A COMPARATIVE STUDY OF ALUMINIUM, STAINLESS STEEL, BRASS AND EARTHENWARE COOKING UTENSILS WITH REGARD TO PALATA-BILITY OF FOODS AND TIME AND MONEY EXPENDITURE

By

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A Thesis Submitted to the University of Madras
In Partial Fulfilment of the Requirements for
The Degree of Master of Science

May 1962.

ACKNOWLEDGEMENT

The investigator expresses her grateful thanks to Dr. (Mrs.) Rajammal P. Devadas, M.A., M.Sc., Ph.D.(Ohio State), Principal, Sri Avinashilingam Home Science College, for her valuable guidance; Miss M. Usha, M.Sc., Lecturer in Home Science for her help in the preparation of the thesis; to Sri N.V. Manuel, M.A., M.Ed., Head of the Research Department, Sri Ramakrishna Mission Vidyalaya, for his assistance in Statistical Analysis of Data; to Miss P.S. Nirmala, M.A., Lecturer in Physics for her help in the physical concepts used in the study; to the Swedish Consumer Research Institute, Stockholm, Sweden; and to the Nickel Information Bureau, Bombay for the information supplied.

TABLE OF CONTENTS

Table		Page
I	The composition of the different types of grains	17
II	Number and percentage of the families using the different types of utensils	30
III	Number and percentage of families using the different types of utensils for the various food preparations	40
IV	Reasons of the homemakers for using the different utensils	43
V	Reasons for not using certain types of utensils	45
VI	Problems encountered in using certain utensils	47
VII	Total time taken for cooking rice and the analysis of mean differences in the four utensils	50
VIII	Total time taken in seconds for cooking beans and the analysis of mean differences in the four utensils	52
IX	Total time taken in seconds for cooking tamarind kazumbu and the analysis of mean differences in using the four utensils	53
X	Summary of the palatability scores for rice	54
XI	The analysis of mean differences of the palatability scores for rice among the four utensils	55
XII	Summary of the palatability scores for beans cooked in the four utensils	58
XIII	Analysis of mean differences of the palatability scores for beans among the four utensils	59
XIV	Summary of the palatability scores for tamarind kuzhambu	61
XV	Analysis of mean differences of the palatability scores for tamarind kuzhambu among the four utensils	62
XVI	Total cost for cooking rice, beans and kuzhambu and the analysis of mean differences in using the four utensils	64
XVII	The time taken in seconds to clean and the analysis of mean differences in using the four utensils.	65

LIST OF FIGURES

LIST OF APPENDICES

I. INTRODUCTION.

Food is one of the basic necessities of man. In order to become digestible and assimilable, food must undergo certain physical and chemical changes before and after ingestion. These changes are brought about by cooking before food is consumed and by digestion, absorption and metabolism after food is ingested. Cooking is essential not only to make food digestible, but also to render it attractive, tasty and to improve its flavour. As Dowd and Dent (1948)[1] point out, "Cooking, the preparation of food by the application of heat, is the first step in making food available to the body". Therefore cooking of food has become one of the main activities in our daily living and consumes more of the homemaker's time than any other job.

Cooking of food is as ancient as the discovery of fire. In the primitive days, cooking was not always carried out in a container. The oldest method of cooking was to hold the food directly over the fire. As time progressed, man discovered the use of utensils for cooking.

Many materials are now used for manufacturing cooking utensils, such as aluminium, brass, bronze, stainless steel, iron, copper, enameled ware, earthenware, glass, wood and stone ware. In India, the most commonly used materials for cooking utensils are iron, steel, copper, bronze, aluminium, brass and some varieties of stones. A survey conducted by Kanagaraj (1960)[2] in Coimbatore, which covered a sample of eighty households, showed that the cooking utensils used in those households were aluminium, stainless steel, brass, bronze, copper, iron, earthenware and stoneware, known as 'kalchatty'. Among these, aluminium, brass, stainless steel and earthenware utensils were used by more than 50 per cent of the households. Aluminium utensils were used by 52 per cent, brass by 81 per cent, stainless steel by 61 per cent and earthenware by 60 per cent of the households.

Cooking utensils are used daily in every household. They must possess some qualities which will help them to withstand the daily wear and tear. Baragar (1941)[3] suggests that the following points should be given consideration in the selection of cooking utensils:-

(1) Durability; (2) Sanitation; (3) Ease of handling; (4) Performance and (5) Cost.

He defines the durability of an utensil as its ability to retain its shape, to resist scratching, pitting, warping and chipping and to withstand the action of water, acids, alkalies and high temperatures. By sanitation he means that the cooking utensil should be easy to clean and easy to be maintained clean, without requiring much special effort or care by the homemaker. Cooking utensils should not be too heavy for ease of handling. Selection of heavy utensils will not always result in good management, since cost of time and energy involved in handling the heavy utensil may be much greater than the actual saving effected through its durability.

'Performance' is referred to by Baragar (1941)[3] as the ability of the cooking utensil to absorb and transmit heat from the heat source to the food contained in it. Performance of the utensil is important from the point of view of fuel economy.

Cost is yet another factor in determining the type of utensil to be purchased by a particular family. The cost of the utensil has to be considered in relation to all the other desirable qualities, namely, durability, sanitation, ease of handling and performance.

The qualities mentioned above depend upon the physical, chemical and mechanical properties of the materials used for manufacturing the utensils. For example, the performance of a utensil depends upon physical properties such as thermal and electrical conductivity*, radiational qualities and heat-absorbing qualities, which determine the extent to which the utensil can absorb, transmit or retain heat. The

* Thermal and electrical conductivity is the measure of its ability to conduct heat and electricity.

durability and ease of handling depends upon the fragility, malleability*, ductility** and specific gravity. Chemical properties such as action of water, air, acids and alkalies also determine the quality of the utensil.

Unfortunately, all the desirable qualities do not exist together in any single material used for manufacturing cooking utensils. The reason for this is that materials differ from one another in terms of their physical, chemical and mechanical properties. Earls (1950)[4] points out that iron, steel and aluminium and sometimes copper, are used for cooking utensils, mainly due to their high thermal conductivities favouring transmission of heat. Hence foods get cooked sooner in these utensils than in others.

Some materials, such as brass and copper, react with foods cooked in them, unless they are given some special treatment like tinning before putting them to use. Some other materials such as earthenware and glassware do not react with the food materials and hence need no special treatment before they are used. Stainless steel and enameledware are easier to clean than others because of

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* Malleability is the property of metal which enables it to be hammered and beaten into forms such as that of thin sheets.

** Ductility is the property of metals which enables the metal to be given a considerable amount of mechanical deformation.

their smooth surfaces and thus help to save time and energy. Materials like brass, collect dust, soil and tarnish easily, when they are not put to use frequently.

In short, none of the materials fulfill all the requirements necessary for a good cooking utensil. For example, the more durable the utensil, the more costly it may become. In the same way, from the cooking point of view, the material may be suitable, but not durable. All these show that proper selection of cooking utensils is a skill to be acquired by the homemaker. As Beveridge (1950)[9] points out, "Since cooking is a regular three-meals-a-day job, the homemaker will do well to select her pots and pans with as much care as any craftsman."

Knowledge of the differences in the qualities of the materials used for manufacturing cooking utensils and the criteria for selecting them will, therefore, help a homemaker immensely in the selection of cooking utensils. Such knowledge is almost lacking in India, while in some of the countries abroad, the commercial concerns which manufacture cooking utensils take the responsibility of informing the consumers, characteristics of their products and the criteria for selection of cooking utensils. This practice is beneficial to both the producer and the consumer, in that it helps to promote the sales and at the same time keep the homemaker adequately informed.

These concerns usually have a Home Economics Department, where trained Home Economists conduct tests on the different utensils and make available the information to the consumers. They also educate the consumer by publishing valuable literature.

In view of the paucity of such information, the present study was undertaken to compare four commonly used materials for manufacturing cooking utensils in the Indian homes namely, aluminium, stainless steel, brass and earthenware with reference to the initial cost, the time taken to cook the food and the palatability of foods cooked in them. It is hoped that the findings of this study will help the homemaker in the proper choice and purchase of cooking utensils.

II. REVIEW OF LITERATURE.

Cooking utensils are the most important household equipments. They are used daily and often put to rough use. They are subjected to high temperatures and the action of air, water, solutions of salts, alkalies and acids and other substances, which may be naturally occurring in foods or added during the process of cooking. Cooking materials are also subjected to the action of washing materials and detergents. Sometimes as a result of these treatments the cooking utensils may get damaged, depending on the type of material used for manufacturing them.

Child and Niles (1938)[6] state, "It is desirable to understand the characteristics of the different materials used for cooking utensils in order to know how to use the cooking utensil, how to care for it and how to clean it". Hence a brief description of the different materials namely aluminium, stainless steel, brass and earthenware is given in the following paragraphs:-

Aluminium.

Aluminium was once considered as a luxury metal as can be seen from the following extract taken from Weaver and Foster (1954)[7]:-

"When Napoleon III (1808-1873), nephew of Napoleon Bonaparte, dined in state, his guests had to be content to use gold forks. Napoleon himself used an aluminium fork; only the great were privileged to use such an expensive and light metal as aluminium".

Sorum (1957)[8] states that aluminium became cheap and available to all people when Hall in 1886 discovered the process of manufacturing aluminium on commercial basis at very low cost.

<u>Occurrence.</u> According to Dayal (1961)[9], "Aluminium is the most abundant element forming eight per cent of the earth's crust". It is of secondary importance to iron, partly because it never occurs in a free state and partly because of the difficulties in its extraction. Noholm, as quoted by Neymark (1950)[10] states that aluminium is extremely widespread in nature and occurs in the earth's crust, in water, in vegetation and also in animal tissues but in smaller quantities. The most important aluminium minerals are Bauxite ($Al_2O_3H_2O$), Cryolite (Na_3AlF_6), Feldspar ($KAlSi_3O_8$) and some varieties of clay. Aluminium is usually extracted from Bauxite for commercial purposes.

<u>Composition and Properties of Pure Aluminium and its Alloys.</u> Sorum (1957)[8] states that aluminium is a light metal with a bluish tinge, capable of taking a high polish. It is very ductile and malleable. The specific gravity of aluminium is 2.66, the melting point 660°C and the boiling point 1800°C. It is a good conductor of heat and electricity.

Black and Conant (1956)[11] state that pure aluminium is made harder by alloying it with other metals, such as copper, manganese, zinc and chromium, so that they can be worked more easily. According to Holmes (1959)[12] aluminium which is used for commercial purposes contains 99.2 per cent pure aluminium and the remaining percentage is made up of iron and silicon. Aluminium which is used for manufacturing cooking utensils contains the following elements in the percentages specified below:-

Aluminium.	89.5
Manganese.	6
Copper.	4
Magnesium.	0.5

There are also other types of aluminium alloys, such as:

1) Magnalumin which contains:

Aluminium.	80 - 90
Magnesium.	10 - 20

2) Aluminium Bronze:

Aluminium.	88 - 95
Copper.	5 - 12

Aluminium alloys are stronger and harder than pure aluminium. As Parkes (1956)[13] points out, the addition of other materials increases the tensile strength of pure aluminium from four tons/square inch to 25 or 30 tons/square inch.

