DEVELOPMENT OF A SUYA KILN PRODUCTION MACHINE

BY

ATOLAGBE IBRAHIM OLANSHILE

2003/14782EA

AGRICULTURAL AND BIORESOURCES ENGINEERING

DEPARTMENT, FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA. NIGER STATE

NOVEMBER, 2008

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BEING A FINAL YEAR PROJECT SUBMITTEF IN PARTIAL FULFILLMENT FOR THE AWARD OF BACHELOR DEGREE OF ENGINEERING (B. ENG.) IN AGRICULTURAL AND BIORESOURCES ENGINEERING DEPARTMENT. FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA. NIGER STATE

NOVEMBER, 2008

DECALRATION

I hereby declare that this project is a record of research work that was undertaken by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communication published and unpublished work was dully referenced in the text.

.... 18/11/08 ....

Atolagbe Ibrahim Olanshile DATE

DEDICATION

This project work is dedicated to God almighty, His messenger prophet Muhammed (S.A.W.) and to m y beloved parent (Alhaji) Idris Atolagbe and (Alhaja) Atolagbe Afusat for their efforts to make me succeed in this project work and I pray, may God Almighty spares their life to witness good thing in life.

CERTIFICATION

This project entitled "Development of Suya Kiln Production Machine" by Atolagbe Ibrahim Olanshile, meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literacy presentation.

....

Project supervisor
Engr. Prof. E.S.A Ajisegire

DATE

.... 26/11/2008

Engr. Dr. (Mrs) Z.D. Osunde
Head of Department

DATE

....

External Examiner

DATE

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ABSTRACT

A suya kiln machine was design and constructed at the department of Agriculture and Bioresources Engineering. The machine was evaluated using charcoal as source of fire in dehydrating of meat over or around, an open fire is employed to dry meat and enhance shelf-life. Suya kiln could be a rectangular, cylindrical, or square in shape of design in which a low-burning glowing fire is produce over or around it by burning the charcoal and the meat pieces singly or in stakes are placed on a wire mesh over or around the fire. The machine was tested and the efficiency of the machine was found to be 87.70% and also the overall cost of the machine was =N=21,293 only.

TABLE OF CONTENTS

List of Tables

List of Figure

CHAPTER ONE

1.0 INTRODUCTION

Industrials whose production involves smoking, drying, roasting, melting and so on, will definitely need the help or assistance of kiln or oven. Kiln could also be used domestically for

The kiln could be said to be a chamber for heating, drying, or dehydrating of a substance. The importance in the foundry shop involves, annealing, tempering, forging, hardening, determination of water/moisture content of sand, just to mention in few.

Furthermore, kiln is made of various design which could be classified under the style of the chamber and means of firing, for example; rectangular kiln shape, square kiln shape, or cylindrical kiln shape, kiln chamber firing means involves; wood, coal, oil, gas, or electricity.

The suya kiln in this study is a single-fired kiln, made of cylindrical chamber. It is fired by only coal. The suya kiln has maximum temperature of 200 °C (473k) and could be used for any operation within this temperature limit.

The suya production is the analysis carried out within the scope of this study. The temperature for roasting the suya varies depending on the fire intensity and size of the meat pieces

The coal-fired kiln used in the study is highly economically in sense of comparing it with other means of firing kiln.

1.1 Definition of the Suya Kiln

Suya kiln could be defined as the dehydrating of meat over or around an open fire is employed to dry m eat and enhance shelf-life. Suya kiln could be a rectangular, cylindrical, or square in shape of design in which a low-burning glowing fire is produce over or around it by burning hard, rather than soft, woods and the meat pieces singly or in stakes are placed on a wire mesh over or around the fire. Kiln can also be used in processing of tsire (or suya) and balangu-two-to eat popular West Africa delicatessen meat

products that are prepared mostly by the Hausa and Fulani tribesmen.

1.2 Objectives of the Suya Kiln

a. To design and fabricate standard suya kiln.

b. To discover and gather some local sourced materials in related to the design of the suya kiln.

c. To invent and implement suya kiln design separated from the common local ones.

d. To drastically increase the rate and standard of suya production.

1.3 Problems of Suya Kiln Production

A major problem with kiln design is that, the process of economic development in any society presupposes a structural, social and technological transformation. For this to be possible in the dried meat industry, new methods new machines, and new/improved products need to be developed to revolutionize aesthetic qualitative and quantitative production. Unfortunately, however, dried meat production in most parts of tropical Africa is still in its technological infancy in which age-old production methods, materials and machinery remain largely unchanged. A structural transformation of the industry is need to meet rising demand for better and more hygienically, processed meat products. At present, very little is known of the industry, the production technology and needs, product quality, stability and safety, handling, storage and market needs. Process personnel are largely poor and ignorant and need the help and education has its carryout in this study, to enhance their know-how, efficiency and productivity as for improvement of this industrial sector of our food economy.

1.4 Justification of the Study

The essence of this study is to design suya kiln and carryout analysis on the dehydration of meat in order to improve efficiency, productivity, product quality control and stability of meat in any industrial sector.

The study also base on analysis of adverse effects of traditional method of meat dehydration such as, insect infestation, microbial stability and safety, enzymic and non-enzymic deterioration of meat and other effect on appearance, odour, texture, taste and water activity in the meat dehydration.

1.5 Scope and Limitation of the Study

This project is basically restricted to design and fabricate standard suya kiln production. The limitation of this study includes unavailability of proper working tools and difficulties in getting required material for fabrication of the machine.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical Background of Suya

Tropical Africa has vegetation well-suited to livestock production, and tradition pastoral herdsmen, with age-old experience, in whose hands the bulk of our livestock is kept. According to FAO (1985) livestock production and slaughter estimates (Table 1), Africa has some cattle, goats and sheep than Europe, comparing absolute number of cattle, for example, kept with human population many tropical countries in Africa have over 0.8 cattle/person/annum. Yet the meat industry in Africa remains largely undeveloped and the peoples diets shockingly deficient in animal protein despite huge imports of raw and processed meats. Mann (1967) and Obanu (1986) have reviewed the problems of meat handling in tropical Africa; some of these problems and solution hinge no meat processing.

