Constructional details of the gas plant:

The constructional details of the gas plants are as follows:

a. Source of motivation to construct a gas plant
b. Source approached for financial help
c. Strength of the cattle available
d. Year of construction
e. Place of construction
f. Method and Materials Used for the construction
g. Details of the gas drum
and h. Expenditure for the construction of the gas plant

a. Source of motivation to construct a gas plant:

Table III presents details regarding the source of inspiration and motivation for the construction of the gas plants.

TABLE III

SOURCE OF MOTIVATION TO CONSTRUCT A GAS PLANT

S.No.	Source of motivation	Number of families	Percentage %
1.	Khadi and Village Industries Board (Erode)	37	46.2
2.	Khadi Vasthiralayam (Veerapandi Tirupur)	15	18.7
3.	Khadi and Village Industries Board (Coimbatore)	12	15
4.	Thiru Krishnaswami Gounder, Coimbatore (Pioneer in this field)	10	12.5
5.	Khadi and Village Industries Board Officer (Bombay)	2	2.4
6.	German Journal	1	1.3
7.	Government Hostel for Boys (Bhavani)	1	1.3
8.	Madhavaram Milk Society(Madras)	1	1.3
9.	Tudiyalur Co-operative Agriculture Society	1	1.3

The above Table indicates that the Khadi and Village Industries Board had taken tremendous steps in the installation of cowdung gas plants. Nearly 46 per cent of the families had received information from Erode Khadi and Village Industries Board. The pioneer who started the work on cowdung gas plant, Thiru Krishnaswamy Gounder of Coimbatore, was contacted by 13 per cent of the families. Only negligible per cent of the families gathered information through journals and societies.

b. <u>Source approached for financial help:</u>

The Government sanctions loans to the people for the construction of the gas plants through Khadi and Village Industries Board with the help of Nationalised Banks. Table IV denotes the amount of subsidy received by the people for the construction of gas plant.

TABLE IV

SUBSIDY RECEIVED BY THE OWNERS OF THE GAS PLANTS

S. No.	Capacity of gas plant (c.ft)	Estimated cost Rs.	Subsidy Rs.	Number of families
1.	100	3015	753	2
2.	150	3359	839	5
3.	200	4175	1043	31
4.	250	5000	1250	2
5.	300	5000	1250	26
6.	350	6100	1525	2
7.	400	8500	2125	3
8.	500	8500	2125	5
				76

The above Table reveals that, amount given as subsidy is based upon the capacity of the gas plant and the estimated cost. Among the 80 families surveyed 95 per cent of the families made use of the subsidy given by the Government.

c. <u>Number of the cattle available:</u>

One of the pre-requisities for setting up a gas plant is to have sufficient number of animals. The animals preferably should be stable bound. If the animals are of the free grazing type their dung would be lost in the pasture. It is not economic to establish even the smallest size gas plant, unless fresh dung of weight 45 kgs. is available everyday.

Table V explains the strength of cattle required for each plant as specified by the Khadi and Village Industries Commission and the actual strength of cattle available in the surveyed families.

TABLE V

STRENGTH OF CATTLE REQUIRED AND AVAILABLE FOR VARIOUS SIZES OF GAS PLANT

S.No.	Capacity of the gas plant (c.ft.)	Number of animals	
		Required	Available
1.	100	8	5 - 8
2.	150	12	11 -16
3.	200	18	16 -25
4.	250	20	17 -28
5.	300	24	22 -36
6.	350	30	30 -38
7.	400	35	33 -39
8.	500	40	40 -48

Table V reveals all the families surveyed had the required strength of cattle. The table also reveals that, the number of animals increased as the size of the gas plant increased.

d. Year of construction:

An analysis of the year in which the gas plants were constructed reveals that only five per cent of the families constructed the gas plants prior to 1970. The remaining 95 per cent of the families set up their gas plants during 1970-1975. This may be attributed to the reason that the Khadi and Village Industries Board had decided to give subsidy for the members who would like to own gas plants.

e. Place of construction:

The selection of a suitable place for the construction is very important before setting up a gas plant. There should be sufficient place for constructing the gas plant and to locate the pits for collecting slurry. This place again must be very near to the stable and close to the place where gas is to be used.

Table VI reveals the placement of the gas plants surveyed:

TABLE VI

PLACEMENT OF THE GAS PLANT

Distance	Number of gas plants with a distance of				
	Below 6 m	6.1-12 m	12.1-18 m	18.1-24 m	24.1 and above
Between cow-shed and gas plant	14 (17.5%)	7 (8.7%)	54 (67.5%)	4 (.5%)	1 (1.3%)
Between kitchen and gas plant	10 (12.5%)	6 (7.5%)	61 (76.3%)	3 (3.7%)	—

The Table reveals that, the gas plants are located in 67.5 per cent of the families at a distance of 12 - 18 metres from the cowshed since it is not adviseable to transport the dung over long distance and normally the distance should be within 20 metres. In only one family the distance between cowshed and the gas plant is 26 metres and this may be due to the non-availability of space to construct the gas plant nearby. The Table also shows that the point of use, mostly the kitchen, is located at a distance of 12-18 metres from the gas plant, since the use of gas as fuel may be difficult if the location of the kitchen is far from the gas plant.

f. <u>Method and Materials used for the construction:</u>

The two methods generally employed for constructing the gas plant are centre guide frame method and water jacket method. Khadi and Village Industries Commission gives subsidy and technical help only to those plants which are constructed following centre guide frame method. So 90 per cent of the families surveyed adopted this method. The remaining 10 per cent constructed the gas plants prior to the grant of subsidy.

