PARTICLE BOARD PRODUCTION FROM GROUNDNUT SHELL

BY

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PGD/SEET/2001/161

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PARTICLE BOARD PRODUCTION FROM GROUNDNUT SHELL

A RESEARCH PROJECT PRESENTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA IN PARTIAL FULFILMENT OF REQUIREMENT FOR THE AWARD OF POST GRADUATE DIPLOMA IN AGRICULTURAL ENGINEERING (SOIL AND WATER OPTION), FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA.

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DECLARATION

I hereby declared that this research project has been conducted by me under the guidance of my supervisor in person of Engr. Onuachu A.C. of the Department of Agricultural Engineering, School of Engineering and Engineering Technology Minna, and that I have neither copied some ones work nor has some one else done it for me.

The writer whose works has been referred to in this project have been acknowledged.

NAME OF STUDENT

SANTALI USMAN

PGD/SEET/2001/161

SIGN.....

DATE. 20- October 2004

DEDICATION

To Late Mohammed Babanna (AHYEE) for his understanding, love and concern which served as an anchor to me and the family.

APPROVAL PAGE

This is to certify that this is an original work embarked upon by Santali Usman PGD/ AGRIC. ENG./ 2001/2002 /161 and has been prepared in accordance with the regulations governing the preparation of research project in the Department of Agricultural Engineering, Federal University of Technology, Minna.

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ABSTRACT

This project work was aimed at producing particle board from groundnut shell using molasses as the resin binders. The essential results obtained during the course of the work shows that; the properties of particle board produced depend on the kind and shape of groundnut particles, quality of the resin binder, pressure and method of forming. It was found out that groundnut shell produced quality and durable board using molasses as resin binder.

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CHAPTER ONE

1.0 INTRODUCTION

Particle board, which is also known as chip board, Flake board, shavings board or waste fibrous material board, has in recent years become increasingly important as a furniture and building sheet materials. Major areas where particle boards are newly introduced, includes Laboratory attires, Accessories of house hold equipments, cabinet fittings, wall cladding, partitioning, flooring, table tops, furniture carcase construction and built in fitments e.t.c. The uses of particle board are numerous but the most important thing is that, such materials should be homogeneous. Examples of such raw materials used in the production of particle board includes wood clips, saw dust from sawmill, straw of plants flakes of log e.t.c. These materials are largely generated but unmanaged as they are either wasted or burnt in Africa and most part of the world without any industrial applications. The continuous uses of raw materials from wood plants for the production of particle board is seriously affecting the sustenance and growth of our natural resources.

The project discussed the importance of using an Agricultural by product (Groundnut shell) instead of the conventional wood products; as sources of raw materials by which particle boards can be produced. **(John, 1971).**

Particle board was formed as a flat rigid panel to withstand screw/nail Impact and abraision. It consist of ground nut shell, broken into smaller chips, sieved using British Standard sieve and using 1.18mm, 1.17mm, and 600um pan by gradation method. The particles are then dried to a Uniform Moisture Content and mixed with resins, (sugar molasses). Mat-forming into a panel of model sizes (0.15m x 0.15m x 0.025m). The above method was used in place of extrusion method, because, the mat – formed method has limited production and usage. Additives to increase fire – resistance and resistance to fungi and insects attack are not added to the mixture, due to limitation of the project to laboratory method.

These particle boards are used in numerous ways, but the most important thing is that, the materials used, should be homogeneous (Same consistency through out).

The particle board (with size 0.15m x 0.15m x 0.025m) produced from an iron mould and the raw materials are source from Groundnut (Arachi Hypogaea) in the family of papilionacea and sugar cane plantation. The board is produced as a simply layer particle board, that is perpendicular to the board's faces. The particle used tends to lie parallel to the faces of the boards so formed, vary according to the density, sizes and the quality of the particles used. The strength of the boards is based on the application of the pressure during forming process, the static binding, the internal

binding of the resins used, Abrasion resistance and modulus of rapture. All these defines the class within which the board falls into **(John, 1982)**.

Agricultural statistics shows the availability in commercial quantities of the groundnut crops and sugar cane plantation in Nigeria, Predominantly in the Northern part of the Country. Such as Kano, Jigawa, Sokoto, Niger and Kebbi State.

Generally, the particleboard is used in the construction company both on large and small scale. It is used in furniture making, cabinets, mobile home decking and sheathing.

1.1 AIMS AND OBJECTIVES

The aims and objectives of this project work is to utilize the quantities of groundnut shell (pods) as waste generated in Nigeria; to be converted to use as effective raw materials in the manufacturing of particle board known as chips board.