When aluminium is exposed to air, its brilliant lustre is destoryed by the formation of a layer of aluminium oxide. But Parkes (1956)[13] states that aluminium remains practically unaltered by dry air, while in moist air and in boiling water, the superficial film of aluminium oxide protects the metal from further action. According to Weaver and Foster (1948)[7] reaction takes place between aluminium and hot water, only when the layer of aluminium oxide is removed completely from the metal. The reaction is vigorous and hydrogen and aluminium hydroxide are formed.

$$2Al + 6H_2O \rightarrow 3H_2 + 2Al(OH)_3$$

Studies were conducted by Heymark (1950)[10] on the effect of three different samples of water on aluminium utensils which showed that aluminium is corroded by hard water due to the presence of salts contained in it. He also states that aluminium dissolves both in acid and alkaline solutions. Acids dissolve the oxide film on aluminium and attack the metal beneath. The action of hydrochloric acid is vigorous with the liberation of hydrogen and aluminium chloride. The reaction is represented by the formula given below:-

$$2Al + 3HCl \rightarrow 2AlCl_3 + H_2$$

Aluminium is also corroded by treatment with organic acids but not to the same extent as with inorganic acids. Experiments carried out by Heymark (1945)[10] on the effect of tap water with a pH of 8.4

per cent acetic acid solution, 0.5 per cent oxalic acid solution and 0.5 per cent bicarbonate solution showed that of the acids, oxalic acid had a considerably greater corrosive effect than other acids and acetic acid is somewhat more corrosive than citric acid.

The inherent qualities of aluminium, both physical and chemical discussed above, makes aluminium a good metal for manufacturing cooking utensils. Due to its high ductility, malleability and tensile strength, it lends itself admirably to welding and riveting, which are helpful in making utensils of any shape and size.

Walley (1960)[14] points out that aluminium is available in two forms, 'Cast' and 'Wrought', the latter constituting about 80 per cent of the total production of aluminium industry. Both forms are used for manufacturing utensils. Alexander and Street (1954)[15] define a 'wrought' aluminium utensil, as "One that has been forced into a desired shape by mechanical means; it may be rolled into sheets, bars or strips; it may be hammered, forged, extruded, pressed or spun". 'Wrought' aluminium utensils are made from aluminium sheets of varying thicknesses from 16 to 22 gauge.*

*Gauge is the unit of measurement for the thickness of metal sheets (Smithels 1955)[17]. As the gauge increases, the thickness decreases as for instance for the standard gauge zero the thickness is 0.324 inches and for the gauge ten the thickness is 0.128 inches. The gauges of utensils generally is around 20 for which the thickness is 0.036.

'Wrought' aluminium utensils made from sheets of medium and thicker gauges are durable. Utensils made of thinner sheets may be light and less costly, but may not stand hard wear. 'Cast' aluminium utensils are shaped by pouring liquid aluminium into moulds of desired patterns. 'Cast' aluminium is soft and tensile. Generally 'cast' aluminium utensils are heavier and thicker than those made from 'wrought' aluminium. Moreover 'cast' aluminium utensils are rigid and do not warp. A study conducted by [illegible]ater and [illegible] (1933)[16] to find out the effect of the thickness of a utensil on its thermal efficiency* showed that for general use, pans of medium gauges may prove more efficient than those of either the thickest or the thinnest gauges. Another study carried out by Good (1923)[18] on the thermal efficiency of stew kettles of aluminium ware and enameledware, showed a slightly higher efficiency than the thinner ones of 'cast' aluminium. This was due to the fact that the bottom of the 'cast' aluminium was rougher than that of the thin-walled 'cast' aluminium utensil. Hence it was concluded that the efficiency of the utensil depended more on the heat-absorbing quality of the material than on the thickness of the

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* Thermal efficiency: [illegible]ater and [illegible] (1933)[16] give the following formula for thermal efficiency:-

$$E = \frac{\text{Weight of water in grams} \times \text{rise in temperature in °C}}{(\text{watts} \times \text{[illegible] seconds}) \div 4.18}$$

1 calorie (g.cal.) = 4.18 watts seconds.

same. It was also found that the heat-absorbing quality was more in the case of rougher surfaces than in the case of smoother areas.

Alexander and Street (1954)[15] state that aluminium utensils are given a treatment known as 'Anodisation', in which the film of aluminium oxide on the surface of the utensil is increased upto one thousandth of an inch and the bottom is darkened. This treatment increases the corrosion resistant quality of the aluminium utensils. Although darkening of the bottom of the utensil makes them less attractive, it is advantageous, as it increases the heat-absorbing quality of the utensil.

<u>Action of Foods Acids and Alkalies on Aluminium Cooking Utensils.</u> Fitch and Francis (1955)[19] point out, when any acid containing food is cooked in an aluminium utensil, the acids in the food react with the aluminium and small quantities of aluminium salts are formed. For example, aluminium tartarate or citrate is formed when foods containing tartaric acid or citric acid are cooked in an aluminium utensil as indicated below:-

$$3\begin{matrix}CHOH - COOH\\ | \\ CHOH - COOH\end{matrix} + 2Al \longrightarrow \left(\begin{matrix}CHOH - COO\\ | \\ CHOH - COO\end{matrix}\right)_3 Al_2 + 3H_2$$

(Aluminium Tartarate)

$$2\begin{array}{l} CH_2 - COOH \\ | \\ CHO - COOH \\ | \\ CH_2 - COOH \end{array} + 6Al \longrightarrow 2\left.\begin{array}{l} CH_2 - COO \\ | \\ CHOCOO \\ | \\ CH_2COO \end{array}\right\rangle Al + 3H_2$$

(Aluminium citrate)

The formation of these salts, however, do not seem to affect the flavour of the foods cooked nor are they harmful, if absorbed from the intestinal tract.

Stainless Steel.

Composition and Properties of Stainless Steel. Stainless steel is the general name given for a number of alloys of steel used for manufacturing cooking utensils and other equipments. It is an alloy of steel and chromium, with iron as the basic metal. Other metals may also be added to the steel-chromium combination to obtain steel with special characteristics such as: resistance to high temperatures and corrosion. Broughton (1961)[20] indicates that there are approximately 30 varieties of stainless steel obtained by the addition of different elements such as nickel, manganese, molybdenum, phosphorus, selenium, silicon, sulphur, titanium and sinconin, to the basic steel-chromium combination. The quality of the particular variety of stainless steel also depends on the proportion of the ingredients added to the basic alloy of steel.

The stainless steel which is used for cooking utensils is generally known as the 18/8 type which means that the alloy contains 18 per cent chromium and 8 per cent nickel besides other elements. One of the stainless steel manufacturers of Madras State (1961)[21] use ordinarily the 18/8 type stainless steel sheets of 22 gauge for manufacturing cooking utensils. The percentages of other elements which are included in the combination known as the number 302 type are:-

Carbon.	0.08 to 0.15
Manganese.	2
Silicon.	1
Phosphorus.	0.04
Sulphur.	0.03

Another type of stainless steel has been recommended by The American Iron and Steel Institute (1955)[22] known as the number 304 type for manufacturing cooking utensils. The percentage of other elements added to the basic combination are:-

Chromium.	18 to 20
Nickel.	8 to 12
Carbon.	0.08
Manganese.	2
Silicon.	1
Phosphorus.	0.045
Sulphur.	0.03

All stainless steel utensils have the ability to resist rusting and staining. The Nickel Information Bureau of Bombay (1961)[23] proclaims that stainless steel is preferable for cooking purposes because of its heat-resisting and corrosion-resisting properties.

Stainless steel is a solid metal and as strong as ordinary steel. It is harder than the alloys of copper and aluminium. Hence it does not chip, peel or flake away.

Stainless steel is not affected by alkalies and acids. Child and Niles (1938)[6] state that stainless steel does not tarnish when exposed to atmospheric air. According to Peet and Thye (1955)[24] stainless steel always retains the new look because it can take and retain high polish.

Stainless Steel Cooking Utensils. Broughton (1961)[20] remarks that in Britain and U.S.A. stainless steel has been in use for working surfaces, kitchen tools and cutlery for the past several years. Greater use of stainless steel for cooking utensils as saucepans and frying pans has been facilitated by new techniques in the production and increased availability of the metal.

Stainless steel utensils are becoming more and more familiar in the Indian kitchens. However, the use of stainless steel for cooking purposes is limited since the stainless steel varieties which contain a higher percentage of chromium and nickel than other types are not good conductors of heat. Therefore the food gets burnt more readily at the bottom of the utensil where the heating is intense and not evenly distributed. When a stainless steel utensil is heated for a long time at a high temperature, it becomes discoloured at different parts which is known as 'hot spots'.

In spite of these drawbacks and its exorbitant cost, stainless steel is becoming popular day by day due to its other qualities such as durability, resistance to corrosion, ease of cleaning and attractive appearance.

Brass.

Composition and Properties of Brass. Walley (1960)[14] defines brass as an alloy of copper and zinc. According to Sisco (1941)[25], there are two varieties of brass known as the 'high brass' and the 'low brass' which are widely used. The high brass contains 30 per cent or more of zinc and the low brass contains less than 25 per cent zinc. There are also other varieties known as the muntz metal, commercial bronze, red brass and manganese bronze.

The colours of the different types of brass vary from bright yellow to a reddish yellow. The composition of some of the well-known types of brass is given in Table I.

TABLE I.

* THE COMPOSITION OF THE DIFFERENT TYPES OF BRASS.

Names.	Composition-Percentage.					
	Copper.	Zinc.	Tin.	Lead.	Nickel.	Manganese.
1. High brass.	65	35	-	-	-	-
2. Low brass.	80	20	-	-	-	-
3. Muntz metal.	60	40	-	-	-	-
4. Commercial brass	90	10	-	-	-	-
5. Red brass.	85	5	5	5	-	-
6. Manganese brass.	59	39.8	0.7	-	-	0.5

* From Sisco (1941)[25]

For manufacturing cooking utensils, the composition of brass used is 66 per cent copper and 34 per cent zinc.

Brass Cooking Utensils. Brass is a strong and ductile alloy. It tarnishes when exposed to air and water because of its copper content reacting with the carbon dioxide of air, forming copper carbonate, which is green in colour, known as verdigris. Long contact of brass utensil with food acids such as tartaric acid, citric acid and acetic acid results in the formation of poisonous copper salts of the respective acids. Valley (1960)[14] cautions that due to this reaction, the use of brass as such for cooking purposes should be prohibited. Therefore, in order to avoid tarnishing brass utensils are tinned. A thin coating of tin prevents the contact of food acids with the copper in the alloy.

Earthenware.