In all the gas plants, Cement, brick, sand and jalli were used for masonry work. 18 gauge M.S.Sheet was used to fabricate the gas drum. Polythene pipe was used to connect the gas holder. Galvanised iron pipe was used to carry the gas to the place of use.

g. <u>Details of the gas drum:</u>

The gas drum is an important component in the construction of the gas plant. The drum collects the gas which bubbles out from the cattle dung slurry put in the digester. The gas so accumulated flows out through the pipe provided at the top.

The details of the measurement of the gas deum possessed by the families are presented in Table VII.

TABLE VII

DETAILS OF THE MEASUREMENT OF THE GAS DRUMS

S.No.	Capacity of the gas plant in c.ft.	Measurement of the gas drum		Number of families
		Height (metre)	Diametre (metre)	
1.	100	0.9	1.5	2
2.	150	1.0	1.8	5
3.	200	1.3	2.4	31
4.	250	1.5	2.4	5
5.	300	1.6	2.5	27
6.	350	1.7	2.6	2
7.	400	1.8	2.7	3
8.	500	1.8	2.8	5

The above Table shows clearly that the measurement of the gas drum increases in accordance with the capacity of the gas plant.

h. <u>Expenditure for the construction of the gas plant:</u>

The expenditure on the construction of the gas plant includes the amount spent for materials and the amount spent for labourers who were engaged in construction. This is given in Table VIII.

TABLE VIII

EXPENDITURE FOR THE CONSTRUCTION OF THE GAS PLANT

S.No.	Capacity of the gas plant in c.ft.	Number of families spending Rupees 1000-3000	3001-5000	5001-7000	7001 and above
1.	100	1	1	-	-
2.	150	1	4	-	-
3.	200	3	21	6	1
4.	250	4	1	-	-
5.	300	-	7	16	4
6.	350	-	-	-	2
7.	400	-	1	1	1
8.	500	-	-	1	4

Table shows the variation in the expenditure incurred on the construction of the gas plant. This may be due to the time of construction and high cost of materials used for the construction and labour charge.

4. <u>Details of regarding the fuels used prior to the construction of the gas plant:</u>

Ninety per cent of the families used firewood as fuel and the remaining families used indane gas for cooking prior to the construction. Those who used indane gas spent Rs.30 and those who used firewood spent Rs.66.70 per month.

Those who used firewood for cooking saved two hours and others saved 30-60 minutes per day after the construction of the gas plants (Figure 5).

5. <u>Details regarding the uses of the gas plant among the surveyed families:</u>

The gas is used as fuel for cooking and lighting and the slurry obtained after the gas production is used as manure in their own lands.

a. <u>Cooking purpose:</u>

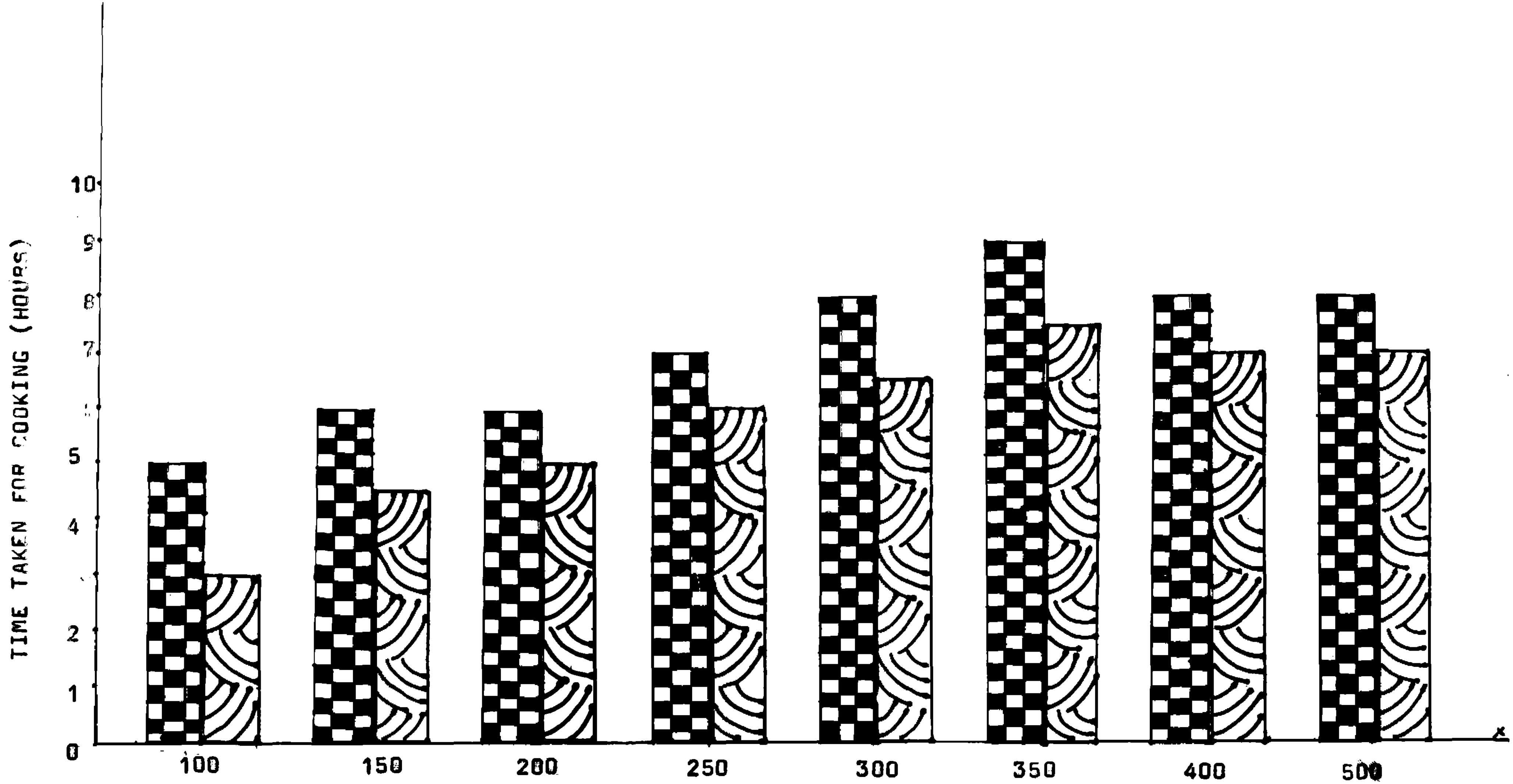
The gas used for cooking purposes contains 55 per cent methane and 45 per carbon-di-oxide. Since this composition is different from the coal gas or Burshane gas the appliances like burners to be used for cooking have also to be of special design.