1 To substitute the use of imported synthetic Resin adhesive known as urea formaldehyde with liquid sugar molasses from sugar cane product as an effective stabilizer in the production of particle boards.

2. To ensure effective management of our Agricultural waste product such as groundnut shell.

3. To reduce the production cost in the building and furniture industries that produces particle boards, ceiling board, and chip boards, e.t.c.
4. To encourage drastic measures for a better way of utilizing our Agricultural by product such as Groundnut shell, Rice Husk and Palm kernel shell.

1.2 LIMITATION

This project work is not protracted to industrial scale, but restricted to laboratory research method only. Although both method still shares similar processes and steps, depending on the method of production adopted and the usage of the finished product; such as Drying, Milling and pressing relignification; Extrusion method, & Cold / hot mat – formed method e.t.c. Due to available Technology, only the cold mat pressing method of production was used. The method Virtually eliminates high pressure and temperature coupled with modern equipments that are limited in this project works.

The binder used for the production of particle board is not the synthetic Resins types; rather, it belongs to Agricultural by – product (sugar molasses). The sugar molasses have higher holding strength properties but prone to fungi attack. When Additives are added, will give a perfect

protection against fungi attack and thus make Ground nut shell as the alternative raw materials in the production of particle board.

CHAPTER TWO

2.0 LITERATURE REVIEW

Manufacturing of particleboards started in 1940s after the development of synthetic resins. Particle board is made from natural fibrous materials such as wood particles e.g chips, splinters, shavings, flakes or saw dust. Many of these materials where once considered wasted at the saw mill, now they are combined with synthetic resins adhesive (urea formaldehyde) under heat and pressure to form a medium density board used for interior purposes e.g Kitchen cabinets, partitioning and shelving e.t.c. **(see fig. 1).**

The properties of particle board depend on the kind and shape of chips, and amount of adhesive. (Resins), pressure and method of forming. The corresponding value of a particle board also depend on amount, nature and softness of the cellulose present in the cell-wall of the fibrous materials.

Particle board are classified into 5 different group of density grades in relation to weight of the product, per cubic foot. (or cubic cm) These density grades are usually obtained by different pressure applications, during manufacturing processes. Basically, particleboard are classified into low density, (ie insulating type with density of 350kg/m^3 – 1400Kg/m^3), medium density (ie decorating type with density of

1400Kg/m^3-1600Kg/m^3) and the higher density (ie hard board types for heavy construction 1600Kg/m^3-2100Kg/m^3). A standard particle board in market size of 1.2m x 2.4 m x 0.025 m should fall within these regions or its density grade would be rejected. The boards are available as unfinished sheets or in various stages of finishing, with the surfaces and edges filled, coloured and sealed. They are also available in thickness. The most common panel size available in the markets ranges from thickness of 12.5mm to 25mm.

The two basic methods of producing particle board are the Extrusion and mat- forming method, with the later being more obsolete. The mat – formed method of producing particle board consist of binding together plant chips or particles with synthetic resin through heating and application of pressure to achieve the desired density (strength). Before the forming process, the particle are grinded in homogeneous pattern and dried to uniform moisture content. The pressed boards was cure for one week, they are them cut and trimmed to standard sizes with multiple saws and precision sanded on both sides to accurate thickness. Then parked for dispatch **(see fig. 2)**.

The characteristics that defines the quality of a particular particle board is dictated by the quality of the resins that glues the particle readily, enabling a simplified car case or Box joints to be used. Another factors are the nails and screw, holding properties that varies between types of

boards produced. Higher holding power in boards is obtained when nails and screw are inserted into the faces than the edges. Manufactures recommend boring for screws especially in edges grains where relatively long screws should be used such at shake proof and twin fast screws **(John, 1982)**.

2.1 MOLECULAR STRUCTURE OF CELLULOSE MATERIALS.

Cellulose is a linear polymer of D- glucose linked in the Beta- 1,4 Glucosidic bondages. The bonding is theoretically valuable to hydrolysis. Cellulose containing materials such as fibers are difficult to hydrolyze because of the following.

1. The secondary and tertiary arrangement of cellulose materials that confers a high crystallinity on them with composition of $C_6 H_{10} O_5$.
2. The presence of lignin in the fibrous materials. When cellulose is hydrolyzed with acid, a portion known as amorphous zone that makes up to 15% is easily hydrolyzed leaving a highly crystalline part occurs as a small rod – like particle which can be hydrolyzed only with strong acid **(Peter, 1985)**.

2.2 TYPES OF BINDER

The choice of a particular type of binder is dictated by the presence of cellulose and lignin in fibers of the raw material used. Binders are

chemical substances which aid in binding (holding) together the flaky (chips) particles known as adhesive or Resin. Adhesive are available in various types such as urea formaldehyde, Phonetic Resins, Gum Resin and tannin adhesives e.t..c. These bonding agents are useful in preventing the flakes of particles from loosening out of shape and to increase the strength and resistance to moisture, heat, insects and decay.