De Sager (1952)[26] defines pottery as "ware of any kind made from clay and hardened by fire, comprising the three important fields of earthenware, stoneware and porcelain". The Khadi Gramodyog Vidyalaya of the Gandhiniketan Ashram at Kallupatti (1960)[27] reports that the origin of pottery industry is not known. From ancient times clay has been use for making fireproof and impervious household utensils. Hundreds of specimens found on the site of Mohanjadaro and Harappa indicate that the art of making pottery goes back to the times of the Indus valley civilisation from 3000 to 2000 B.C. The art of colouring, the application of glaze and the geometric pattern on the pots show a high level of technicality and richness of thought. They further state that Egypt which is considered to be the cradle land of civilisation knew the art of making pottery about the same time as India. Earthenware was largely used in Egypt for domestic purposes. In the same way, China had made the greatest contribution to pottery-making by the invention of porcelain potteries. The potteries of China and Japan are considered to be highly artistic. The art of making pottery was also found to be highly developed in countries like Scandinavia, Greece, Spain, France, Rome, Denmark and Russia.

<u>Composition and Properties of Earthenware.</u> According to the report of the Khadi Gramodyog Vidhyalaya of Gandhiniketan Ashram of Kallupatti (1960)[27] clay is the basic material used in the making of pottery. Clay is formed in nature by the disintegration or weathering of rocks. Binns (1955)[28] states that clay differs from earth and soil in that it possesses certain characteristics which earth and soil do not possess. Although clay is distributed widely in nature, most of it is concealed under the soil. It usually appears as a greenish or bluish substance of close and uniform structure. Binns (1955)[28] further points out that "Such clays as are commonly found can be used for the manufacture of some kind of pottery, but in the great

majority of cases, the ware will be red when fired because the clay contains a portion of oxide of iron". Pure clay is known as hydrous aluminium silicate as it contains silica, alumina and water in its composition. Commercial or workable clay also contains sand, other impurities such as lime or oxide of iron. The physical and chemical nature of sand vary widely. Binns (1955)[28] states that the physical properties of sand depend upon its fineness. Pure sand is known as quartz sand. Feldspar is formed by a crushed rock of almost any composition. Each of these ingredients clay, quartz and feldspar has an important part to play in making pottery.

The quality of pottery depends upon the physical properties of the clay used. The Khadi Gramodyog Vidhyalaya of Gandhiniketan, Kallupatti (1960)[27] refers to the physical qualities of clay as follows: Plastic when moist and hard when dry and able to retain its shape when dried and capable of forming into a rock-like mass when heated to incandescence. Binns (1955)[28] points out that plasticity, porosity and vitrification are the physical qualities required of clay. Plasticity is the quality which helps in shaping the clay into the required shape.

The second property required of clay is porosity. A porous clay helps in permitting the water to escape freely, preventing warping and cracking of potteries when dried. Porosity is produced by adding sand to the natural clay. Coarse sand is more effective than a fine sand. However, too coarse a sand may interfere with the delicate working, while too fine a sand may produce a dense substance. Hence porosity and plasticity should be balanced properly.

The third important property which is required of clay is its ability to yield to the action of high temperature, so that it is possible to get a ware hard, durable and sonorous. This property is known as 'vitrification' or 'densification'. Vitrification or densification is due to the presence of feldspar or fusible sand. Vitrification is greater with fine grained feldspar than with a coarse feldspar. It gives the pottery the ability to withstand high temperatures.

Types of Clays. De Sager (1952)[26] enumerates five types of clay used for making pottery. They are: Kaolin or China clay, which is a white burning residual clay used in making china wares; Ball clay is a plastic clay. Owing to its high plasticity it is used as one of the ingredients for making porcelain; Stoneware clay is also a plastic clay, which becomes a dense impervious body on burning; Yellow clay is a semi-refractory clay employed for making yellow ware; Retort clay is a dense burning fire clay frequently used for the manufacture of stoneware. The Khadi Gramodyog Vidhyalaya of Kallupatti (1960)[27] mentions two more varieties of clay, the feldspar and sedivatory clay. Feldspar clay which contains silicate of aluminium or potassium is available in large quantities.

Process of Manufacture of Pottery. In India, three types of clay are available in ready-made form for making potteries. They are the white, brownish black and black clays. Since the properties of these clays differ with each other, they are always used in combination to give the best product.

The first step in manufacture of pottery is to remove the foreign particles such as: weeds, small stones and leaves from the clay. The clay is first dried and then beaten well with a bat into small bits. The clay is then dissolved in a cistern at an elevated position which has three outlets one above the other at different levels. When the clay is dissolved completely the heavy matters like stones go to the bottom and light foreign matters like leaves, weeds, float on top. These are removed from the mixture with the help of a net sieve. The pure solution of clay which stands over the thick paste-like slurry is decanted through the topmost and middle outlets. This process is repeated until all the heavy impurities are collected at the bottom and thrown away. The clay particles of the solutions are allowed to settle and the water at the top is filtered. The thick clay strip thus obtained is baked in the sun and made into clay cakes which are pure clay without any impurities. In the next step the half-baked clay is spread on a thin layer of sand and kneaded with leg or hand after sprinkling water to make it into a workable smooth paste. The kneaded clay is then thrown on the potter's wheel and shaped by an experienced potter to the required form when the wheel is rotated at a good speed. When the pots are still moist, they are beaten up well with a flat wooden bat to release any air-space in the clay body or to fill in gaps that might have formed in the layers.

After drying, the potteries are glazed. Binns (1955)[27] defines glazes as "Impervious silicate coating which are developed on ceramic articles by the fusion of mixtures of inorganic materials". Glazes prevent the penetration of liquids and give a smooth, easily cleanable surface.

The potteries are coated with glaze and are dried and then fired to facilitate the melting and fusion of the glaze. Firing of pottery is also necessary to make it hard and insoluble in water. De Sager (1952)[26] states that "for firing pottery either muffle or sagger kiln is used ... for earthenware, the muffle kiln is generally used which may be permanently built-in or portable furnaces". According to the Khadi Gramodyog Report of Kallupatti (1960)[27] Indian potters use open bhattis for firing pottery.

Earthenware Cooking Utensils. Walley (1960)[14] states, earthenware utensils are brown in colour. They fuse above 1800° C. They are brittle and are poor conductors of heat. They do not take a high polish. Earthenware is not attacked by atmospheric air, water, acids and alkalies. Since the raw materials are easily available the cost of earthenware utensils is comparatively cheaper and they are widely used in many parts of India, especially in rural areas.

III. EXPERIMENTAL PROCEDURE.

The experimental procedure consisted of two parts, namely a survey of the cooking materials used in order to enable the selection of cooking materials for the cooking experiments and then compare the different materials used for cooking utensils with regard to palatability of food, time and money expenditure.

Survey of the Cooking Materials.

The purpose of the survey was to find out the various types of cooking utensils used and the extent to which they are used in homes belonging to different income groups. The steps involved in the study were as follows: Selection of survey method; selection of the sample of homemakers; framing the interview schedule (Appendix I); Collection of data; tabulation and interpretation of results.

<u>Selection of Survey Method.</u> Interview method was chosen as the tool for the study since it is possible to obtain all the required information by this method.

<u>Selection of Sample.</u> A sample of 75 families was selected for the study on random basis. Of these, about 20 families were from students of Sri Avinashilingam Home Science College and 20 families of the pupils of Sri Avinashilingam Trust High School and the rest from the R.S.Puram Suburban Elementary School, as it was thought that such a sample would include all income groups. The families were selected

by taking every fourth member from the respective classes.

Framing the Interview Schedule. An interview schedule (Appendix III) was framed to elicit information on the following: The types of cooking utensils used; the preparations for which they are used; reasons for using and not using the utensils; problems involved in using them; materials used for cleaning and washing the various types of utensils; household fuel used and the major criteria for buying cooking utensils.

From the data given in the Appendix (II) it is found that stainless steel and brass are used by families of all income groups, whereas aluminium andearthenware are used mainly by families of middle income groups. Moreover, except in the case of brass, all these utensils are put to daily use. Although the percentage of families using iron, bronze and kalchatty are high, they are used only for certain preparations (Table III). Hence, for cooking experiments, aluminium, stainless steel, brass and earthenware were selected.

Cooking Experiments With the Four Utensils.

The object of the experiment was to compare four different materials used for manufacturing cooking utensils, namely, aluminium, stainless steel, brass and earthenware, with regard to cost, palatability of the foods cooked in them, time taken for cooking and consumption of fuel and ease of cleaning, by cooking the selected preparations: rice, beans and 'tamarind kushambu'. This was done in the following stages:

Selection of Recipes. Rice, which is the staple food of South Indians was one of the three common South Indian food preparations selected for the study. French beans, a vegetable commonly eaten in the Indian homes, was chosen as the vegetable, in order to study the quality of the product, cooked in the different types of utensils. Tamarind Kuzhambu was selected as tamarind is widely used in South Indian preparations, such as 'sambar' and 'rasam' to give tartness (Srinivasan, Rao and Sastry 1959)[29].

Selection of Equipment and Procedures for their Working.

Cooking Utensils. Utensils made of the four commonly used materials, aluminium, stainless steel, brass and earthenware were selected for the study (Figure 1). The thickness of the utensils other than the earthenware one, were identical (19 gauge). The earthenware utensil was of greater thickness because of the non-availability in the market of earthenware utensils of 19 gauge. The capacity of the utensils were also identical:

Aluminium.	1903 ml.
Stainless steel.	1900 "
Brass.	1898 "
Earthenware.	1908 "

Aluminium, stainless steel and brass utensils had perpendicular sides and flat bottoms. In the case of

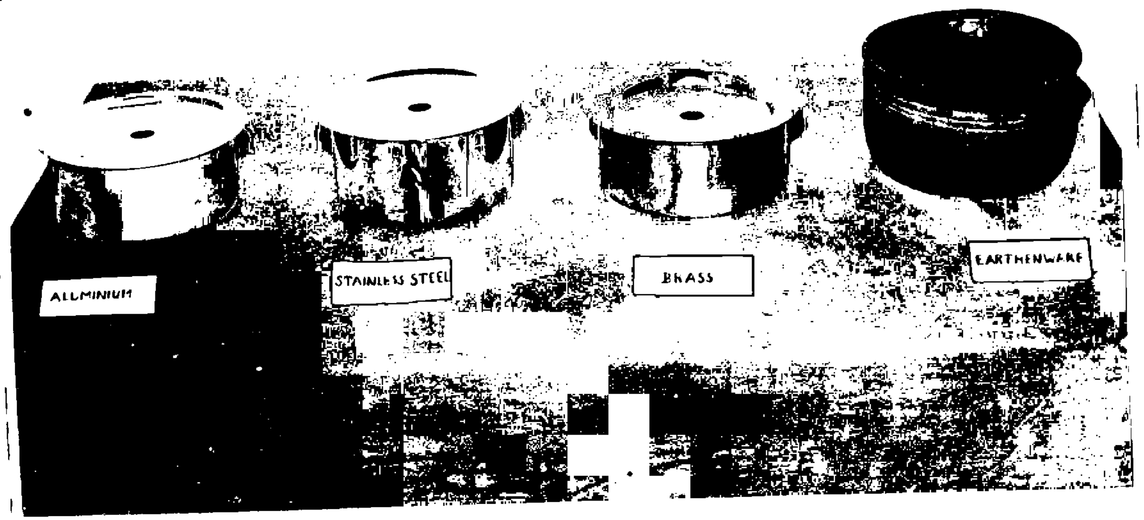

FIGURE I

DESCRIPTION OF THE COOKING UTENSILS

the earthenware utensil, one with the least curves on the sides and bottom was selected, as it was impossible to get earthenware utensils with straight sides and flat bottoms. Identical lids made of the same material as the utensils were also purchased. Each lid was provided with a hole of 3/4 inch diameter, to insert the thermometer.