By far the most popular method of meat preservation in tropical Africa dehydration especially with solar energy or by smoking. Meat dehydration is traditional in these countries and the products are customarily accepted and desired. The essential feature of dehydration as a food preservation method is that, the availability of water, that is water activity (aw), in the food is lowered to a level at which there is no danger from microbial growth (Scott, 1982) and in so doing, the water content is reduced to minimize rate of biological, chemical and physical processes which limit the storage of life of foods. The quality and stability of dehydrated foods are thus related to the reduction of (aw) in these foods. Since the reduction aw results from the concentration of the internal aqueous environment, it may be achieved by removing water as in evaporative dehydration (i.e. drying) and/or by adding solutes to tie up the water as in salting and sugar

Table 2.1: Livestock Production and Slaughter Estimate

CATTLE (in thousands)			
YEAR	NO. Reared	NO. Killed	% Slaughter
IN AFRICA			
1974/76	155,772	18,853	12.10
1982	175,357	21,944	12.51
1983	176,229	21,875	12.41
1984	176,206	22,129	12.56
IN EUROPE			
1974/76	134,200	49,205	36.67
1982	133,174	46,293	34.76
1983	133,049	46,362	34.85
1984	133,737	47,894	35.81
IN NORTH AND CENTRAL AMERICA			
1974/1976	192,684	56,468	29.31
1982	197,923	51,002	27.14
1983	194,290	51,973	28.10
1984	193,284	52,704	28.76
IN SOUTH AMERICA			
1974/76	213,690	31,653	14.82
1982	243,745	34,349	14.09
1983	245,734	33,004	13.43
1984	248,016	33,036	13.32

CATTLE (in thousands)			
YEAR	NO. Reared	NO. Killed	% Slaughter
IN AFRICA			
1974/76	300.616	90,480	30.10
1982	336.372	105,376	31.32
1983	340.584	107,925	31.69
1984	340.958	109,876	32.23
IN EUROPE			
1974/76	137,051	78,771	57.48
1982	153,362	85,248	55.59
1983	154,577	85,661	55.42
1984	157,343	87,442	55.57
IN NORTH AND CENTRAL AMERICA			
1974/1976	36,713	12,130	33.04
1982	36,074	11,725	32.50
1983	35,192	12,190	34.64
1984	34,503	11,386	34.30
IN SOUTH AMERICA			
1974/76	121,016	24,852	20.54
1982	125,684	24,285	19.32
1983	124,765	24,413	19.57
1984	127,234	23,189	18.23

2.2.0 Processing Method of Traditional Meats

2.2.1 Processing Method of Suya/Tsire

Tsire or suya roasted meat pieces: "Suya" is an Hausa word meaning roasted or fire treated meat. It is in this sense a generic term for partly or fully roasted meats like kilishi, suya and balangu. Of these, however, the single product most commonly called suya in the trade is tsire and two name used synonymously for the product described hereunder.

Tsire or suya is a widely marketed snack meat product defined as boneless meat pieces staked, smeared with a mixture of salt, spices, groundnut flavour and oils, and roasted over or around a low-burning or glowing smokeless fire. Suya or tsire is prepared mostly commonly from boneless beef and occasionally mutton and goat meat.

In the production of suya or tsire, meat is boned and cut into chunks about 10cm long and 8cm wide. The chunks are later sliced with a curved knife into slices about 1cm thick. The meat slices are stakes on to slender sticks about 30cm long and dusted with a mixture of salt, spices, groundnut oil and groundnut flavuor for seasoning. The meat stakes are then pinned, or inclined on a wire mesh, around low-burning/glowing smokeless fires at a distance of 35cm from the fire. Alternatively, the meat stakes are placed on a wire mesh on top of an oven containing low-burning or glowing fire-wood. Hard wood, low in resins, is used. Roasting takes 20-40minuites with occasional turning of the meat stakes. The product is displayed unpackaged for sales and wrapped with paper on procurement. It receives no further treatment to enhance stability and it shelf-life is only about 24 hour under ambient condition. AS table 2 show product moisture content is about 20-25%.

Table 2.2.1: Compositional Characteristics of Commercial suya/tsire

Nature of the Product	Retain Net Wt of Product (kg)	Moisture (Wet Wt) (%)	Ash (Dry Wt) (%)	Protein (Dry Wt) (%)	Total Lipid (Dry Wt) (%)
Raw suya/tsire (before roasting)	0.14+0.02	68.6+1.0	1.2+0.2	21.1+1.1	8.4+1.6
Roasted suya/tsire	0.12+0.01	23.3+2.3	1.6+0.1	59.1+1.4	16.2+2.2

Valves are means std for 176 samples each of raw and roasted tsire/suya from 40 processors/vendors (Igene and Abulu, 1984)

2.2.2 Processing Method of Balangu

Balangu-Roasted Meat slab: Balangu may be defined as boneless slabs of lean/organ m eat se asoned w ith s alt s pices, groundnut f lour and o il a nd roasted o ver a low-burning/glowing smokeless fire. Like tsire/suya it is prepared mostly from beef but also occasionally from mutton and goat meat.

The meat is boned and cut into chunks which are sliced with a curved knife into slabs not less than 1cm thick. Mostly commonly 4-6cm or more. The meat slabs are dusted on both surfaces with a seasoning mixture of salt, spices, groundnut flour and oil and then placed on a wire mesh over an oven of low-burning/glowing smokeless fire to roast slowly until done. Roasted takes 30-60min. depending on meat thickness and fire intensity. As for tsire/suya, the product receives no further stabilizing treatment. It is marketed unpackaged and wrapped with paper on procurement. It is similar in moisture content (20-30%) a nd composition t o t sire/suya, a nd a lso a bout 2 4hour u nder a mbient conditions.

2.2.3 Processing Method of Banda

Banda-Hot-Smoked meat pieces: Banda consists of hard smoked pieces of meat from rejected cattle, discarded transport beasts like donkey, horse, asses, Carmel, buffalo and elephant as well as wildlife. Banda is produced in larger quantities and more widely than other traditional African dried meat.