Adhesive (Resins) are obtained chiefly from plants or made synthetically by addition of other Chemicals to be used in medicine, perfumes, soap, paints and plastic products. These Resins oozes out from wounds in the bark of tree and others are obtained by distilling wood, others are extracted from plants body by solvent, such as sugar molasses in sugar cane.

In the manufacturing process of particle boards, some adhesive are recommended such as Animal glues, casein starch, plant Resins polyvinyl alcohol (PVA) and Acrylic based emulsion.

This project will consider using Resin in sugar cane plant (sugar molasses) as the binder for holding the groundnut shells particles, because it offers high gloss, odorless and good ink retention, but has the disadvantages of sweetness effect on end product, that will make it prone

to insects attack introduction of aldrin preservative and wax emulsion and dehydration chemical may be injected into the mixture which is beyond the scope of the project **(New standard Encyclopedia 1982)**.

2.3 BOTANICAL CONSIDERATIONS OF GROUNDNUT

Groundnut plant is a major cash crop of the savanna, grown annually at altitude below 1,500m. They required moist conditions about 400mm depth of rainfall. Groundnut refers to as "Arachi hypogaea" are obtained from the family of "papilionaea" largest and most important of the three division of leguminosae.

Groundnut or peanut is a native of south America. It was introduced into Nigeria as. Major cash crops of the savanna in the 16^{th} century. They required warm temperatures and cannot withstand frost. They grow in variety of soils needing relatively little in the way of soil nutrients and are not recommended for heavy water log area of soil as these make harvesting the nuts very difficult, e.g Acidic soil of PH value <5. Groundnut occurs in two contrasting habit as erect (upright) and creeping or spreading. The upright types varieties mature in 3-3.5 months and are easier to harvest. The runner varieties have larger seeds and are mature after 4-5 months of planting **(MacDonald and John, 1990)**.

From statistics, the total hectare planted to groundnut, through out the world average over 22million hectares per year and in Nigeria about

1.4million hectares are planted to groundnut but most of these hectarage is however intercropped. In Niger State alone, annual groundnut crop yield survey revealed the availability of the crops in Niger State **(see Table 1)**.

Groundnut is highly nutrition's food that contains approximately 25% protein and 45-50% oil. The skin of the seeds are high in vitamin B.

The pods or shells of the groundnut crop are either wasted or burnt in most part of the world as the economic importance of these shells are not utilized in terms of industrial applications.

2.3.1 COMMERCIAL UTILIZATION OF GROUDNUT SHELL IN THE PRODUCTION OF PARTICLE BOARD.

The production of particle board is facilitated by the availability of the natural fibrous raw materials e.g flakes of plant wood and the resins chosen. The quality and suitability of these raw materials depend on the nature of the fibrous materials, the cellulose present in the cell-wall which may be single, or combined with pectin or lignin in the cell wall of the materials **(Britt, 1970)**.

For the purpose of their project works the choice of groundnut shell as raw material in place of wood product is based on the availability in large commercial quantities of the groundnut shell, predominantly considered as waste in Africa.

TABLE 1. SHOWS ANNUAL GROUNDNUT CROPS AREA YIELD SURVEY IN NIGER STATE

SOURCES-: NIGER STATE AGRICULTURAL DEVELOPMENT PROJECT MINNA

YEAR	AREA (HA) OF PLANTATION	Production (tens) of groundnut crops
1996	329371	281, 863
1997	329,371	329,371
1998	236,001	224,201
1999	291,350	346620
2000	301420	550720
2001	498647	698106
2002	845249	1,523263
2003	1,643242	3,824576

2.4 CHEMICAL COMPOSITION AND STRUCTURE OF SUGAR MOLASSES

When used by non –scientists, the term sugar generally refers to the substance used to sweeten foods which is almost pure sucrose.

Sugar is obtained through shredding the cone stem and washed while being sprayed, with water. The aqueous mixture is filtered, heated and calcium hydroxide added to precipitate the solution. The scum was formed as the juice is concentrated to a thick syrup and then evaporated

under vacuum to produced a viscous liquid called molasses from which the sager crystallizes.