Stoves. Preliminary experiments were conducted to select the right type of kerosene stove, which would be identical in all respects and in which the flame could be controlled easily. After the experimentation four stoves were selected for cooking.

Each of the selected stoves consisted of a combustion chamber Figure 2A, where kerosene is poured. The combustion chamber is fitted on top with a wick-dish Figure 2B, which consists of the following parts: A wick control for raising and lowering the wicks and an opening or mouth for pouring kerosene. The wick-dish is fitted with ten holders for wicks, through which the wicks are passed. The inner cylinder is kept on top of the wick holders. This cylinder can be removed and replaced and it stands inside the circle of the wicks. The outer cylinder covers the inner cylinder. The inner cylinder is opened on one side and the outer cylinder is opened on both sides. The cylinders are provided with rows of small holes as shown in Figure 2a.

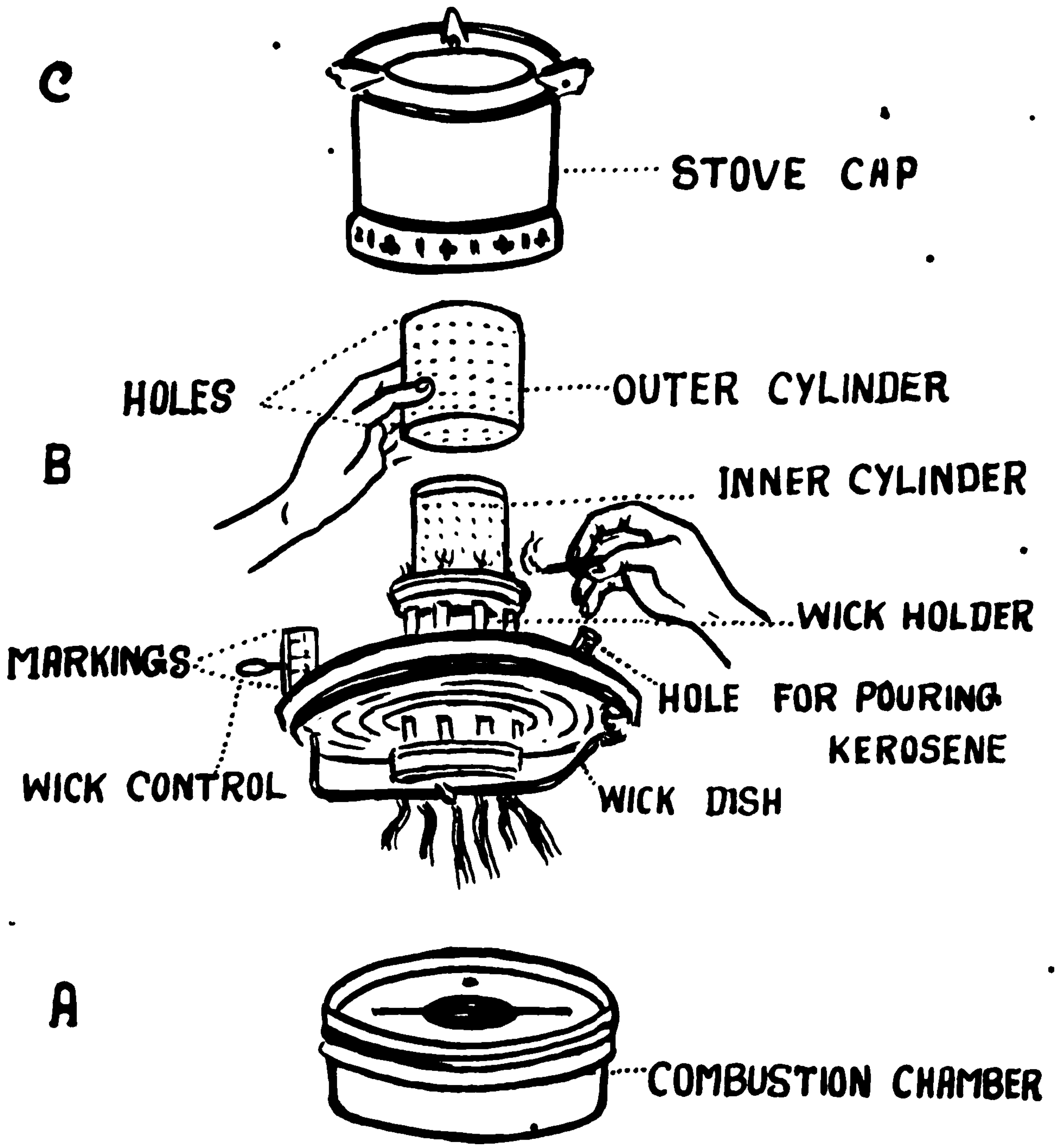

FIGURE 2

PARTS OF A JANATHA STOVE.

The stove cap Figure 2c, is placed on the wick-dish covering the wick holders and the cylinders. In order to regulate the burning of the stoves, wicks of the same length (11 inches) were used for all the four stoves at the start of the experiment. The quantity of kerosene taken in the beginning was also kept constant as 600 ml. in all the four stoves, in order to keep the level of kerosene in the combustion chamber constant.

Before starting the experiments, the wick regulator was marked at three different levels as shown in Figure 2b. To start with, the wicks were raised to the first marking and lighted. After two minutes when the utensils were placed on the stoves with water the wick control was lowered to the second marking and kept in that position until the water boiled. The flame was then reduced by lowering the wick control to the third mark, to prevent rapid evaporation of water. Thus by raising and lowering the wick control to the same markings at the same time, the flames were regulated in all the four stoves uniformly.

Measuring devices. The devices used for the measurements were as follows: Rice was measured both by weight and volume. For measuring the volume of rice and water, a standard measuring cup of eight ounces was used. The Hanson's Dietetic Scale graduated from 0 to 500 grams was used for determining the weights of rice, beans, tamarind, masalas and salt. Standard measuring spoon of capacity five ml. was used for measuring the gingelly oil. A time-piece with a second hand was used in order to find out the time taken in minutes to cook the different preparations. Four Centigrade thermometers (0°C - 110°C) were used for recording the temperature. A bottle with a narrow mouth and a graduated cylinder (0 - 100 ml.) was used for measuring kerosene. Six hundred ml. of kerosene was poured and a white strip of paper was stuck on the bottle to indicate the kerosene level.

Cleaning Material. For cleaning the utensils, the cleaning material chosen was soapnut powder.

Standardisation of Experimental Procedures.

Standardisation of Recipes. For cooking rice, the amount of rice used was one cup or 200 grams, this being the amount sufficient for two servings (Pearson et. al. 1948)[29]. The capacity of the utensil was suitable only to cook one cup of rice without boiling over.

One hundred and fifty grams of beans was chosen as this amount was found to be sufficient to cover the bottom of the utensil and to give a uniform surface of heating.

For Tamarind Kuzhambu, (Appendix III) the amount of water and tamarind used were one cup and 30 grams respectively. This proportion was just sufficient to prevent spurting of the liquid during vigorous boiling of the kuzhambu.

<u>Studies on Time Consumption.</u> Rice was cooked in just as much water as it would imbibe in all the four utensils (Patwardhan 1952)[30]. The order of starting of the utensil was earthenware, aluminium, brass and stainless steel. All were started within 29 minutes. The experiments were conducted as described below, in order that the final cooked products were at a temperature of 85°C in all the four utensils, when served to the judges.

The stoves were cleaned and the wicks trimmed. The measured quantity of kerosene (600 ml.) was poured into each stove. The utensils were cleaned and three cups of water were placed in each of them and covered with the lid. A cork with an inserted thermometer was placed in the hole of the lid, so that the bulb was immersed in water. 200 grams of rice was cleaned and washed in 1½ cups of soft water. The excess of water was drained off, using a colander. The stoves were lighted and when the blue flames were steady for two minutes, the utensils were kept on the stoves. The rice was added when the water came to boiling and covered. After five minutes the wicks were lowered to reduce the flame. The rice was cooked on the slow fire until it was done, absorbing all the water. The time taken for cooking was noted. The time taken to cool the rice to 85°C in all the four utensils was noted. A time table as given in the Appendix V was drawn in such a way that the samples were at 85°C when given to the judges. Thus the amounts of rice and water were standardised, and the procedure for the experiments finalised. The same procedure was followed for cooking beans and preparing tamarind kuzhambu. The time taken to cook beans until tender in utensil and the time taken for the raw smell of tamarind juice to disappear.

Studies on Fuel Consumption. Kerosene was chosen as the fuel for these experiments because of its current popularity as a household fuel and the ease with which it can be measured accurately. With a kerosene stove, it is easy to get a uniform flame.

The kerosene used was measured in terms of millilitres. Before each experiment the stove was filled with 600 ml. of kerosene and the wicks were adjusted (as described on page 31). At the end of each experiment the kerosene was emptied into the graduated bottle, the wicks were squeezed to extract the excess of kerosene. The difference between this reading and the 600 ml. originally taken was noted as the kerosene consumed.

Palatability Test. The following were the steps used to carry out the test:

Selection of the taste panel; forming score cards and administering the test.

Selection of the Taste Panel. A panel of five judges was selected for the palatability of the foods cooked. These judges were administered the 'triangle test', described by Lowe (1955)[35] as a pre-test for selection. Three samples of 'tamarind kuzhambu' of which two samples were identical and one was different, were given for tasting to nine members of staff of The Avinashilingam Trust Home Science High School, Coimbatore. The variation in the samples was that the time for which one sample of the 'kuzhambu' was boiled 20 minutes, and the other 25 minutes. The samples were given to the judges in small porcelain cups, and they were requested to identify the differing sample, giving the reasons. The experiment was repeated five times. From the results shown in Appendix IV, five judges were selected, based on their ability to locate the different samples consistently.

Score Cards. In order to facilitate the objective rating of the food preparations by the judges, in the tasting panel, score cards as shown in Appendices V, VII and VIII were developed on a five point scale for rice, beans and tamarind 'kuzhambu', separately. The qualities to be judged were chosen, according to the standards given by Child and Niles (1938)[6], for scoring cereals and vegetables. For rice, the following qualities were judged: Colour, fluffiness and tenderness of the grains, odour and taste of the products. For beans, the qualities judged were: Colour, tenderness, taste and odour. For tamarind 'kushambu': Colour, consistency, taste, flavour and odour were the qualities rated.

Administering the Test. The test was given in a room which was well lighted and ventilated.

The cooked products were served on white porcelain quarter plates and given to the judges. The score cards were given. The judges were instructed to test the products for the different qualities and mark on the score cards according to the directions given in them.

Studies on Cleaning Utensils. The time taken to wash the utensils after each preparation was determined as described below.