The animal, after slaughter is eviscerated, butchered and larger bone removed. Virtually all of the carcass, including the lean, organs, neck bones, ribs and legs a well as hides/skins and intestines, are used up. These are cut in to spices about 3-6cm and cooked with a small amount of added water in half-drums for 15-30min. with intermitted stirring. When done the meat spices are shoveled out and spread on the floor or mat or on wire mesh over the smoking pit or oven to drain-dry. The meat pieces are then smoked with fire generated from burning hard wood in the smoking pit or earthen oven directly below the meat pieces. This involves high-temperature (hot) smoking leading to further cooking, drying and shrinkage. Smoking lasts 18-30hour, depending on meat size and intensity, during which the meat pieces are turned periodically to ensure uniform smoke-drying. A mat is used to cover the meat pieces to trap the smoke while the fire intensity is controlled by regulating the quantity of burning wood so as to prevent meat charring. At the end of smoking, the fire is quenched and the meat pieces allowed to cool down to ambient temperature before storage or packaging in sack and jute/mat bags. The product is dark in colour and of a stone-dry texture with 5-16% moisture and a chemical composition as show in table 3. It is a very stable product with shelf-life of 6-12months or even up to 2years under ambient conditions.

Table 2.23: Composition Characteristics of Commercial Banda

Meat type	Moisture content (%)	Wet basis protein (%)	Total fat (%)	Ash (%)
Donkey	9.0	61.3	18.5	8.5
Donkey	5.0	63.0	24.0	8.0
Donkey	4.5	67.7	20.0	7.0
Donkey	10.0	67.4	13.0	7.0
Beef	8.0	68.0	16.0	7.0
Beef	15.4	61.5	18.0	6.0
Beef	16.1	60.4	24.0	8.0
Beef	15.2	63.2	14.5	9.0

2.2.4 Processing Method of Ndariko

Ndariko; Sun-dried meat strip: Ndariko is a Fulfulde (i.e. Fulani) and Hausa name foe sun-dried meat with or without a seasoning of salt and spices. It is prepared mostly from beef and occasionally mutton and goat meat.

Meat is boned and the flesh turn in to long strips no more than 2cm thick. The best products are obtained by tearing the muscle to pieces so that a group of muscle fibres can be dried as a unit. Salt, if applied, is only at seasoning, rather than preservative, level; so also is the used of spices the meat strip and cleaned intestines, with or without salt seasoning, are hung out in the sun on sticks, rope and galvanized/barb wires or spread grass mats to dry. Dry takes usually 6-7days depending mainly on the weather and, to some extent, the nature and size of the meat strips. During drying the me at strips are turned daily, especially if spread on mats, to uniform dehydration. The dried product is stored in sacks, pots, or metal cans and has a shelf-life of 3-6months under ambient conditions.

2.2.4 Processing Method of Kilishi

Kilishi; sun-dried meat roasted meat sheet: Kilishi is a long thin sheet of sun-dried meat seasoning with salt, spices and groundnut flour and lightly roasted. It is a high-priced delicatessen product especially among the Hausa and Fulani tribesmen and the Arabs of Saudi Arabia. It is usually prepared from boneless beef and rarely from mutton or goat meat. It is made from hind-leg muscles.

The meat is cut in to large lumps that almost round in shape, and expertly trimmed free of adipose tissue, connectives tissue and veins. The lumps are carefully sliced into continuous thin sheets not more than 2mm thick and up to 0.5-1.5m long. The sheet are then spread singly on grass mat placed on the on ground or tracks made of sticks in the sun to dry for at least 3.5hour, the meat sheet are turned and pressed on a flat surface (like a table) to smoothen them and further dried for another 1-2hour before the sheet are soaked in a seasoning of salt, groundnut flour, spices and flavour. The sheets are then roasted lightly over a low-burning smokeless fire for 3-5min. and fully sun-dried for another 1-2hour. The products is marketed unpackaged as a high-priced delicacy which is wrapped with paper on procurement. It has a moisture content of 10-15% and a shelf-life of up to 12months.

2.2.5 Processing Method of Biltong

Biltong; sun-dried salted meat strips: "Biltong" popular in South Africa, is the best documented of all Africa dried meat products. It is like ndariko in ali aspects except that its in infused with more salt by curing

Boneless meat is turn into strips not more than 1-2cm thick. The strips are cured by rubbing in salt or by covering them with salt and leaving overnight when a lot of water oozes out of the strips. Spices such as pepper and ground chilies, are sometimes added; so also is saltpeter, which imparts a bright red (cured meat) colour to the product. Drying in the sun is carried out by hanging the salted meat strips on strands of galvanized/barb wire. The biltong is ready when a pieces, broken or cut off, shows a uniform structure.

2.2.6 Processing Method of Jirge

Jirge; sun-dried fermented meat strips: jirge is the Hausa name for the sour sun-dried meat strips prepared and consumed by shuwa tribesmen. It is a fermented sun-dried meat prepared mostly from beef and occasionally from mutton or goat meat. Jirge is like ndariko in all respects except that its fermented prior to tearing into strip and drying.

Meat for jirge is boned and cut into chunks which are left until the meat starts to ferment to develop the desired sour taste. It is then turn into strips not more than 2cm thick and sun-dried with or without addition of salt and spices for seasoning. Drying in the sun is by hanging strips over sticks, ropes and galvanized/barb wire or by spread over a mat. Drying takes about 5days, depending on weather, and the meat strips turned daily to ensure uniform drying. Storage is as for ndariko, in sack, pots and metals cans, and product shelf-life is up to 6months or more.

2.3.0 Traditional Type of Meat Dehydration

2.3.1 Meat Dehydration by Roasting

Roasting of meat over or around an open fire is employed to dry meat and enhance shelf-life. Generally a low-burning or glowing fire is produced by burning hard, rather than soft, woods and the meat pieces singly or in stakes are placed on a wire mesh over or around the fire. More specific detail are evident from the processing of tsire (or suya) and balangu-two-to eat popular West Africa delicatessen meat products that are prepared mostly by the Hausa and Fulani tribesmen.