i) Table IX denotes the size of gas burners designed specially by the Khadi and Village Industries Commission used in the surveyed families.

TABLE IX

GAS BURNERS USED IN THE FAMILIES

S.No.	Size of the gas burner (in cu.ft.)	Number of families	Percentage
1.	40	9	11
2.	8	16	20
3.	16	10	13
4.	16 and 8	45	56



Scale

X axis 1 cm = capacity

Y axis 1 cm = 1 hour

CAPACITY OF THE GAS PLANTS(c.ft)

FIGURE 5

TIME TAKEN FOR COOKING PRIOR TO AND AFTER THE CONSTRUCTION OF THE GAS PLANT

Key

Prior to construction

After the construction

The Table reveals that 56 per cent of the families are using the Double-Delux Economy size (16 and 8 c.ft of gas/hr) since the cooking may be done simultaneously in both the burners to reduce the cooking time and burden of cooking. The Table also indicates that 40 cu.ft. burners are possessed only by 11 per cent of the families since the size of the family may be large.

ii) <u>Total hours used per day for cooking:</u>

The daily gas production depends upon the amount of dung used daily to the gas plant and the quantity of water used. Normally the cattle dung is mixed with equal quantity of water before feeding into the gas plant.

Table X gives the total hours of use for cooking in the surveyed families.

TABLE X

TOTAL HOURS OF USE OF THE GAS FOR COOKING/DAY

S.No.	Capacity of the gas plant (c.ft)	Amount of dung fed daily (kg)	Number of houses using gas for cooking per day (Hours)				
			5	6	7	8	9
1.	100	80	-	2	-	-	-
2.	150	120	-	1	2	-	2
3.	200	180	3	15	4	5	4
4.	250	200	-	3	-	-	2
5.	300	240	1	5	14	6	1
6.	350	290	1	-	1	-	-
7.	400	350	-	-	1	-	-
8.	500	400	1	2	-	1	2

From the above Table we can infer that 37 per cent of the families are using 6 hours daily for cooking and 25 per cent of the families are using the gas for 7 hours daily for cooking. The type of the meal and the amount to be cooked may be the reasons accounted for the variation in the daily cooking time.

Lighting:

Eventhough all the houses were provided with 100 Candle power gas lights (110 litres/hr or 4.5cft/hr of gas) they never made use of the light for day to day living. Only during the failure of electricity, the gas lights were used.

5. Benefits derived from the gas plant:

The benefits accruing from the functioning the gas plant elicited from the owners of the gas plants are presented below in Table XI.

TABLE XI

BENEFITS DERIVED FROM THE GAS PLANT

S. No.	Benefits derived from the gas plant	Number of families
1.	Avoids smoke and smell	41
2.	Economic and efficient	36
3.	Ease in cooking	32
4.	Promotes cleanliness and sanitation	28
5.	Saves cooking and cleaning time	26
6.	Avoids flies, mosquitoes and weed cultivation	25
7.	High yielding due to high nitrogen content of slurry	24
8.	Reduces the eye and heart diseases	22
9.	Recycling of waste-help in promoting prosperity of the country	17
10.	Saves fuel cost	16
11.	High calorific value of the gas	15
12.	Minimises the burden of the homemaker	15
13.	Saves current consumption	11
14.	Avoids money spent on chemical fertiliser	5

6. **Problems encountered and suggestions given by the users:**

Problems encountered in using the gas plant as stated by the owners are as follows:

During the festivals and functions, amount of gas generated daily is not sufficient. Hence certain methods must be adopted to store the gas generated daily in cylinders.

Water is accumulating in the gas pipe once in a month and it blocks the passage of the gas. The material of the drum is such that it is very easily corroded and the life time of the drum is reduced. So it gives an extra burden to the users.

During winter and cloudy season the gas production is less; so more amount of dung has to be fed to produce the adequate amount of gas.

Suggestions given by the users:

1. The drum can be made in cement and zinc sheet to withstand the action of cowdung mixture and also to increase the gas production by providing high pressure.
2. The distance between the plant and the kitchen should be minimised to increase the pressure of the gas.
3. To cut down the amount of money spent in buying the gas burners, the pipe can be directly connected to the ordinary chula.
4. The materials needed for the construction should be marketed at control prices.
5. The government should take steps to minimse the expenditure incurred on the construction of the gas plants by increasing the amount of subsidy

and to decrease the rate of interest of the loan amount sanctioned by the Nationalised Banks.

6. The Gov rnment should encourage the people to install of the gas plants through attractive advertisements.

8. <u>The Utility of the gas in the Hostel:</u>

Table XII reveals the utility of the gas generated from the cow-dung gas plant in the hostel kitchen.