In the case of rice, the utensils were emptied and soaked soon after the rice was served to the judges. The utensils were washed, using soap nut powder, coconut fibre. For the brass utensil, half an ounce of tamarind was also used along with oil cake. The amount of washing materials used, the number of times the utensils were scrubbed and the time taken to clean the utensils were noted.

Cost of Utensils.

The standard rates per Kilogram weight of the three metals used in the experiment, namely aluminium, stainless steel and brass are as follows:

Stainless steel.	Rs. 20/00 per Kilogram
Aluminium.	Rs 9/75 "
Brass.	Rs. 10/00 "

The cost of earthenware utensils vary with each individual potter. There is no standard rate for earthenware utensils.

The cost of the four utensils used for the study are as follows:

Aluminium utensil.	Rs. 1/84.
Stainless steel utensil.	Rs. 11/80
Brass utensil.	Rs. 6/50
Earthenware utensil.	Rs. 0/50

IV. RESULTS AND DISCUSSION.

Survey on Utensils for Cooking Experiments.

The data obtained through the survey has been analysed and discussed under the following heads:

Number and percentage of families using the different types of utensils.

Cooking preparations for which the various materials are used.

Reasons for using the different types of utensils.

Reasons for not using the different types of utensils.

The problems encountered in using the various types of utensils.

Number and Percentage of the Families Using the Different Types of Utensils.

Table II gives the number and percentage of families using the different types of utensils for the various cooking purposes.

TABLE II.

Number and Percentage of the Families Using the Different Types of Utensils.

Types of utensils.	Families.	
	Number.	Percentage.
Aluminium	24	32
Stainless steel	45	60
Brass	48	64
Bronze	40	53
Earthenware	23	31
Lead	35	47
Kalchatty	37	49
Iron	75	100
Copper	5	7

From Table II it is seen that the different types of utensils used for cooking purposes are aluminium, stainless steel, brass, bronze, earthenware, lead, kalchatty, iron and copper. Among these, iron is used by all the families. Brass is used by about two-thirds of the sample, stainless steel is used next by three-fifths of the sample; bronze, lead and kalchatty are used by about half the sample; aluminium and earthenware are used by about one-third of the families respectively.

Cooking Preparations for which the Various Materials are Used.

The number and percentage of families using the different materials are presented in Table III.

TABLE III.

NUMBER AND PERCENTAGE OF FAMILIES USING THE DIFFERENT TYPES OF UTENSILS FOR THE VARIOUS FOOD PREPARATIONS.

Food Preparations.	Aluminium. * Number.	Aluminium. * Percentage.	Stainless steel. Number.	Stainless steel. Percentage.	Brass. Number.	Brass. Percentage.	Bronze. Number.	Bronze. Percentage.	Earthenware. Number.	Earthenware. Percentage.	Lead. Number.	Lead. Percentage.	Kal chatty. Number.	Kal chatty. Percentage.	Iron. Number.	Iron. Percentage.
Rice	5	21	4	9	19	40	14	35	13	56	-	-	-	-	-	-
Dhal	5	21	4	9	1	2	15	38	14	61	1	3	12	32	-	-
Tamarind kuzhambu	7	29	10	22	12	25	5	13	8	35	12	34	27	73	-	-
Vegetables	4	17	5	11	7	15	10	25	12	52	13	37	18	49	-	-
Rasam	5	21	9	20	1	2	3	8	6	26	28	80	6	16	-	-
Milk	6	25	32	71	8	17	13	33	1	4	-	-	-	-	-	-
Curds	4	17	18	40	1	2	4	10	2	9	11	31	2	5	-	-
Frying & seasoning.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75	100
No. of purposes for which used.	7		7		7		7		7		5		5		1	
No. of entries	36		82		49		64		56		65		65		75	
No. of families using each utensil.	24		45		48		40		23		35		37		75	

* The percentages is calculated from the ratio of the number of families using the metal for each preparation for the total number using the metal.

Eight purposes for which the cooking utensils are put have been mentioned by homemakers namely: cooking of rice, dhal, tamarind kushambu, vegetables and rasam, boiling of milk, keeping curds and frying and seasoning. Of these, iron which has been used by all families is used only for one purpose, namely for frying and seasoning. No other material has been reported by anybody as being used for this purpose. All the other seven purposes mentioned are served by aluminium, stainless steel, brass, bronze and earthenware. Lead and kalchatty are used only for five purposes. They are not used for cooking rice, boiling milk and keeping curds. The most frequent use of stainless steel appears to be boiling milk and preparing curds, 71 per cent employing it for the former and 40 per cent for the latter. Twentytwo per cent use stainless steel for tamarind kushambu, and 10 per cent for cooking rice and dhal. The use of aluminium is distributed almost evenly over the various purposes. Brass is used mainly for cooking rice, tamarind kushambu, boiling milk and vegetables. Earthenware is used mainly for rice, dhal, vegetables, tamarind kushambu and rasam. Bronze is used by about one-third of its total users for rice, dhal and milk. Lead is used by four-fifth of its total users for rasam, and about one-third for tamarind kushambu, vegetables and curds. The main use of kalchatty is for preparing tamarind kushambu, vegetables and dhal.

Based on the above frequency of the use of the various materials for the several food preparations, the selection of cooking utensils for this experiment has been made.

Reasons for Using the Different Types of Utensils.

Table IV gives the reasons expressed by the homemakers for using the different types of utensils.

TABLE IV

REASONS OF THE HOMEMAKERS FOR USING THE DIFFERENT UTENSILS

Sr. No.	Reasons.	Aluminium.	Stainless steel.	Brass.	Bronze.	Earthenware.	Lead.	Kalchatty.	Iron.	Total entries of reasons
1.	Quality of the food cooked is good.	4	13	15	23	15	23	20	9	122
2.	Convenience.	10	42	7	19	9	1	10	2	100
3.	Takes less time when used for cooking.	9	10	6	3	-	1	3	1	33
4.	~~It is~~ durable.	5	7	6	9	-	2	1	5	35
5.	Good appearance.	5	36	1	-	-	1	-	-	43
6.	Tradition and customs.	3	-	8	13	5	2	3	10	44
7.	Other reasons.	1	1	0	1	3	12	10	1	29
	Total Entries.	37	109	43	68	32	42	47	28	406
	Total number of user families using each utensil.	24	45	48	40	23	35	37	75	(75)

The reasons expressed by the homemakers for using the various types of utensils were classified into six major groups and the total entries for each reason against all the metals is used as an index of the importance of each of these reasons. From the data given in Table IV the quality of the foods cooked is considered to be most important by the homemakers with the total entries of 122. Convenience is found to be next in importance (100 entries). The other important reasons are tradition and customs (44), good appearance 43 entries, of which 36 are contributed by stainless steel, durability (35), time saved (33) of which 19 are contributed by stainless steel and aluminium. From these reasons, quality of food cooked, convenience, and time saved have been chosen as the experimental variables on account of their frequency and feasibility for experimentation.

Reasons for not Using Certain Types of Utensils.

The reasons for not using certain types of utensils are analysed and presented in Table V.

TABLE V

REASONS FOR NOT USING CERTAIN TYPES OF UTENSILS

Reasons.	Aluminium.	Stainless steel.	Brass.	Bronze.	Earthenware.	Lead.	Kalchatty.	Iron.	Copper.	Total entries for each reason.
Quality of food cooked is not good.	10	3	14	21	-	2	-	-	-	40
Not convenient.	-	-	-	-	1	-	1	-	-	2
Takes more time to get heated.	-	1	-	-	1	-	-	-	-	2
It is not durable.	7	-	-	3	13	2	5	-	-	30
Appearance is not good.	-	-	-	-	3	-	-	-	-	3
Using is against customs and traditions.	13	6	4	5	13	15	11	-	-	73
Have other utensils.	-	2	10	10	2	3	4	-	-	31
Lack of information about the utensils.	-	-	-	-	-	1	3	-	-	4
Not cheap.	-	5	-	1	-	1	-	-	-	7
Total entries.	30	17	28	40	33	24	24	-	-	192

The most frequent reason for not using certain types of utensils is that it is against tradition and customs, with a total of 73 entries. A very closely related reason is "We have other utensils" (31). Non-durability is mentioned by 30, mainly with regard to earthenware, aluminium and kalchatty. Another reason is that the quality of food cooked is not good.

<u>The Problems Encountered in Using the Various Types of Utensils.</u>

The problems encountered by the homemakers in using the various types of utensils are presented in Table VI.

TABLE VI

PROBLEMS ENCOUNTERED IN USING CERTAIN UTENSILS

Problems.	Aluminium.	Stainless steel.	Brass.	Bronze.	Earthenware.	Lead.	Kalchatty.	Iron.	Total entries.
Quality of food is not good.	8	7	6	-	-	-	-	-	21
Not convenient.	-	3	10	14	4	4	13	1	49
Not durable.	3	1	1	5	4	16	8	2	40
Appearance is not good.	1	-	-	-	1	-	-	-	2
Do not like the utensil.	-	-	-	-	1	-	-	-	1
Do not have the utensil.	-	-	-	-	-	1	-	-	1
Total number of problems entries.	12	10	17	19	10	21	21	3	
Total number of families using each metal.	24	45	48	40	23	35	37	75	

From the data given in Table VI three problems expressed by the homemakers stand foremost. Inconvenience is the most frequent problem encountered by the homemakers. It has a total of 49 entries, of which 14 entries are with reference to bronze, 13 with kalchatty and 10 with brass. Non-durability is another important problem with 40 entries mainly contributed by lead (16) and kalchatty (8). Defect in quality of the food has 21 entries contributed almost evenly by aluminium, stainless steel and brass.

From a study of frequency of the use of various materials for several food preparations given in Table III, stainless steel, earthenware, bronze, brass and aluminium are most commonly used for the maximum number of preparations. Of these, aluminium, stainless steel, brass and earthenware were chosen to study the time taken for cooking and cleaning, palatability of the food cooked and the cost of fuel involved.

<u>Cooking Experiments with the Four Utensils.</u>

The results of the cooking experiments with the four utensils are discussed in the following order: time taken for cooking rice, beans and tamarind kuzhambu, palatability of the food preparations, cost of fuel, and time taken for cleaning the utensils after cooking.

The statistical treatment in all the experiments is as follows: the analysis of variance with the 'F' ratio and the 't' test were used to establish the significance of the differences obtained in the experiments.

Snedecor (1946)[52] explains that 'F' is a ratio of the variances (or mean square) between the experimental variables and within the replicates. If F, the probability of its occurrence by chance is less than 0.01, it indicates that the differences obtained in the experiments as a whole are very significant. In order to find out which of the differences between the four means are significant, the 't' test is applied using the method suggested by Garrett (1958)[53]. In this method, the standard error for the data presented in each table is multiplied by the relevant 't' and the minimum differences required for significance is established. The minimum difference required at one per cent level is indicated by $D_{.01}$ and at five per cent level is indicated by $D_{.05}$.

Time Taken for Cooking.

Rice. The total time taken for cooking rice and the analysis of mean differences in the four utensils under the standard conditions are given in Table VII, the detailed calculations of which are shown in Appendix IX.

TABLE VII

Total Time Taken for Cooking Rice and the Analysis of Mean Differences in the four Utensils.