2.3.2 Smoke-drying of Meat

Meat preservation by smoking in tropical Africa is by HOT SMOKING which usually involves smoking, drying and high-temperature treatment as opposed to COLD SMOKING which involves dense smoking at low-temperature with little or no thermal and drying effects. While in cold smoking distilled (dense, grey, moisture-laden) smoking from air limited incomplete combustion is used, hot smoking employs hard wood subjected to complete combustion (with air supply) to produce blown smoke which is light and hot containing little moisture; this is, therefore, a cooking-and-drying smoke which causes a lot shrinkage but produces a cooked-dried shelf-stable product. Meat may be smoked raw or cooked with without salting. Smoking devices used traditionally vary from smoke pits to one or multi-chambered ovens with wall made of mud or clay. The method used also vary in details. The simplest and the oldest method of smoking, still used at kitchen-level for meat preservation, is to hang meat slices above an open kitchen fire. Hot-smoking at both domestic and commercial levels is applied to whole carcasses of small animals like rodents or to meat pieces.

2.2.3 Sun-drying of Meat

Sun-drying of meat is more common in the drier tropics with high sunshine, low humidity and low rainfall for most of the year. In the more humid areas it is restricted mostly to the season. Meat for sun-drying is commonly in the form of thin strip or sheet, raw or cooked and product shelf-life may be entirely dependent on the sun-drying or only partly dependent as in heavily salted or fermented products.

2.4 Quality and Deterioration of Traditional Dried Meat

The quality and stability of traditional dried meats, as for other dried foods, depend on the extent of water activity depression and water removal (Labuza, 1971) which with the degree of roasting, smoking, sun-drying, salting and fermentation during processing.

2.4.2 Insect Infestation

Insect infestation is a serious problem in all fully dried meats. Initially infestation is usually by deterring species; maggots and pup aria of calliphorid and muscid flies are common on exposed meat during early drying. These are subsequently replaced by dermestid and clerid beetles; the succession of infestation is directly related to changing moisture regimes in the meat. The two principal beetle species most commonly associated with dried meat are Dermestes. maculates and Necrobia rufipes. Beetle infestation occurs during sun-drying and post-drying cooling of hot-smoked meats when mated females oviposit on the meat. Consequently, the product is usually moved into storage substantial level of infestations especially eggs and early instars larvae. These undergo rapid development under the conditions of meat stores. The larvae of both Dermestes maculates and Necrobia rufipes are voracious feeders, reducing the meat to mere press within weeks. Control with insecticides should be careful to the consumer. As a routine, all the stores and sacks in which dried meat is kept should be evenly dusted with 0.5% gammezane powder. The use of gammexane, within legal limits, for dusting the meat is recommended, since gammexane evaporates during meat boiling. Application is recommended at10ppm on weight basis. If treated meat is not boiled before consumption, the water in which it is soaked should be discarded.

2.4.3 Microbial Stability and Safety

The microbiological stability and safety of tradition dried meat depend, as do other dried foods, on the control of water activity and moisture content below the lower limit at which microorganism are able to multiply or produce toxins. That the water sorption isotherm shifes with temperature such that at a higher imposes serious microbiological problems when dried meat are produced in colder climates for sales in hotter areas. Also important are consumer-abuse problems under our prevalent in sanitary practices (Mann, 1967; Obanu, 1986). Of the usual food-borne pathogens only staphylococcus aureus is able to grow at water activity as low as 0.86 (Scott, 1982). In addition to its ability to produce one or more potent toxins, staphylococcus aureus grows rapidly over a relatively wide range of PH; it is frequent found in the nasopharyngeal passages of human and thus may readily gain access to meat through handler; it produces toxins of remarkable stability heat; and it is capable of growth at water activity which prevent the growth of most other bacteria. However, the minimal water activity for staphylococcus entero-toxin formation in artificial media is somewhat higher than that of dried meats, especially of intermediate water activity; it is desirable that growth of staphylococcus aureus should be controlled. Even more meats tend to quickly pick up moisture from atmosphere thereby raising their water activity and moisture content to levels that encourage mould growth. In absence of packaging and suitable treatments mould growth is a serious cause of product deterioration and health hazard from mycotoxins, especially aflatoxin.

2.4.4 Enzymic Deterioration

Enzymic of widespread occurrence such as peroxides are completely inactivated at water activity of 0.85 or less (Loncin, et al; 1968). However, some hydrolyses and lipases are actives at water activity low as 0.3 or even 0.1 (Acker, 1969). Nevertheless, as currently processed, enzymic deterioration of additionally dried meats may not be significant.

2.4.5 Non-enzymic Browning

Among the chemical reactions capable of causing deterioration of dried meats, non-enzymic browning reactions of aldehyde-amino condensation (i.e. Maillard type) is of prime important and reach a maximum at 0.6-0.7 water activity (Locin *et al*; 1968). These reactions cause a wide range of defects including darkening development of scorched off-flavour and odours, toughing in texture, loss of rehydratability, and loss of nutritive values, particularly by lysine destruction. Meat develops a reddish brown discoloration and simultaneously the initial fresh flavour diminishes and is replaced, in the early stages of storage, by a stale flavour followed, in later storage, by unpalatable, bitter, burnt flavour (sharp, 1957).

2.4.6 Oxidation Deterioration

Lipid oxidation: lipid oxidation is another major reaction controlling the stability of tradition dried meats. This involves the reaction of oxygen with unsaturated fatty acids producing off-odours. In dehydrated meat an unpleasant "tallow", "acid", or even "paint-like" odour is developed (sharp, 1983) and the meat becomes totally unacceptable.

During fat oxidation essential fatty acid are destroyed and free radicals produced which can react with protein to produce solubility and biological values (Obanu *et al*, 1980) as well as destroy fat-soluble vitamins. It is also known that unsaturated carbonyls produced in lipid oxidation can take part in non-enzymic browning reactions (Reynol do, 1965). There is evidence that oxidized lipids, when consumed, may have harmful physiological effects (Schultz et at, 1962) Protein interactions with oxidized lipids.

Formation of peroxides in oxidation leads to reaction with protein in lipid-protein systems (Schultz et al; 1962, Karel et al; 1975). Carbonyl breakdown products are especially reactive. Among the effects of lipid peroxides on protein in Vitro are loss of solubility due to aggregation or complex formation, chain scission and loss of specific amino acids; the basic and sulphur containing amino acids are the most susceptible (Obanu el at. 1980).