TABLE XII

UTILITY OF THE GAS IN THE HOSTEL KITCHEN

S.No.	Total hours used per day	Number of days
1.	4	2
2.	5	3
3.	6	3
4.	7	10
5.	8	12

The strength of the hostel being 730, the gas was utilised only for some selected purposes like, boiling water and milk and cooking dhal for sambar. As can be revealed from the Table, the gas it utilised for 8 hours in most of the days. The low production of the gas can be attributed to the changes in weather condition. Details are given in Appendix V.

C. Comparison of cowdung gas and Indane gas:

The data obtained in the experiments conducted as described in Experimental procedure were studied in relation to time and money management.

(a) Time taken for cooking the lunch:

The time taken for cooking selected items in a lunch using cow dung gas and indane gas is given in Table XIII.

TABLE XIII

TIME TAKEN FOR COOKING DIFFERENT ITEMS OF A SELECTED LUNCH

Triplicates	Items cooked	Time taken (in minutes)		't' value
		Cowdung gas	Indane gas	
1	Rice	23	24.5	5.2 **
2		23	25	
3		24	25	
1	Onion sambar	45	48	
2		45	48	
3		46	47	
1	Cabbage Porriyal	10.5	11	
2		10	11.5	
3		10.5	11.5	
1	Raw Plantain curry	12	13	
2		12	14	
3		13	13	

** Significant at 1% level.

As can be seen from the above Table the time taken to cook the lunch using cowdung gas was less than the time taken to cook the lunch using indane gas. The difference in time taken for cooking all the items found to be significant (Appendix VI).

(b) Cost of fuels used:

The cost of fuels were calculated on the basis of the consumption of the gases (cowdung and Indane).

Consumption of gas and cost incurred:

The gas consumption for the total cooking time in terms of cubic feet was calculated (Appendix VII).

Table XIV presents the mean consumption of gas and cost incurred for cooking the selected items in a lunch.

TABLE XIV

MEAN CONSUMPTION OF GASES (COW DUNG AND INDANE) AND COST INCURRED FOR COOKING SELECTED ITEMS IN A LUNCH

Items	Mean consumption of gas in c.ft.		cost incurred in paise		Savings
	Cowdung gas	Indane gas	Cowdung gas	Indane gas	
Rice	6.22	3.8	0.03	0.11	
Sambar	12.05	7.2	0.06	0.21	
Cabbage poriyal	2.73	1.70	0.01	0.05	
Raw Plantain curry	3.26	2	0.01	0.03	80%
Total amount of gas used and cost incurred	24.27	14.80	0.08	0.40	

The above Table shows that the total amount of cowdung gas consumed for cooking the selected food items on an aver[illegible]e amounted to 24.27 c.ft. The cost of cowdung gas to prepare the lunch comes up to 8 paise but where as the cost incurred for indane gas comes up to 40 paise. This result in saving of 80 per cent of the cost, if cowdung gas is used as a fuel.

Table XV depicts the acceptability of the cooked lunch by cowdung gas and indanes gas.

TABLE XV

MEAN SCORES AWARD FOR THE SELECTED LUNCH

Item	Colour		Flavour		Taste		Doneness		't' Value
	A	B	A	B	A	B	A	B	
Rice	4.33	4.4	4.33	4.4	4.13	4.26	4.36	4.2	
Sambar	4.13	4.06	4.13	4.06	4	4.06	4	4.53	
Cabbage poriyal	4.4	3.33	4.8	4.06	3.53	4.66	3.[illegible]	4.6	
Raw Plantain Curry	4.4	3.3	4.8	4.06	3.5	4.6	3.5	4.66	0.11

On statiscally analysing the data given in Table XV using the 't' test (Appendix VIII) the difference in characteristics of the cooked food using cowdung gas and indane gas was not found to be significant. This indicates that the items prepared by using cowdung gas is acceptable as items prepared by using indane gas.

e) Time taken for roasting, frying and steaming:

Table XVI deals the time taken for roasting, frying and steaming.

TABLE XVI

TIME TAKEN FOR ROASTING FRYING AND STEAMING

Triplicates	Method of cooking	Items cooked	Time taken (in mts) Cowdung gas	Indane gas	't' value
1	Roasting	Green Gram	4	5	4.16 *
2			$4\frac{1}{2}$	4	
3			$4\frac{1}{2}$	5	
1	Frying	Potato chips	7	8	
2			6	8	
3			7	7	
1	Steaming	Rice pittu	8	9	
2			8	9	
3			7	8	

* Significant at 5 per cent level.

The data indicates that the cowdung gas takes less time to cook when compared to indane gas. The statistical analysis shows, the significance at 5% level (Appendix IX).

b. Consumption of gas and cost incurred:

Table XVII denotes the mean consumption of gas and cost incurred for cooking the selected three items namely Roasting, Frying, and Steaming.

TABLE XVII

MEAN CONSUMPTION OF GASES AND COST INCURRED FOR COOKING SELECTED THREE ITEMS

Items	Mean consumption of gas in cft.		Cost in paise		Savings
	Cowdung gas	Indane gas	Cowdung gas	Indane gas	
Roasting green gram	1.1	0.70	0.01	0.02	
Frying potato chips	1.73	1.15	0.01	0.03	
Steaming Rice Pittu	2	1.30	0.02	0.04	56%
Total amount of gas used and cost incurred	4.83	3.15	0.04	0.09	

The above Table shows that the total cowdung gas consumed for cooking the selected food items amounted to 4.83 c.ft.

TABLE XVIII

MEAN SCORES AWARDED FOR THE THREE ITEMS

Items	Colour		Flavour		Taste		Texture		't' value
	A	B	A	B	A	B	A	B	
Roasted green gram	3.53	4.6	3.6	4.33	3.53	4.4	4.06	4.8	
Potato chips	4.33	4.8	4	4.6	4	4.33	4.2	4.7	1.6
Rice pittu	4.06	4.13	4.06	4.13	4	4.26	4	4.06	

As indicated above all the items received more or less same scores. On analysing the data statistically it was found to be not significant (Appendix X).