Replicates.	Earthenware.	Aluminium.	Brass.	Stainless steel.	Analysis of mean differences.
	Utensils used. (IN SECONDS)				
I	3300	2940	2700	2400	$D_{0.01} = 189$; $D_{0.05} = 134$
II	3372	2748	2580	2340	$D_{E\&S.S} = 913.75^{**}$
III	3360	2643	2520	2402	$D_{E\&Br} = 708.00^{**}$
IV	3180	2700	2580	2415	$D_{E\&Al} = 546.25^{**}$
Total	13212	11031	10380	9557	$D_{Al\&S.S} = 366.50^{**}$; $D_{Br\&S.S} = 205.75^{**}$
Mean	3303	2757.75	2595	2389.25	$D_{Al\&Br} = 162.75^{*}$
$F = 81.2$		$P < 0.01$			

The results given in Table VII indicate that earthenware takes the maximum time to cook rice, followed by aluminium and brass, while stainless steel takes the minimum time. The difference between the time taken by aluminium and brass is significant beyond five per cent level, and the differences in others are significant beyond one per cent level. Moreover, the differences in cooking time between earthenware and all the other utensils

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Note:- The following abbreviations are used in Table VII:

E = Earthenware. Al = Aluminium.
Br= Brass. S.S= Stainless steel.

** indicates significance at one per cent level.
* indicates significance at five per cent level.

are very much larger than the differences among the metal utensils themselves. The time taken in earthenware is about one and a half times that of the stainless steel. Earls (1955)[3] states that the high heat conductivity of aluminium favours the transmission of heat from the outer surface inward to the contents of the utensil. According to him, the thermal conductivity of aluminium is 0.504, whereas the thermal conductivity of porcelain, which is a poor conductor of heat is only 0.003. DeSager (1952)[26] states, that clay is the chief component of both porcelain and earthenware. Therefore, it can be assumed that earthenware may also be a poor conductor of heat. This explains the differences in the time taken to cook rice in aluminium and in earthenware utensils. The thermal conductivity of aluminium is very high, being 0.504 when compared to that of stainless steel, being 9.4 Btu/Hr/Sq. Ft/Ft/Deg.F (1955)[22]. (0.003 in Metric units).

However, the total time taken to cook rice in aluminium utensil is greater than that taken in stainless steel. This may be explained as due to the fact that aluminium has a high specific heat when compared to that of stainless steel. Therefore aluminium absorbs more heat when heated, than stainless steel, and consequently requires more time to get heated before it can transmit the heat to the contents of the utensil.

Beans. The total time taken for cooking beans and the analysis of mean differences in using the four utensils given in Table VIII.

TABLE VIII

Total Time Taken in Seconds for Cooking Beans and the Analysis of Mean Differences in the Four Utensils.

Replicates.	Utensils used. Earthenware.	Aluminium.	Brass.	Stainless steel.	Analysis of mean differences.
					$D_{0.01} = 111$
					$D_{0.05} = 79$
I	1,740	1,500	1080	730	$D_{E\&S.S} = 971.50$
II	1,800	1,465	1080	735	$D_{Al\&S.S} = 709.25$
III	1,688	1,500	1028	837	$D_{E\&Br.} = 696.50$
IV	1,743	1,457	997	783	$D_{Al\&Br.} = 454.25$
Total	6,971	5,922	4185	3,085	$D_{Br\&S.S} = 275.00$
Mean	1,742.75	1,480.5	1046.25	771.25	$D_{E\&Al} = 262.25$
	$F = 270.7$		$P < 0.01$		

The data given in Table VIII indicate that the earthenware utensil takes maximum amount of time, and stainless steel takes the minimum, with aluminium and brass falling within the range. These results are similar to those obtained in cooking rice. All the differences in cooking time in Table VIII are significant at one per cent level (vide Appendix X for analysis of variance). Moreover the difference is very high between earthenware and stainless steel.

Tamarind Kuzhambu. The total time taken for cooking tamarind kuzhambu and the analysis of mean differences in using the four utensils are given in Table IX.

TABLE IX

TOTAL TIME TAKEN IN SECONDS FOR COOKING TAMARIND KUZHAMBU AND THE ANALYSIS OF MEAN DIFFERENCES IN THE FOUR REPLICATES

Replic-ates.	Stainless steel.	Aluminium.	Brass.	Earthen ware.	Analysis of mean difference.
I	1683	1380	1337	1200	$D_{0.01}$ = 105
II	1670	1416	1330	1103	$D_{0.05}$ = 65
III	1683	1465	1283	1210	$D_{S.S\&E}$ = 536.50
IV	1703	1517	1345	1080	$D_{S.S\&Br.}$ = 361.00
Total	6739	5778	5295	4593	$D_{Al\&E}$ = 296.00
Mean	1684.75	1444.5	1323.75	1148.25	$D_{SS\&Al}$ = 240.25
F = 82.7			P <0.1		$D_{Br\&E}$ = 175.50
					$D_{Br\&Al}$ = 120.75

The data given in Table IX indicate that the mean differences among the utensils in cooking time for tamarind kuzhambu are significant at one per cent level (vide Appendix XI). Moreover, the difference is very large between earthenware and stainless steel. The results also indicate that stainless steel takes the maximum amount of time to prepare tamarind 'kuzhambu' which presents a picture totally opposite to that of cooking rice and beans. The explanation for this may be that tamarind 'kuzhambu' needs large amount of heat which has to be absorbed in order to cook it down to a thick consistency and earthenware is capable of absorbing and retaining such a large amount of heat. Therefore the tamarind 'kuzhambu' is cooked sooner in earthenware utensil than in the others. The criteria for tamarind kushambu is the particular stage of semi-solid consistency which is achieved, much sooner in earthenware than in any metal utensil. This may be also due to the fact that earthenware being porous, absorbs water so that the required consistency is reached quickly.

<u>Palatability Tests.</u>

<u>Rice.</u> A summary of the palatability scores for rice and the differences between the mean scores obtained by rice cooked in the four utensils are given in Tables X and XI.

TABLE X

A SUMMARY OF THE PALATABILITY SCORES FOR RICE

Qualities	Utensils used				Level of significance
	Earthenware	Aluminium	Brass	Stainless steel	
Grains separate.	4.80	3.60	3.55	2.50	F = 56.20 P < 0.01
Colour	4.50	3.50	3.00	3.75	F = 50.77 P < 0.01
Fluffiness.	4.60	3.55	2.80	2.82	F = 50.16 P < 0.01
Tenderness.	4.65	2.85	3.00	3.50	F = 50.29 P < 0.01
Odour.	4.25	3.05	3.10	3.00	F = 20.30 P < 0.01
Taste.	4.55	3.50	3.45	3.15	F = 50.13 P < 0.01
Total	27.85	20.05	18.90	18.72	
Mean	4.56	3.34	3.15	3.12	

TABLE XI

THE ANALYSIS [illegible] DIFFERENCES OF THE PALATABILITY FOR RICE AMONG [illegible] INDICATES

Qualities	D [illegible] & Al	D [illegible] & Br.	D [illegible] & S.G	D Al & Br.	D Al & S.G	D Br. & S.G
1. Grains separate $D_{0.01}$ = [illegible].47; $D_{0.05}$ = 0.36	1.20**	1.25**	2.30**	0.05	1.10**	1.05**
2. Colour $D_{0.01}$ = 0.4[illegible]; $D_{0.05}$ = [illegible]	1.00**	1.50**	0.75**	0.50**	- 0.25	- 0.75**
3. Fluffiness $D_{0.01}$ = [illegible].46; $D_{0.05}$ = 0.35	1.05*	1.80**	1.78**	0.75**	0.73**	- [illegible]
4. Tenderness $D_{0.01}$ = 0.43; $D_{0.05}$ = 0.35	1.40**	1.65**	1.15**	- 0.15	- 0.65**	- 0.50**
5. Odour $D_{0.01}$ = 0.57; $D_{0.05}$ = 0.44	1.20**	1.15**	1.25**	- 0.05	0.05	[illegible]
6. Taste $D_{0.01}$ = 0.52; $D_{0.05}$ = 0.40	1.05**	1.10**	1.40**	0.05	0.55	[illegible]

Note:- In the pairs of material the one which is superior in score is [illegible] first. When the second material is superior, the difference is indicated by ne[illegible]tive sign.

The results given in Table X and XI indicate a summary of the palatability scores and the analysis of mean differences (Vide Appendix XII) of the different qualities judged for rice in all the four utensils. From the average scores obtained for palatability of rice in all the four utensils as judged from the different qualities of the rice grains, it is found that earthenware obtains maximum scores, stainless steel obtains minimum scores, aluminium and brass falling within this range. From the data given in Table XI it is seen that earthenware is superior in all aspects to the three metals. Aluminium is superior to brass and stainless steel in fluffiness, to brass in colour, to stainless steel in separateness of grains. Stainless steel is superior to aluminium and brass in tenderness. According to Child and Niles (1938)[6] the standard for cooked cereal is as follows:- "It should not have lumps; it should tend to retain its shape when hot; it should be soft and at the same time the shape of the particle should be retained". Judging from these standards rice cooked in earthenware utensil is found to have obtained highest scores followed by aluminium and brass, and stainless steel obtaining the poorest scores. This wide variation in the qualities of rice cooked in earthenware utensil and other metal utensils may be due to the fact that rice requires slow heat for giving a satisfactory product as stated by Hanley and Cline (1950)[34]. Earthenware being a poor conductor of heat unlike metals, helps in retaining low heat for a long time, which facilitates gelatinisation of starch and fluffiness of the grains. Due to its high porosity, earthenware absorbs the excess of water, so that the grains are more separate than rice cooked in other utensils. In the case of metal utensils, cooking is accomplished sooner due to the quick transmission of heat, than in the case of earthenware utensil, and the grains remain slightly moist due to their non-absorbability and non-porosity.

Beans. Tables XII and XIII give a summary of the palatability scores and the mean differences in scores among the four utensils obtained by beans respectively.

TABLE XII

SUMMARY OF THE PALATABILITY SCORES FOR BEANS COOKED IN THE FOUR UTENSILS

Qualities.	Utensil used				Level of significance.
	Earthenware.	Aluminium.	Brass.	Stainless steel.	
Colour	2.55	3.80	3.80	4.00	F = 32.12 P < 0.01
Tenderness	4.75	4.50	4.25	4.50	F = 4.00 P < 0.05
Doneness	3.50	4.50	4.75	4.25	F = 37.52 P < 0.01
Odour	3.00	3.80	4.00	4.65	F = 32.29 P < 0.01
Taste	2.10	4.00	3.50	4.50	F = 24.39 P < 0.01
Total	15.30	20.60	20.30	21.90	
Mean	3.18	4.12	4.07	4.38	

TABLE XIII

ANALYSIS [illegible] PALATABILITY SCORES
FOR [illegible]

Qualities	D S.G&Al	D [illegible]&Br	D S.[illegible]	D Al&Br	D Al & [illegible]	D Br & [illegible]
Colour D0.01= 0.48 D0.05= 0.36	0.20	0.20	1.45*	0.00	1.25**	1.25**
Tenderness D0.01= 0.42 D0.05= 0.32	0.00	0.25	- 0.25	0.25	- 0.25	0.50**
Doneness D0.01= 0.40 D0.05= 0.30	-0.25	-0.50**	0.75**	-0.25	1.00**	1.25**
Odour D0.01= 0.45 D0.05= 0.34	0.85**	0.65**	1.65**	-0.20	0.80**	1.00**
Taste D0.01= 0.57 D0.05= 0.46	0.50	1.00	1.40**	0.50**	1.90**	1.40**

From the results given in Table XII the average scores obtained for palatability of beans are found to be highest for stainless steel followed by aluminium, and brass and earthenware obtaining the poorest scores. Moreover, the results given in Table XIII (vide Appendix XIII) also indicate that all the metals are superior to earthenware with regard to retention of colour and doneness of beans cooked in them.