2.5 Technological Problems and of Traditional Dried Meat

2.5.2 Industrial Organization

A major problem with traditional dried meat production is that the industry is not organized; processors work in isolation and are ignored even by governments. Often production is shrouded in secrecy and takes place far remote from built-up areas (Okonkwo and Obanu, 1984). There is, therefore, no encouragement from any sector; operational capital and investments are also extremely poor. Production inspection and control are difficult and quality control is ignored. Development of traditional dried meat production necessitates proper organization of the processors.

2.5.2 Environmental and Personal Hygiene

Abattoirs or, more appropriately, slaughterhouses are located almost exclusively in urban areas; even in these, the scene is busy and dirty, with the air strikingly polluted and heavily charged with both spoilage and pathogenic microorganism. Refrigeration is almost always non-existent or non-functional, when provided, and meat is left complete exposed to the polluted air, intense sunshine, high ambient temperature and humidity, all of which greatly accelerate the proliferation and metabolic activity of the numerous biological contaminants as well as intrinsic and extrinsic physical, enzymic and chemical changes in meat supply of potable water is either totally lacking or grossly irregular or otherwise inadequate. Drains, if provided, are often non-fluent, dirty and stinking. Most often refuse is dumped in heaps close-by; sewage, including human and animal faeces, are similarly heated. Vultures, rodents, flies and several other insects abound as ready vector that freely infest and infest the meal. Within the slaughterhouse, facilities are minimal, frustration good abattoir practice. Skinning, evisceration and cutting up of the carcass are often carried out on filthy platforms and tables. Rural areas completely devoid of abattoirs. At best what exist are slaughter slabs with roofs over them. In most remote dried meat production unite, slaughtering is on bare ground or over leaves/mat. Water is generally lacking and is sparingly used. To talk of personal and meat hygiene is to over-flog an obvious case.

2.5.3 Inferior Raw Material and Equipment

In all tropical Africa, meat animals are mostly in the hands of traditional pastoral herdsmen found mainly in poorer savannah belts. These herdsmen are to some extent nomadic in search of green pastures. Also they pride themselves on the size of their herd which they guard jealously and hardly part with except when such animals are spent, stick and weak, or when extreme financial need forces sales to meet the need. Under such management, animal are rarely culled for slaughter at the prime stage when they should yield well finished meat processors, housing no in document or control for quality, busy and use the cheapest meat animal available; often the haggard spend or discarded animal. This may will process discarded transport beast like asses, donkeys, and horses and sell them as desired beef products (Okonkwo and Obanu, 1984).

Processing equipment used in traditional meat drying are simplistic and, in some cases, primitive (Okonkwo and Obanu, 1984) making process control difficult, if not impossible. The processor is often at the mercy of the weather for sun-drying or smoking-drying. Product quality is uncertain and variable, so standards are met only by lucky and sheer artistry.

2.5.4 Poor Technical Know-how

A major problem with kiln design is that, the process of economic development in any society presupposes a structural, social and technological transformation. For this to be possible in the dried meat industry, new methods new machines, and new/improved products need to be developed to revolutionize aesthetic qualitative and quantitative production. Unfortunately, however, dried meat production in most parts of tropical Africa is still in its technological infancy in which age-old production methods, materials and machinery remain largely unchanged. A structural transformation of the industry is need to meet rising demand for better and more hygienically, processed meat products. At present, very little is known of the industry, the production technology and needs, product quality, stability and safety, handling, storage and market needs. Process personnel are largely poor and ignorant and need the help and education has its carryout in this study, to enhance their know-how, efficiency and productivity as for improvement of this industrial sector of our food economy.

CHAPTER THREE

3.0 METHODOLOGIES

3.1 Description of Suya Kiln

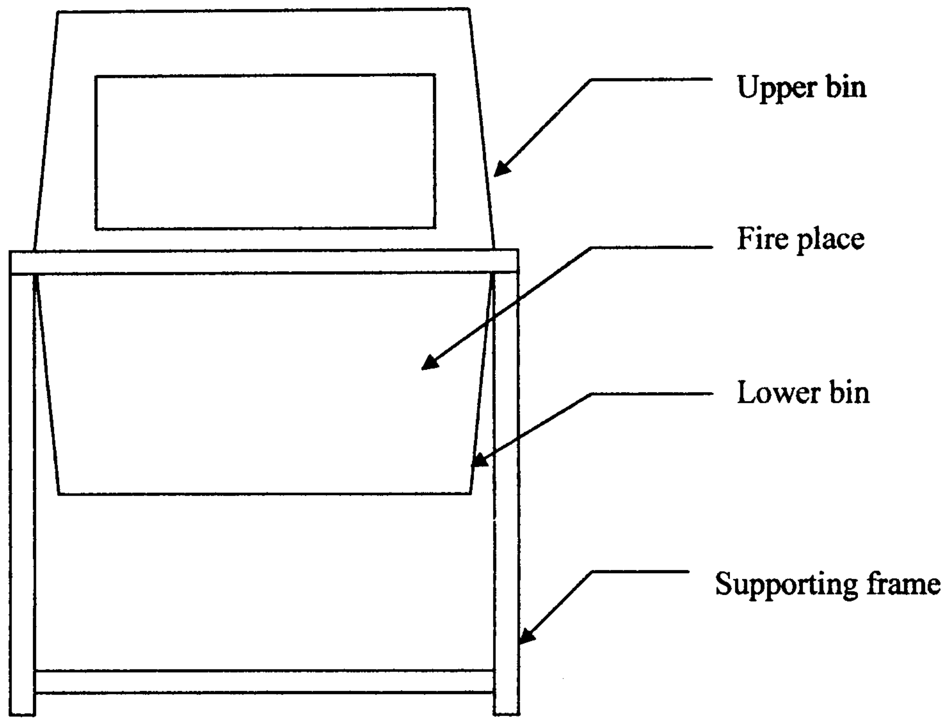


Fig 3.1: **Diagram of the Suya Kiln**

3.2 Mode of operation

The suya kiln is powered by firewood or wood coal hence the mode of heat transfer is by radiation. The fire wood is set in place in the lower bin of the kiln and lighted until the fire sufficiently burns the fire wood to red coal this takes between 8 minutes to 15minutes to achieve depending on the nature of the fire wood. When the wood is sufficiently burnt to coals then the prepared meat to be grilled is laid on the wire gauze above the lower bin. The meat is constantly turned over on its both sides until the meat is fully and well roasted this takes between 40 minutes to 600minutes depending on the heat intensity. After grilling, the meat (SUYA) is removed from the kiln and ready for consumption or storage.