V SUMMARY AND CONCLUSION

The present investigation designed to find out the extent of use of cowdung gas as a household fuel and the utility of the gas in a hostel kitchen revealed the following facts.

1. The families surveyed had cowdung gas plants of 200 and 300 c.ft.

2. The Khadi and Village Industries Commission was instrumental in constructing gas plants in 80 per cent of the families surveyed.

3. Ninety per cent of the sample received financial help from the Khadi and Village Industries Commission in the form of a subsidy which amounts to 25 per cent of the estimated cost of construction.

4. Sixty eight per cent of the families had a distance of 20 metres between cowshed and gas plant. Cooking was the only activity for which cowdung gas was used in all the families surveyed.

5. Economy and efficiency in operation, absence of smoke, ease in cooking and the high nitrogen content of the slurry were the common benefits.

6. Inadequate facilities to store the cowdung gas, accumulation of water in the gas pipe which affects gas formation and the corrosion of gas

drum were the main problems cited by the owners.

Experiments conducted using the cowdung gas at Sri Avinashilingam Home Science College hostel revealed the following:

7. On an average the cowdung gas was utilised for seven hours in the hostel kitchen for cooking.

8. Eighty per cent of money could be saved over indane gas if cowdung gas is used as a fuel.

9. The items cooked with cowdung gas were as acceptable as those cooked over indane gas.

In conclusion it may be said that cowdung gas is an accepted fuel in the rural households. By extending the knowledge on cowdung gas plant and by reducing the interest on loans, a large number of households may be enthused to establish this beneficial scheme.

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APPENDICES

APPENDIX I

கோவை மாவட்டத்தில் சாண வாயுவை எரிபொருளாக உபயோகப்படுவதை அறிந்துகொள்ளும் வினாத்தாள்

. . .

I 1. பேட்டியாளர் பெயர் :

2. பேட்டியளிப்பவர் பெயர் :

3. முகவரி :

II. <u>குடும்பத்தைப் பற்றிய விபரங்கள்:</u>

1. குடும்ப வகை : தனிக்குடும்பம்/கூட்டுக்குடும்பம்

2. குடும்ப அங்கத்தினர்களின் எண்ணிக்கை:

அ) குழந்தைகள் :

ஆ) பெரியவர்கள் :

3. மொத்த மாத வருமானம் :

III. <u>சாண வாயு சாதனத்தைப் பற்றிய விபரங்கள்:</u>

1. சாண வாயு சாதனத்தின் கொள்ளளவு :

2. சாண வாயு சாதனத்தை கட்டுவதற்கான யோசனையை எங்கிருந்து பெற்றீர்கள்?) :

3. கட்டுவதற்கான பணத்தை பெற்றவகை

அ) கடன் :

ஆ) கடன்தொகை பெற்ற இடம் :

இ) மானிய தொகை :

4. கைவசம் உள்ள மாடுகள்

அ) பசுக்கள் :

ஆ) காளை மாடுகள் :

இ) எருமை :

ஈ) தினமும் உபயோகிக்கும் சாணத்தின் அளவு)

உ) சாணத்துடன் கழிவுகளைச் சேர்க்கும் விகிதம்)

அ) தண்ணீர் :

ஆ) கோமயம் :

5. சாண வாயு சாதனம் கட்டப்பட்ட வருடம்)

6. சாண வாயு சாதனம் அமையுமிடம் :

7. சாண வாயு சாதனத்திற்கும் மாட்டுத் தொழுவத்திற்கும் இடையே உள்ள தூரம்)

8. சாண வாயு சாதனத்திற்கும் சமையல் அறைக்கும் இடையே உள்ள தூரம்)

9. அ) சாணவாயு சாதனம் தண்ணீரில் இருக்கின்றதா, சாணத்தில் இருக்கின்றதா?)

ஆ) எரிவாயு நீக்கிய சாணத்தை எங்கு சேகரித்து வைக்கின்றீர்கள்)

இ) எரிவாயு நீக்கிய சாணத்தை எதற்கு உபயோகப்படுத்துகின்றீர்கள்?)

10. சாண வாயு சாதனத்தை கட்டுவதற்கு உபயோகித்த பொருட்கள்)

11. சாண வாயு சாதன டிரம்மின் அளவு :

12. கட்டுவதற்காக செலவழித்த)
மொத்த தொகை)

அ) கட்டுவதற்கு உபயோகித்த)
பொருட்களுக்காக செலவழித்த)
தொகை)

ஆ) வேலையாட்களுக்காக செல)
வழித்த தொகை)

IV. <u>மற்ற விபரங்கள்</u>

1. சாண வாயு கட்டுவதற்கு முன்)
உபயோகப்படுத்தப்பட்ட எரி)
பொருள்)

2. எரிபொருளுக்காக அப்பொழுது)
ஒரு மாதத்திற்கு செலவழித்த)
தொகை)

3. சமைப்பதற்காக எடுத்துக்)
கொள்ளப்படும் நேரம்)

அ. சாணவாயு சாதனம் கட்டுவதற்கு
முன் :

ஆ. கட்டிய பின் :

4. சாண வாயுவுடன் உபயோகப்படுத்தப்)
படும் எரிபொருள்)

V. <u>சாண வாயு சாதனத்தின் உபயோகங்கள்</u>

1. ஒருநாளில் சாண வாயு உபயோகப்
படுத்தும் நேரம் :

அ) காலை

ஆ) மதியம்

இ) மாலை

ஈ) இரவு

2. சாண வாயு அடுப்பின் எண்ணிக்கை
அடுப்பின் அளவு/அதன் விலை :

சிறியது

பெரியது

தனியானது

இரண்டு சேர்ந்தது.