According to Child and Niles (1938)[6], the cell structure of plant is broken down during cooking. They further state that the standards for cooking vegetables should be that natural green colour should be retained, the vegetable should be tender and at the same time should hold their shape and the water should be completely absorbed. Judging from these standards, the palatability scores obtained by beans cooked in stainless steel are the highest, followed by aluminium, and brass, earthenware obtaining the lowest scores. Lowe (1955)[35] points out that chlorophyll, the pigment which gives the green colour to the vegetable is destoryed by heat. The chlorophyll decomposes more rapidly at high temperature and longer period of heating. Hence the retention of colour by beans cooked in stainless steel utensil may be due to the fact that the vegetable in in contact with heat for a comparatively shorter period of time. Hence the loss of chlorophyll, due to heating might have been minimised, whereas in the case of earthenware utensils, the vegetable is in contact with the boiling water for a long time, which may lead to a greater loss of chlorophyll.

Tamarind Kuzhambu. Table XIV and XV gives a summary of the palatability scores and the mean differences between the palatability scores obtained for tamarind kuzhambu in the four utensils.

TABLE XIV

A SUMMARY OF THE PALATABILITY SCORES FOR TAMARIND KUZHAMBU

Qualities.	Utensils used. Earthen-ware.	Aluminium.	Brass.	Stainless steel.	Level of significance.
Colour	2.55	2.55	3.80	2.50	F = 14.91 $P < 0.01$
Consistency	1.55	3.50	3.00	2.00	F = 69.33 $P < 0.01$
Odour	4.75	4.50	3.80	4.00	F = 89.11 $P < 0.01$
Taste	4.80	4.20	4.50	4.50	F = 10.38 $P < 0.01$
Total	13.65	14.75	15.10	12.50	
Mean	3.41	3.69	3.78	3.13	

TABLE XV

ANALYSIS OF MEAN DIFFERENCES OF THE PALATABILITY SCORES FOR TAMARIND [illegible] AMONG THE FOUR UTENSILS

Qualities.	D Br&Al	D Br&E	D Br&S.S	D Al&E	D Al&S.S	D E&S.S
Colour $D_{0.01}=0.51$ $D_{0.05}=0.38$	1.25**	1.25**	1.30**	0.00	0.05	0.05
Consistency $D_{0.01}=0.75$ $D_{0.05}=0.56$	-0.50	0.45	1.00**	1.95**	1.50**	-0.45
Odour $D_{0.01}=0.42$ $D_{0.05}=0.27$	-0.70**	-0.75**	-0.20	-0.25	0.50**	0.75**
Taste $D_{0.01}=0.54$ $D_{0.05}=0.32$	0.30	-0.80**	0.50*	-0.60**	0.20	0.80**

It is seen from Table XIV that tamarind kuzhambu prepared in brass gets maximum scores, followed by aluminium, earthenware and stainless steel. Tamarind kuzhambu prepared in earthenware obtains highest scores for odour and taste and the scores obtained for consistency and colour are poor. The reason for the low scores in consistency is that the tamarind kuzhambu prepared in earthenware becomes thick very soon after the removal from fire. As it thickens, the kuzhambu also becomes dark, assuming a poor colour. Similarly, tamarind kuzhambu prepared in stainless steel obtained the lowest scores for colour and consistency. From the data given in Table XV (vide appendix XIV) it is seen that brass is very significantly superior to the other three materials in colour. It is superior to stainless steel in consistency and taste. Aluminium is superior to earthenware and stainless steel in consistency. Stainless steel and brass are inferior to aluminium and earthenware in odour.

Cost of Fuel.

The total cost of fuel for cooking rice, beans and tamarind kuzhambu and the analysis of mean differences in the four utensils are given in Table XVI.

TABLE XVI

THE TOTAL COST FOR COOKING RICE, BEANS AND 'KUZHAMBU' AND THE ANALYSIS OF MEAN DIFFERENCES IN THE FOUR UTENSILS

Replicates.	Utensils used				Analysis of Mean Difference.
	Earthen ware	Aluminium	Brass	Stainless steel	
	Cost in nPs				
I	6.0	5.7	5.3	5.0	$D_{0.01} = 0.48$
II	5.9	5.5	5.4	5.1	$D_{0.05} = 0.349$
III	6.2	5.5	5.1	5.3	
IV	5.9	5.6	5.25	5.3	$D_{E\&S.S} = 0.82$
Total	24.0	22.3	21.05	20.7	$D_{E\&Br} = 0.74$
Mean	6.00	5.58	5.26	5.18	$D_{E\&Al} = 0.42$
	$F = 21.2$			$P < 0.01$	$D_{Al\&S.S} = 0.40$
					$D_{Al\&Br} = 0.32$
					$D_{Br\&S.S} = 0.08$

It is seen from Table XVI (vide Appendix XV) that the cost of fuel is highest in earthenware followed by aluminium, brass and stainless steel. The difference in cost of fuel is related to the fuel consumption which in turn is influenced by the time taken for cooking. Hence the difference in the cost of fuel may be explained as due to the differences in the cooking time in the different utensils.

[illegible]

Table XVII [illegible] the time taken to clean the four utensils.

[illegible]

[illegible]

[illegible]	Earthenware	[illegible]	Alumin-ium	Stainless steel	Analysis of mean difference
I	300	300	480	120	$D_{0.01}$ = 303.06
II	1217	720	600	240	$D_{0.05}$ = 220.60
III	340	[illegible]	480	145	[illegible] = 7[illegible].00**
IV	360	[illegible]	540	300	[illegible] = 565.75**
Total	2217	[illegible]	[illegible]	845	[illegible] = 454.25**
Mean	379.[illegible]	[illegible]	[illegible]5.00	211.25	[illegible] = 313.75**
					[illegible] = 242.00*
	F = 14.1[illegible]		P < 0.01		[illegible] = 212.25

The results [illegible] Table XVII indicate that earthenware takes the [illegible] amount of time for cleaning, followed by [illegible], aluminium and stainless steel. Moreover, the results also indicate that there is no significant difference in the time taken for cleaning between earthenware and brass. The difference between brass and aluminium is significant at five per cent level, all the others being significant at one per cent level (vide Appendix XVI). The reason that earthenware requires a long time for cleaning may be due to the rough surface of the earthenware utensil so that the rice particles stick to the bottom of the utensil. Hence soaking is needed to soften the rice particles. Brass utensil also requires a long time for cleaning, as it needs scrubbing with tamarind and soapnut powder, to give the original lustre. Stainless steel utensil takes the least amount of time for cleaning.

V. SUMMARY AND CONCLUSIONS.

A survey of the cooking utensils used in 75 households in Coimbatore showed that aluminium, brass, bronze, stainless steel and earthenware were the common materials used. Of these, four materials, aluminium, stainless steel, brass and earthenware were selected for a comparative study of the time and money expenditure involved in cooking, and the palatability of three common South Indian food preparations, namely rice, beans and tamarind kushambu. The following conclusions were arrived at:

1. Earthenware consumes the maximum time and stainless steel consumes the minimum time for cooking all the three preparations, brass and aluminium falling within this range.
2. With regard to the palatability of foods cooked, earthenware is suitable for cooking rice and tamarind kuzhambu and stainless steel for cooking vegetables. The preparations cooked in brass and aluminium are fairly acceptable.
3. The cost of fuel is maximum in earthenware and minimum in stainless steel. However, the initial cost of stainless steel utensils is highest among all the other utensils and earthenware lowest.
4. With regard to the ease of cleaning after cooking, earthenware takes the maximum time, followed by brass, aluminium and stainless steel.

The findings of this study indicate the superiority of stainless steel utensils over all other materials with regard to economy of time and fuel and palatability of vegetables cooked; of earthenware with regard to palatability of rice and initial cost.

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APPENDIX

APPENDIX II

INCOME-WISE DISTRIBUTION OF MATERIALS USED FOR COOKING UTENSILS

Income groups and number of families	Aluminium	Stainless steel	Brass	Bronze	Earthen ware	Lead	Kal-chatty	Iron	Copper
1. Below Rs.100 No. 14	4	8	5	2	4	4	4	14	1
2. Rs.100-299 No. 20	5	14	12	16	5	10	9	20	2
3. Rs.300-599 No.27	9	14	20	16	10	14	16	27	2
4. Rs.600 and above	6	9	11	6	4	7	8	14	0
Total number of families	24	45	48	40	23	35	37	75	5

APPENDIX III

RECIPE FOR MASALA FOR 'TAMARIND KUZHAMBU'

a) **Ingredients required:**

- Red chillies. . . . . . 200 gms.
- Coriander seeds. . . .150 "
- Pepper. . . . . 50 "
- Jeera. . . . . 25 "
- Fenugreek. . . . . 5 "
- Asafoetida. . . . . . . 0.5 "
- Saffron. . . . . 0.5 "
- Curry leaves. . . . . few
- Bengal gram dhal. . . . 200 "
- Black gram dhal. . . . 50 "

b) **Method:**

1. Clean and dry the ingredients in the sun.
2. Roast over a hot frying pan.
3. Grind to a fine powder.
4. Store in a dry, clean bottle, tightly closed.

Kuzhambu:

1. Mix one cup of water and 30 grams of tamarind.
2. Add 2 grams of 'masala' and 4 grams of salt
3. Season the mixture with mustard
4. Boil till the raw smell of tamarind disappears.

APPENDIX IV

RESULTS OF THE TRIANGULAR TEST

Judges	Replicates					Total
	1	2	3	4	5	
I	/	/	/	/	/	5*
II	/	/	/	X	X	3*
III	/	X	/	X	/	3
IV	/	X	X	X	/	2
V	/	/	/	X	/	4*
VI	/	/	/	/	/	5*
VII	X	X	X	/	X	1
VIII	X	X	X	/	X	1
IX	X	/	/	/	X	3*

*Judges who were chosen for the panel.