3.3.0 Components of the Suya Kiln

3.3.1 Frame

The supporting frame is made of ¾" square mild steel pipe, this serves as a support frame for the components of the suya kiln.

3.3.2 Lower Bin

The lower bin is made of galvanized metal sheet. The lower bin serves as the combustion unit for the kiln. The wood or wood coal is burnt in the lower bin

3.3.3 Upper Bin

The upper bin is made of galvanized metal sheet. It serves as an enclosure to conserve the heat generated from the lower bin to enhance effective utilization of the generated heat before it escapes to the surrounding.

3.3.4 Gauze

The wire gauze is made of mild steel strips weaved together. It serves as a platform for placing the meat to be grilled.

3.4 Capacity of the Suya Kiln

The kiln gauze has a cross-sectional area (A_s) given by

$$A_s = \frac{\pi D^2}{4}$$

Where

D = 500mm = 0.5m

$$A_s = \frac{\pi \times 0.5^2}{4} = 0.1963m^2$$

The meat at efficient maximum loading occupies 75% Of the gauze surface area therefore area occupied by meat (A_m) is

$$A_m = A_s \times 0.75 = 0.1472m^2$$

Considering a maximum meat thickness of 20mm (0.02m)

Volume of meat (V_m) is given by

$$V_m = A_m \times 0.02 = 0.002945m^3$$

Given that density of meat to be grilled is 640.74kg/m^3

Mass capacity of the kiln is given as

$$mass = density_{meat} \times volume_{meat}$$

$$mass = 640.74 \times 0.002945 = 1.887kg$$

3.5 Heat Transfer in Suya Kiln

Heat transfer can be represented by numerous different equations. Convective heat transfer is the movement of heat due to fluid movement. Radiant heat transfer is the transfer of heat from a heated surface. The most common form of radiant heat transfer is the transfer of heat from the sun to the earth. This is what keeps us warm. We can also see radiant heat transfer while roasting in the kiln. The kiln is heated up and then the heat is transferred radiantly from the walls of the kiln to the meat in the kiln. Radiant and convective heat transfers are represented by a similar equation. The equation below represents both radiant and convective heat transfer.

$Q = -hA(Ts - T)$

Q = heat transferred Joules (J),

H = heat transfer coefficient of air $W/m^2 K$

k = thermal conductivity of mild steel in (W/mk)

x = thickness of mild steel in (m)

$h = k/x$

k = 45.5 W/mK

$h = 0.024/0.1 = 0.24 W/m^2k$

A_s= surface Area = $0.1963m^2$

T_s= temperature at the surface of the meat 100°C = 373K

T= 72°C = 345K

Therefore, returning to the equation,

$$Q = -0.24 \times 0.1963(373 - 345) = 1.319W$$

Table 3.5: Showing various values for k at 20 °C

Gases	k= $Wm^{-1}K^{-1}$
Air	0.024
Ammonia	0.022
Argon	0.016
Carbon Dio	0.015
Carbon Mon	0.023
Helium	0.142
Hydrogen	0.168
Methane	0.030
Nitrogen	0.024
Oxygen	0.024
Water Vap.	0.016

CHAPTER FOUR

4.0 Test and Discussion of Result

4.1 Test

At the completion of the design and fabrication of the suya kiln, the project was tested to obtain the following results.

Table4.1: Test of suya kiln

TEST	MASS OF MEAT	ROASTING TIME	OUTPUT
1	0.5Kg	40 min	Satisfactory
2	1.0Kg	45 min	Satisfactory
3	1.5Kg	50min	Satisfactory
4	2.0Kg	55min	Satisfactory

4.2 Discussion

From the above test results it was observed that as the mass of meat to be grilled increased and more time was required to grill the meat to the desired satisfactory value.

4.3 Fuel Efficiency of the Suya Kiln

The fuel efficiency of the suya kiln is calculated thus;

$$\text{Fuel Efficiency} = \frac{\text{heat generated in the kiln} - \text{dissipated heat by charcoal chamber}}{\text{heat generated in kiln}}$$

But;

Heat generated in the kiln is can be calculated as follow;

Calorific value of charcoal = 7600kJ/kg (Rogers *et al*, 1987)

Mass of the charcoal used = 4.10kg

Heat produce by 4.10kg of charcoal

= 7600/4.10 = 1854 = 1.854cal

Note;

4.18Kj = 1cal

xkJ = 1.854cal

$x = 4.18 \times 1.854$

x = 7.750kJ

x = 7750J

Where x is the heat generated in the suya kiln

Also;

The dissipated heat by charcoal chamber is given as

$$Q = \frac{hA(T1-T2)}{x}$$

Where;

h = thermal conductivity of the mild steel = 45.5W/Mk

A = cross-sectional of charcoal chamber = 0.196m^2

T_1 = temperature produce by charcoal = 260°C

T_2 = temperature out side the kiln wall = 70°C

x = thickness of the mild steel 0.1mm = 0.0001m

Therefore,

$$Q = \frac{45.5 \times 0.196(250 - 70)}{0.0001}$$

Q = 1605.240W

Heat dissipated charcoal chamber $= \frac{Q}{\text{Roasting time}}$

Time take to roast the (T) = 55min.