3. சாண வாயுவின் மற்ற உபயோகங்கள் :

4. உபயோகப்படுத்தப்படும் விளக்குகளின் எண்ணிக்கை

அ) விளக்குகளின் அமைப்பு/அதன்விலை :

5. எல்லா உபயோகங்களுக்கும் தேவையான அளவு சாண வாயு உள்ளதா? :

6. சாண வாயு உபயோகித்து சமைக்கும் உணவுடைய தன்மை எவ்வாறு உள்ளது? :

7. ஒரு நாளைய உணவுப் பட்டியலை கீழே தரவும்

VI. சாண வாயு சாதனத்தைப் பற்றிய உங்கள் கருத்துக்கள் :

VII. சாண வாயு சாதனத்தை உபயோகிப்பதால் ஏற்படும் பிரச்சனைகள்

VIII. உங்களுடைய ஆலோசனைகள் :

APPENDIX II

ALLOWANCES OF NUTRIENTS FOR THE SELECTED LUNCH

S.No.	Name of food stuffs	Amount gms.	Energy k.cal.	Protein gm.	Calcium mg	Iron mg.	Carotene mg	Thiamine mg	Riboflavin mg	Niacin mg	Ascorbic acid mg
1.	Par boiled rice	325	1125	20.8	29.3	13	-	0.78	0.16	12.4	-
2.	Red gram dhal	100	335	22.3	73	5.8	132	0.45	0.19	2.9	-
3.	Cabbage	200	54	3.6	78	1.6	2400	0.12	0.18	0.8	248
4.	Small onion	75	45	1.4	30	0.9	12	0.06	0.02	0.4	2
5.	Raw plantain	250	160	3.5	25	1.5	75	0.13	0.05	0.1	60
6.	Groundnut oil	65	585	-	-	-	-	-	-	-	-
7.	Coconut	25	111	1.2	2.5	0.5	-	0.01	0.03	0.2	-
8.	Tamarind	10	28	0.3	17	1.1	6	-	0.01	0.1	-
	AI*		2443	53.1	254.8	24.4	2625	1.55	0.64	16.9	310
	R.A.*		2533	51.6	532-664	28.1	2933	1.29	1.11	16.9	59.8

* AI actual intake

RA Recommended allowances

APPENDIX III

STANDARDISED COOKING PROCEDURE

i. <u>Rice:</u>

Three hundred and Twenty five grams of parboiled rice and 750 ml of water were taken to prepare rice using absorption method. According to Davidson and Passmore (1975) Minimum amount of water should be used while cooking rice to preserve the nutrients in it.

ii. <u>Onion Sambar:</u>

Hundred grams of red gram dhal was boiled in 825 ml. of water with a pinch of turmeric powder. 55 grams of cleared small onions 2 tea spoon of salt and 1 tea spoon of chillie powder were added when the dhal was fully cooked. After the onions were cooked 25 ml of tamarinds juice was added, allowed it to boil and seasoning was done.

iii. <u>Cabbage poriyal:</u>

Two hundred grams of cabbage was cut into small pieces and it was cooked with 75 ml of water and salt in a frying pan. It was stirred uniformly till it became tender and seasoning was done.

iv. Raw Plantain curry:

Two hundred and fifty grams of raw plantain was cleaned and was cut into even pieces. 1 tea spoon of chillie powder, a pinch of salt and turmeric powder and 50 ml. of water were added and the frying pan was covered. 20 ml of oil was poured when it was fully cooked.

v. Boiling:

Two hundred and fifty ml of water and 125 ml of milk were boiled and the temperature was noted.

vi. Frying:

Fifty grams of potato was cleaned made into chips and fried in 150 ml. of oil until it turns into golden yellow in colour.

vii. Steaming:

Fifty grams of rice flour was mixed with a pinch of salt and sprinkles of water and steamed until it was fully cooked. Then it was mixed with 20 grams of sugar.

APPENDIX IV

SCORE CARD FORMULATED FOR CONDUCTING ACCEPTABILITY TESTS

A. SCORE CARD FOR ROASTED GREEN GRAM

Characteristics	Maximum marks	Marks given for*	
		A	B
1. <u>Colour:</u>			
Golden yellow	5		
pale yellow	4		
Brown	3		
Dark brown	2		
Black	1		
2. <u>Flavour</u>			
Highly acceptable	5		
Acceptable	4		
Fairly acceptable	3		
Not acceptable	2		
Not at all acceptable	1		
3. <u>Taste</u>			
Excellent	5		
very good	4		
Good	3		
Bad	2		
Very bad	1		

contd.

Characteristics	Maximum marks	Marks given for*	
		A	B
4. Texture			
Very crisp	5		
Crisp	4		
Fairly crisp	3		
Crumpy	2		
Very crumpy	1		

* A - Indane gas

B - cow-dung gas

B. SCORE CARD FOR POTATO CHIPS

Characteristics	Maximum marks	Marks given for* A	B
1. Colour			
Golden yellow	5		
Pale yellow	4		
Brown	3		
Dark brown	2		
Black	1		
2. Flavour			
Highly acceptable	5		
Acceptable	4		
Fairly acceptable	3		
Not acceptable	2		
Not at all acceptable	1		
3. Taste			
Excellent	5		
Very good	4		
Good	3		
Bad	2		
Very bad	1		

contd.....