[illegible]

[illegible]

Sl. No.	Utensil used	Activities carried out	Timings.
1.	Earthenware	Lighting the stove	2.53 p.m.
2.	Earthenware	Keeping the utensil on the fire	2.55 p.m.
3.	Earthenware	Adding rice to the boiling water	3.07 p.m.
4.	Aluminium	Lighting the stove	3.08 p.m.
5.	Aluminium	Keeping the utensil on the fire	3.10 p.m.
6.	Brass	Lighting the stove	3.17 p.m.
7.	Brass	Keeping the utensil on the fire	3.19 p.m.
8.	Aluminium	Adding rice	3.20 p.m.
9.	Stainless steel	Lighting the stove	3.22 p.m.
10.	Stainless steel	Keeping the utensil on the fire	3.24 p.m.
11.	Brass	Adding rice	3.27 p.m.
12.	Stainless steel	Adding rice	3.32 p.m.
13.	Earthenware	Removing the utensil from the fire	3.50 p.m.
14.	Brass	Removing the utensil from the fire	3.55 p.m.
15.	Aluminium	Removing the utensil from the fire	4.00 p.m.
16.	Stainless steel	Removing the utensil from the fire	4.05 p.m.
	Earthenware, Aluminium, Brass, Stainless steel	Serving the rice to the judges	4.15 p.m.

APPENDIX VI

SCORE CARD FOR RICE

Date: Judge:

Kindly judge the given samples without discussion and tick against any one quality under each heading for each sample.

Quality	Sample A	Sample B	Sample C	Sample D
I. APPEARANCE:				
a) Grains Separate:				
Each grain is separate				
One or two grains stick together				
Grains stick together in small lumps				
Grains stick together in big lumps				
Product is in a mess				
b) Colour:				
Very white				
White				
Fairly white				
Slightly discoloured				
Discoloured				
c) Fluffiness:				
Very fluffy and light due to small splits in each grain				
Grains have few splits and not very light				
Grains have very few splits and fairly heavy				
Grains have no splits and look heavy				
Grains are very heavy and are slightly swelled				

APPENDIX VI Contd:-

Quality	Sample A	Sample B	Sample C	Sample D
II. TENDERNESS:				
Very soft				
Soft				
Fairly soft				
Hard				
Very hard				
III. ODOUR:				
Odour of well cooked rice				
No odour				
Odour of uncooked rice				
Slightly foreign odour				
Very unpleasant odour				
IV. TASTE:				
Very good				
Good				
Bland				
Bad				
Very bad				

Note:- Any comments not covered by the above may be given here.

APPENDIX VII

SCORE CARD FOR BEANS

Date: Judge:

Kindly judge the given samples without discussion and tick against any one quality under each heading for each sample.

Quality	Sample A	Sample B	Sample C	Sample D
I. APPEARANCE:				
a) Colour:				
Natural green colour well preserved				
Natural green colour fairly well preserved				
Beans slightly discoloured				
Discoloured				
Highly discoloured				
II. DONENESS:				
Well cooked				
Fairly well cooked				
Just cooked				
Slightly under cooked				
Slightly over cooked				
Under cooked				
Over cooked				

APPENDIX VII Contd:-

Quality	Sample A	Sample B	Sample C	Sample D
III. TEXTURE:				
Very soft				
Soft				
Fairly soft				
Hard				
Very hard				
IV. ODOUR:				
Odour of well cooked beans				
No odour				
Odour of uncooked beans				
Slightly foreign odour				
Very unpleasant odour				
V. TASTE:				
Very good				
Good				
Bland				
Bad				
Very bad				

Note:- Any comments not included by the above may be given here.

APPENDIX VIII

SCORE CARD FOR TAMARIND KUZHAMBU

Date: Judge:

• Kindly judge the given samples without discussion and tick against any <u>one</u> quality under each heading for each sample.

Quality	Sample A	Sample B	Sample C	Sample D
I. APPEARANCE:				
<u>Colour</u>:				
Very light				
Light				
Slightly dark				
Dark				
Very dark				
II. CONSISTENCY:				
Very thin				
Thin				
Slightly thick				
Thick				
Very thick				
III. ODOUR:				
Odour of cooked tamarind				
No foreign odour				
Odour of uncooked tamarind				
Slight foreign odour				
Very unpleasant odour				
IV. TASTE:				
Very good				
Good				
Fairly good				
Bad				
Very bad				

Note:- Any comments not covered by the above may be given here.

APPENDIX IX

ANALYSIS OF VARIANCE FOR THE TIME TAKEN TO COOK RICE IN THE FOUR UTENSILS

Source of variation	Sum of squares	Degrees of freedom	Mean squares	
Between utensils	1855509	3	618503	F = 81.2
Within replicates	92208	12	7609	
F at 0.05 = 3.06		F at 0.01 = 2.18		P < 0.01

Tests for Differences by use of 't'

Standard Deviation – within S.D$_w$ = $\sqrt{\text{Within variance}}$

Standard Error of any two mean differences S.E S.E$_d$ = S.D$_w$ $\sqrt{\frac{1}{N} + \frac{1}{N}}$

$D_{0.05} = t_{0.05} \times S.E_d$

(Minimum difference required between any two means for significance at 5% level).

$S.D_w$	$S.E_D$	$t_{0.01}$	$t_{0.05}$	$D_{0.01}$	$D_{0.05}$	M_E	M_{Al}	M_{Br}	$M_{S.S}$
87.2	61.8	3.06	2.18	189	134	3303	2762.75	2595	2389.75

APPENDIX X

ANALYSIS OF VARIANCE FOR THE TIME TAKEN TO COOK BEANS IN THE FOUR UTENSILS

Source of variation	Sum of squares	Degree of freedom	Mean squares	
Between utensils	2178540	3	726180	$F = 270.7$
Within utensils	32189	12	2682	

F at 0.05 = 3.06 F at 0.01 = 2.18 $P < 0.01$

Tests for Differences by Use of 't'

$S.D_W$	$S.E_D$	$t_{0.01}$	$t_{0.05}$	$D_{0.01}$	$D_{0.05}$	M_E	M_{Al}	M_{Br}	$M_{S.S}$
51.8	36.6	3.06	2.18	111	79	1742.75	1480.50	1046.25	7/1.25

APPENDIX XI

ANALYSIS OF VARIANCE FOR THE TIME TAKEN TO PREPARE TAMARIND KUZHAMBU IN THE FOUR UTENSIL

Source of variation	Sum of squares	Degree of freedom	Mean squares	
Between utensils	594436	3	198145	$F = 82.7$
Within replicates	28899	12	2408	

F at $0.05 = 3.06$ F at $0.01 = 2.18$ $P < 0.01$

Tests for Differences by use of 't'

$C.D_M$	$S.E_D$	$t_{0.01}$	$t_{0.05}$	$D_{0.01}$	$D_{0.05}$	M_S	M_{Al}	M_{Br}	$M_{[illegible]}$
87.2	61.8	3.06	2.18	105	65	1684.75	1444.5	1323	1148.25

APPENDIX XII

ANALYSIS OF VARIANCE FOR THE MEAN SCORES OBTAINED FOR PALATABILITY OF RICE COOKED IN THE FOUR UTENSILS

Quality	Source of variation	S.S	df	m.sq	F	$S.D_W$	$S.E_D$	$D_{0.01}$	$D_{0.05}$
1. Grains separate	Between utensils	53	3	18	56.20	0.56	0.18	0.47	0.36
	Within replicates	24	76	0.32	P 0.01				
2. Colour	Between utensils	48.2	3	16.06	50.77	0.57	0.18	0.48	0.36
	Within replicates	24.1	76	0.32	P 0.01				
3. Fluffiness	Between utensils	44.65	3	14.88	50.16	0.55	0.18	0.46	0.35
	Within replicates	22.55	76	0.30	P 0.01				
4. Tenderness	Between utensils	24.1	3	8.03	25.1	0.57	0.18	0.48	0.36
	Within replicates	24.1	76	0.32	P				
5. Odour	Between utensils	21.7	3	9.23	20.33	0.67	0.21	0.57	0.53
	Within replicates	34.5	76	0.45	P 0.01				
6. Taste	Between utensils	56.8	3	18.93	50.13	0.62	0.20	0.52	0.40
	Within replicates	28.7	76	0.38	P 0.01				

For 76 df $t_{0.01} = 2.64$; $t_{0.05} = 1.99$

$D_{0.05}$ (Minimum mean difference required for significance at 5% level) = $S.E_D \times t_{0.05}$

$D_{0.01}$ (Minimum mean difference required for significance at 1% level) = $S.E_D \times t_{0.01}$

APPENDIX XIII

ANALYSIS OF VARIANCE FOR THE MEAN SCORES OBTAINED FOR THE PALATABILITY
BEANS COOKED IN THE FOUR UTENSIL

Quality	Source of variation	S.S	df	m. sq	F	$S.D_m$	$S.E_D$	$D_{0.01}$	$D_{0.05}$
Colour	Between utensils	31.15	3	10.38	32.12	0.57	0.18	0.48	0.36
	Within Replicates	26.55	76	0.32	P<0.01				
Tender-ness	Between utensils	3	3	1.00	4	0.50	0.16	0.42	0.32
	Within Replicates	19	76	0.25	P<0.05				
Doneness	Between utensils	23.4	3	7.80	37.52	0.46	0.14	0.40	0.30
	Within Replicates	15.8	76	0.21	P<0.01				
Odour	Between utensils	27.75	3	9.25	32.29	0.54	0.17	0.45	0.34
	Within Replicates	21.75	76	0.29	P<0.01				
Taste	Between utensils	33.8	3	11.26	24.39	0.68	0.22	0.57	0.46
	Within Replicates	35.0	76	0.46	P<0.01				

APPENDIX XIV

ANALYSIS OF VARIANCE FOR THE MEAN SCORES OBTAINED FOR THE PALATABILITY OF TAMARIND KU'HAMBU IN THE FOUR UTENSILS

Quality	Source of variation	S.S	df	m. sq	F	S.D$_w$	S.E$_D$	$D_{0.01}$	$D_{0.05}$
Colour	Between utensils	15.95	3	5.32	14.91	0.60	0.19	0.51	0.38
	Within Replicates	27.10	76	0.36	$P<0.01$				
Consistency	Between utensils	49.20	3	16.40	69.33	0.82	0.28	0.75	0.56
	Within Replicates	23.70	76	0.68	$P<0.01$				
Odour	Between utensils	32.4	3	10.80	89.11	0.42	0.13	0.42	0.27
	Within Replicates	23.7	76	0.18	$P<0.01$				
Taste	Between utensils	8.20	3	2.73	10.38	0.51	0.16	0.54	0.32
	Within Replicates	20.00	76	0.26	$P<0.01$				

APPENDIX XV

ANALYSIS OF VARIANCE FOR THE TOTAL COST OF FUEL TO COOK RICE BEANS AND TAMARIND KUZHAMBU IN THE FOUR UTENSILS.

Source of variation	Sum of squares	Degrees of freedom	Mean squares	
Between utensils	12.74	3	4.25	$F = 21.2$
Within replicates	0.60	12	0.05	

F at 0.05 = 3.06 F at 0.01 = 2.18 $P < 0.01$

Tests for Differences by use of 't'

$S.D_W$	$S.E_D$	$t_{0.01}$	$t_{0.05}$	$D_{0.01}$	$D_{0.05}$	M_E	M_{Al}	M_{Br}	$M_{S.S}$
0.22	0.16	3.06	2.18	0.49	0.35	6.00	5.58	5.26	5.18