T = 55×60 = 3600seconds

$$\text{Heat dissipated} = \frac{16052400}{3300} = 4864.3636J$$

Total heat dissipated = heat dissipated ×area

= 4864.3636×0.196 = 953.4153J

Useful heat = heat generated – dissipated heat

= 7750 – 953.4153 = 6796.5847J

Therefore;

$$\text{Fuel efficiency} = \frac{\text{heat generated - dissipated heat by the charcoal chamber}}{\text{heat generated}} \times 100\%$$

$$= \frac{7750 - 6796.5847}{7750} = 87.70\%$$

4.4 Cost Analysis

Table4.4: Cost Analysis

S/No	MATERIAL	QTY	COST	AMOUNT
1	Galvanized mild steel sheet	1 sheet	9000	9000
2	¾" square pipe	1 ½ length	620	930
3	Wire gauze	-	600	600
4	Paint	1 ½ litre	900	1450
5	Thinner	1 bottle	100	100
6	Rivet	20	5	100
7	Electrode	20	10	200
	TOTAL			12380

Total cost of materials for the fabrication of the suya kiln is =N= 12,380

Labour Cost is 60% of cost of materials

Given by

$$Labor = 0.6 \times 12380 = 7428$$

Overhead cost is 20% 0f labor cost

$$\text{Overheadcost} = 0.2 \times 7428 = 1485$$

Total Project Cost = Material Cost + Labour cost + Overhead cost

Total Project Cost is =N= 21,293

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

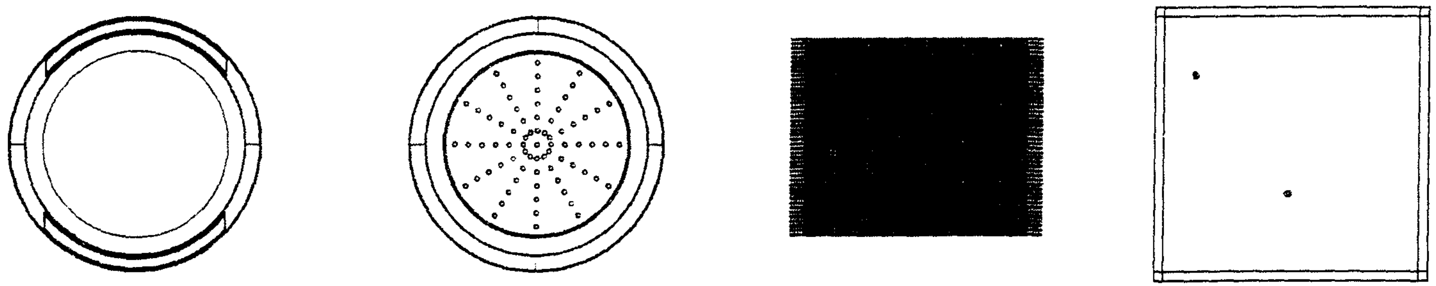
The design and fabrication of a standardize suya kiln have been successfully carried out. The suya kiln consists of upper bin, lower bin, supporting frame and fire place with capacity of 1.88kg of meat and the heat activities in the system is -1.319W.

The test carried out on the machine shown that, there is an improve in the meat taste satisfaction. It can also be observed that as the mass of meat to be grilled increased and more time is need to grill the meat to the desired taste. It can also be concluded that the total cost of the project is =N=21,293 which implies that the project can easily affordable to other oven for making suya.

5.2 Recommendation

From the project performed, the suya kiln can be further improved upon y the following measures.

1. To increase the amount of meat to be grilled, a bigger suya kiln will be need since kiln area determines the quantities of roasted meat.
2. Suya kiln can also be improved by using gas or electricity as sources of heat.
3. A mechanism can be introduced into the machine to enhance the automatic turning of the meat



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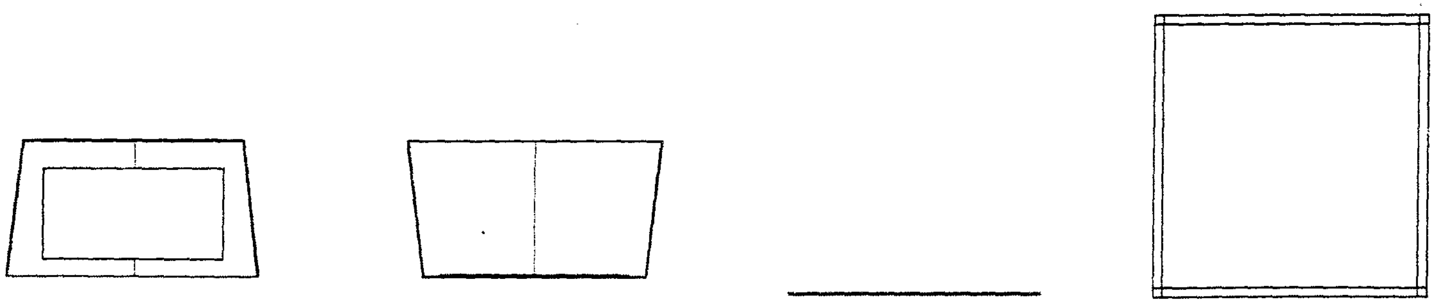