Characteristics	Maximum marks	Marks given for *	
		A	B
4. Texture			
Very crisp	5		
Crisp	4		
Fairly crisp	3		
Pliable	2		
Very pliable	1		

* A – Indane gas

B – Cow dung gas

C. SCORE CARD FOR RICE PITTU

Characteristics	Maximum marks	Marks given for* A	B
1. <u>Colour</u>			
Most acceptable	5		
More acceptable	4		
Acceptable	3		
Slightly acceptable	2		
Un acceptable	1		
2. <u>Flavour</u>			
Pleasant pittu flavour	5		
More acceptable	4		
Acceptable	3		
Non acceptable	2		
Raw flavour	1		
3. <u>Taste</u>			
Excellent	5		
Very good	4		
Good	3		
Bad	2		
Very bad	1		

contd....

Characteristics	Maximum marks	Marks given for*	
		A	B
4. Texture			
Soft	5		
Very soft	4		
Mushy	3		
Slimy	2		
Turgid	1		

* A – Indane gas

  B – Cow-dung gas

D. SCORE CARD FOR RICE AND SAMBAR

Characteristics	Maximum marks	Marks given for *	
		A	B
1. Colour			
Most acceptable	5		
More acceptable	4		
Acceptable	3		
Slightly acceptable	2		
Un acceptable	1		
2. Flavour			
Highly acceptable	5		
Acceptable	4		
Fairly acceptable	3		
Not acceptable	2		
Not at all acceptable	1		
3. Taste			
Excellent	5		
Very good	4		
Good	3		
Bad	2		
Very bad	1		

contd......

Characteristics	Maximum marks	Marks given for *	
		A	B
4. <u>Doneness</u>			
Well cooked	5		
Cooked	4		
Partially cooked	3		
Over cooked	2		
Un cooked	1		

* A – Indane gas

B – Cow-dung gas

E. SCORE CARD FOR CABBAGE PORRIYAL

Characteristics	Maximum marks	Marks given for * A	B
1. Colour			
Light yellow			
Yellow	4		
Greenish yellow	3		
Light brown	2		
Brown	1		
2. Flavour			
Highly acceptable	5		
Acceptable	4		
Fairly acceptable	3		
Not acceptable	2		
Not at all acceptable	1		
3. Taste			
Excellent	5		
Very good	4		
Good	3		
Bad	2		
Very bad	1		

Contd.....

Characteristics	Maximum marks	Marks given for *	
		A	B
4. Doneness			
Well cooked	5		
Cooked	4		
Partially cooked	3		
Over cooked	2		
Un cooked	1		

* A- Indane gas

B- Cow-dung gas

F. SCORE CARD FOR RAW PLANTAIN CURRY

Characteristics	Maximum marks	Marks given for * A	B
1. Colour			
Brown	5		
Light brown	4		
White	3		
Dark brown	2		
Black	1		
2. Flavour			
Highly acceptable	5		
Acceptable	4		
Fairly acceptable	3		
Not acceptable	2		
Not at all acceptable	1		
3. Taste			
Excellent	5		
Very good	4		
Good	3		
Bad	2		
Very bad	1		

Contd......

Characteristics	Maximum marks	Marks given for*	
		A	B
4. <u>Doneness</u>			
Well cooked	5		
Cooked	4		
Partially cooked	3		
Over cooked	2		
Un cooked	1		

* A - Indane gas

B - Cow-dung gas

APPENDIX V

UTILITY OF COW-DUNG GAS IN THE HOSTEL FOR ONE MONTH

Date	Time taken in hours	Items prepared
1.9.75	5	Dhal cooking*
2	3	Boiling water for brew*
2.9.75	2	Boiling milk*
	3	Boiling water for brew
3.9.75	6	Dhal cooking
	1	Boiling drinking water*
4.9.75	6	Dhal cooking
5.9.75	3	Boiling water for brew
	5	Dhal cooking
6.9.75	3	Boiling water for brew
	5	Dhal cooking
7.9.75	3	Boiling water for brew
	5	Dhal cooking
8.9.75	6	Dhal cooking
	1	Boiling drinking water
9.9.75	3	Boiling water for brew
	5	Dhal cooking
10.9.75	1½	Boiling water for brew
	3½	Dhal cooking
11.9.75	3½	Boiling water for brew
	1½	Boiling drinking water

Contd......

Date	Time taken in hours	Items prepared
12.9.75	3	Boiling water for brew
	1	Boiling drinking water
13.9.75	3	Boiling water for brew
	5	Dhal cooking
14.9.75	2	Boiling drinking water
	3	Boiling water for brew
15.9.75	3	Boiling water for brew
	4	Dhal cooking
16.9.75	6	Dhal cooking
	2	Boiling drinking water
17.9.75	3	Boiling water for brew
	5	Dhal cooking
18.9.75	5	Dhal cooking
	2	Boiling milk
19.9.75	3	Boiling water for brew
	4	Dhal cooking
20.9.75	3½	Boiling water for brew
	4½	Dhal cooking
21.9.75	6	Dhal cooking
	2	Boiling drinking water
22.9.75	3	Boiling water for brew
	4	Dhal cooking

contd.......

Date	Time taken in hours	Items prepared
23.9.75	5½	Dhal cooking
	1½	Boiling water for brew
24.9.75	5	Dhal cooking
	3	Boiling water for brew
25.9.75	3	Boiling water for brew
	4	Dhal cooking
26.9.75	5	Dhal cooking
	2	Boiling drinking water
27.9.75	3	Boiling water for brew
	3	Dhal cooking
28.9.75	2	Boiling water for brew
	4	Dhal cooking
29.9.75	3	Boiling water for brew
	5	Dhal cooking
30.9.75	5	Dhal cooking
	1	Boiling milk

* Amount:

Dhal* - 8kg

water for brew - 20 litres

drinking water -15 litres

milk - 10 litres

APPENDIX VI

't' TEST APPLIED FOR TOTAL TIME TAKEN FOR COOKING A SELECTED LUNCH USING COW DUNG GAS AND INDANE GAS

Triplicate	Time taken in minutes: Indane gas A	Time taken in minutes: cowdung gas B	Mean A	Mean B	Standard deviation A	Standard deviation B	't' value
1	96.5	90.5					
2	98.5	90					
3	96.5	93.5	97.1	91.3	1.673	0.82	5.2

<u>Standard</u> <u>Deviation</u> (S.D.)

$$S.D. = \sigma = \sqrt{\left(\frac{\Sigma d^2}{n}\right) - \left(\frac{\Sigma d}{n}\right)^2}$$

where d = (x-A)

A is the Assumed mean

X is the given value

<u>For A</u>

x_1	x_1 -A	d_1^2
96.5	0	0
98.5	2	4
96.5	0	0
	2	4

$$\sigma 1 = \sqrt{\left(\frac{4}{3}\right) - \left(\frac{2}{3}\right)^2}$$

$$\sigma 1 \quad \sqrt{1.03-0.36}$$

$$\sqrt{0.67} = 0.8185$$

For B

x^2	$x_2 - A_2$	d_2^2
90.5	0.5	0.25
90	0	0
93.5	3.5	12.25
	4	13.50

$$S = \sqrt{\frac{4.5 - 1.69}{2.8}} = 1.673$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{n_1 \sigma_1^2 + n_2 \sigma_2^2}{n_1 + n_2 - 2} \times \frac{1}{n_1} + \frac{1}{n_2}}}$$

$$t = \frac{97.1 - 91.3}{\sqrt{\frac{3x2.89 + 3x0.67}{4} x1/3 + 1/3}}$$

$$t = \frac{6.8}{\sqrt{1.76}} = \frac{6.8}{1.3} = 5.2^{**}$$

If 4 is the Degrees of freedom, 't' value from the Table at : 1 percent level = 4.60

5 percent level = 2.70

The 't' value obtained is 5.2**

** The difference is significant at 1% level.

APPENDIX VII

GAS CONSUMPTION AND COST INCURRED

The cow-dung gas consumption for the total cooking in terms of cubic feet was calculated on the basis described below.

The size of the burner used for cooking - 16 c.ft.

In 60 minutes 16 c.ft. gas burner consumes - 16 c.ft. of gas

In x minutes 16 c.ft. gas burner consumes $= \frac{X \times 16}{60}$ = c.ft. of gas

The cost of the cow-dung gas was calculated as

1000 cubic feet of gas costs - Rs. 3

$\therefore$ x cubic feet of gas costs $= \frac{3}{1000} \times X$

The indane gas consumption for the total cooking in terms of cubic feet was calculated on the basis described below.

The capacity of the gas in a cylinder is = 1000 c.ft.

In 1000 c.ft. of gas can be used for = 6600 minutes

$\therefore$ x c.ft. of gas can be used for $= \frac{X \times 6600}{1000}$

The cost of the indane gas was calculated as

1000 c.ft. of the gas costs - Rs. 31(3100

$\therefore$ x cubic feet of the gas costs $= \frac{3100 \times X}{1000}$

APPENDIX VIII

't' TEST FOR THE ACCEPTABILITY OF THE COOKED ITEMS IN A LUNCH USING COWDUNG GAS AND INDANE GAS

Number of judges	Mean marks given for								Mean								Standard deviation								't' value			
	Colour		Flavour		Taste		Doneness		Colour		Flavour		Taste		Doneness		Colour		Flavour		Taste		Doneness		Colour	Flavour	Taste	Doneness
	A*	B*	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B				
1	4	4.5	4	4.5	4.3	4.5	4	4																				
2	4.6	4.5	4.6	4.5	4	4.5	4.5	4.5																				
3	4.5	4.6	4.5	4.6	4	4.5	4.3	4.6																				
4	4.5	4.6	4.5	4.3	4	4	4	4																				
5	4.6	4.5	4.6	4.5	4.5	4.5	4.6	4.6	4.4	4.4	4.4	4.4	4	4.5	4.1	4.5	0.2	0.42	0.2	0.42	0.1	0.12	0.2	0.6	0*	0*	0.5*	0.11*

* – The difference is not significant

*A – Indane gas

*B – Cowdung gas

APPENDIX IX

't' TEST APPLIED FOR TOTAL TIME TAKEN FOR COOKING A SELECTED THREE ITEMS USING COW-DUNG GAS AND INDANE GAS

Triplicates	Time taken in minutes		Mean		Standard deviation		't' value
	Indane gas	cow-dung gas					
	A	B	A	B	A	B	
1	22	19					
2	21	18					
3	20	18.5	21	18.5	0.8	0.4	4.16*

* The difference is significant at 5% level

APPENDIX X

'**t' TEST FOR THE ACCEPTABILITY OF THE COOKED THREE ITEMS USING COWDUNG GAS AND INDANE GAS**

Number of judges	Mean marks given for								Mean								Standard duration								't' values			
	Colour		Flavour		Taste		Texture		Colour		Flavour		Taste		Texture		Colour		Flavour		Taste		Texture		Colour	Flavour	Taste	Texture
	A*	B*	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B				
1	4.3	5	3.6	4.6	4	4.3	4	4.6																				
2	4.3	4.3	3.6	4.3	3.6	4.3	3.6	4.3																				
3	4.3	5	4.3	5	4.3	4.6	4	5																				
4	4.3	5	4	4.3	4	4.3	4.6	5																				
5	4.3	5	4.5	4.6	4	4	4.6	4	4.3	4.8	4	4.6	4	4.4	4.1	4.7	0	0.71	0.95	0.07	0.07	0.2	0.4	0.3	1.6#	1.2#	2#	1#

\# - The difference is not significant

*A - Indane gas

*B - Cowhung gas