S/NO	PART	MATERIAL
4	FRAME	MILD STEEL
3	WIRE MESH	MILD STEEL
2	LOWER BIN	GALVANIZED STEEL
1	UPPER BIN	GALVANIZED STEEL

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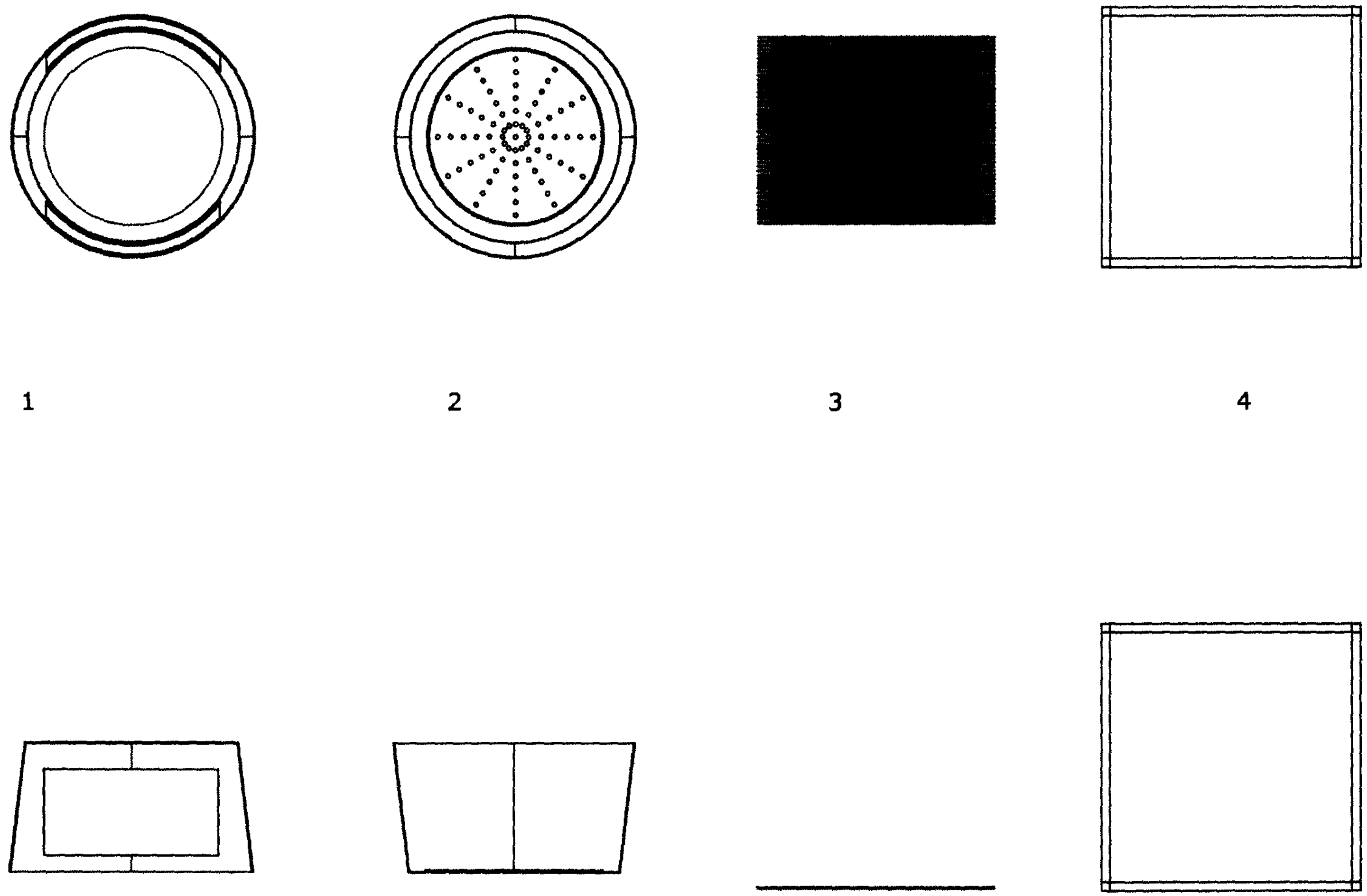

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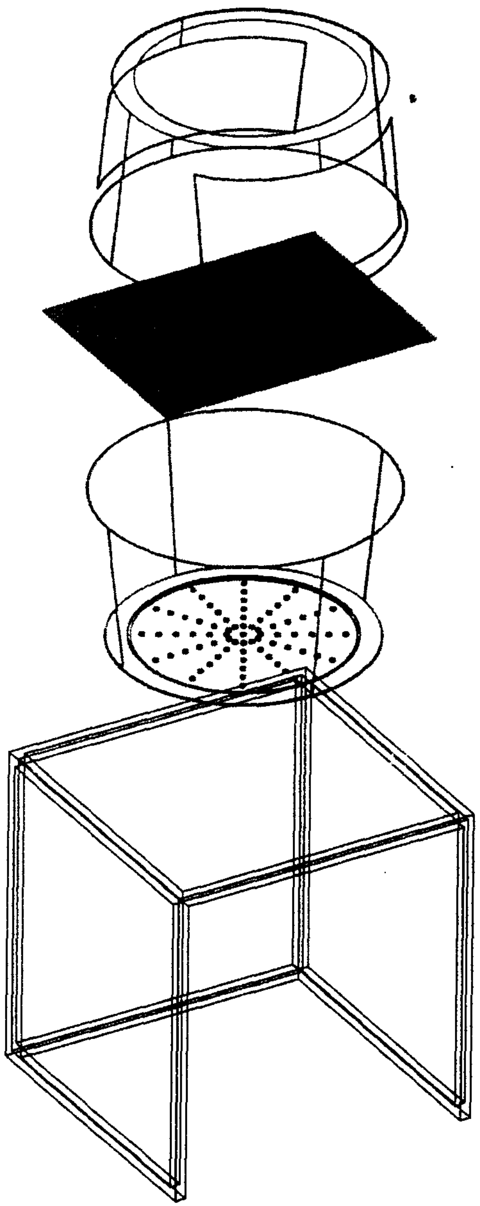
TITLE	PART DRAWING OF SUYA KILN	NOV 2008



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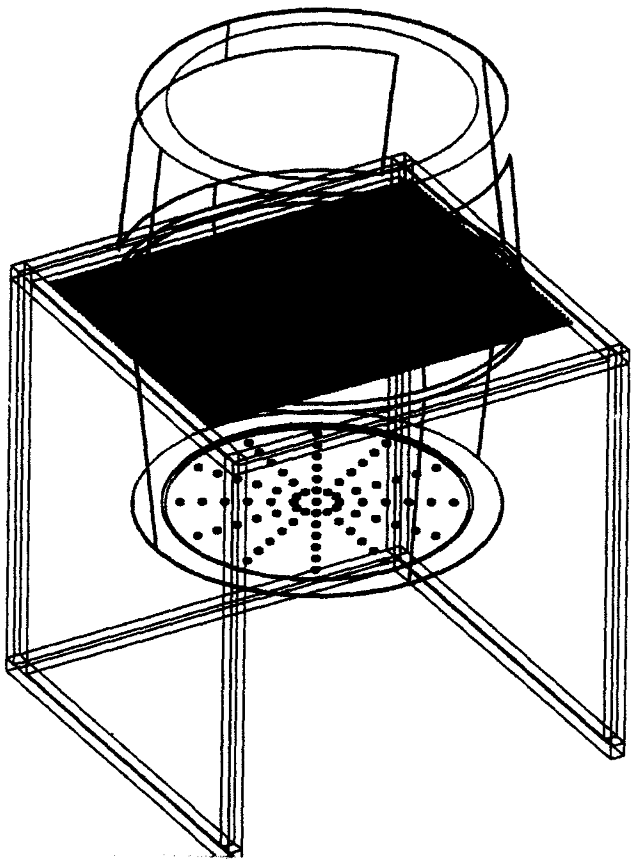

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