The raw sugar which is pale, brown in colour, contains 99% pore sucrose and has the chemical composition (formula) of C_{12} H_{22} O_{11}. molasses can be transformed into two other sugar, such as glucose and fructose, by the addition of one molecule of water; this process of hydrolysis is called "inversion" and can be accomplished by heating a sucrose solution with a dilute acid or by the action of enzymes. The resulting glucose and fructose are referred to as invert sugar and white sugar. The process for the synthesis of glucose was given as $6C_{O2} + 6H_20$ *sunlight* $C_6 H_{12} O_{6+} 6_{02}$. These processes can only take place in cell containing green chlorophyll molecules. Photosynthesis above can only take place under the action of light reaction and dark reaction **(Margaret and Brian, 1994).**

Sugar molasses as an agricultural by product is an effective stabilizer agent (binder) to soils, plant particles e.t.c. its compositions can be affected by variety and maturity of the canes ten used, climatic and soil condition in planting or the processing method adopted by the factories.

A broad range of sugar molasses composition is giver below to illustrate its uses as an industrial raw materials **(see table 2).**

sugar factory. At the factory the grinding extract the sugar from the cane. **(Albert, 1986).**

2.5 MANUFACTURING STEPS OF PARTICLE BOARD

In Nigeria building industries, a simplify steps in the manufacturing of particle board as practiced, includes material Handling machine (logging defibering, refining , forming the mat, hydraulic press, Humidifying and transportation **(See fig. 4).**

The manufacturing of particle board begins by sourcing the raw materials to be used and subjecting it to size reduction into flakes, splits and sawdust e.t.c; using manual operation or milling equipments. The broken particles are then classified, dried to uniform moisture content mixed with a binder (adhesive), compressed to proper density and curing under heat and pressure.

The mixture is consolidated and the resulting particle board is formed by two most important method (a) Extrusion method and (b) cold / hot mat – formed method.

The extruded boards are homogeneous (single layer) in structure and are made by forcing a mixture of manufactured particle and synthetic resin adhesive through on orifice (opening) formed by oil heated metal platens corresponding in size to the thickness and width of the boards. The heated

plates cure the glue as the board is formed in a continuous sheet on a moving belt.

The chips of the extruded board tend to lie at right angles to the face of the board due to the forming pressure being applied in a direction parallel to the face. Extruded boards are generally strengthening by facing with veneers or crimson paper.

In mat – formed particle board, the mixture are consolidated and formed as flat panel consisting of binding particle of wood together with synthetic resin. The particles are treated to remove lignin by digestion method. It also has the advantage of exposing the lignocelluloses attack. In this method a single layer structure and three layers or sandwich structure can be formed. The single layer board has the advantage of forming a solid structure when great pressure is applied while the three layer structure increases the bending strength and stiffens of the board.

There are two broad method of processing fibers to produce particle boards such as mechanical and chemical method. The mechanical method.

The mechanical method involves blending and applying pressure (about 6.9mpa) at high temperature of about 200°c. the blended finished mats becomes very loose particle as its thickness are gradually reduced by application of pressure on the mixture until final thickness is achieved and a solid particles is formed while lignum was removed .

In the chemical method, lignin (a three dimensional polymer formed from cyclic alcohol to protect cellulose from hydrolysis) are removed from fibre mixture by adding pulping chemicals. These chemicals will greatly reduce lignin and hemicellulose in the fibre. It has advantage of lesser application of pressure on the mixture and disadvantage of cost in production than the chemical method.

2.5.1 PROPERTIES OF PARTICLE BOARD

Structural application of particle board shows their unique durability and resistant to impact and abrasion. The properties of particle board are characterized by the kind and shape of chips, kind and amount of adhesive, pressure and methods of forming. Materials to be used for the production of particle board should have the ability to absorb huge amount of moisture and yet retaining its properties. The board should be able to attain high holding properties e.g when nails / screw and joints are driven into it.

The primary influence of binder selected and particle size of the groundnut shell described the performance of a particle board. The smaller the particle size, the more the effectiveness of the binder as its penetrates into the intricate of the bulk of the particles. A suitable binders create a rapport which combines the discrete flakes and the sawdust together under heat and pressure by creating internal bonding (**Shukar, 1977**).

Some basic properties that will facilitate greeter performance and ensure the quality of a particular particle board includes.

1. **Tensile Strength**

   This is the measure of resistance that a material offers to tensile stress. Express as stress per unit cross – sectional area. The relationship between stress and strain in a particular materials is determined by means of tensile test **(Shukar, 1977).**

2. **Hardness**

   Hardness denotes the inherent power, which a material has to resist fracture by bending. In test, it is measured by the capacity for bending through a definite angle one or more times without sustaining a fracture. Hardness and strength are not quite identical, since a material may be strong, i.e. rigid, without being hard. A material of this nature may be able to sustain great tensile force up to a certain point and then give way suddenly without previous warning **(Tuve, 1977).**

3. **Abrasion Test**

   This is a measure of scratch that a material can withstand. Wearing or scratch on the smooth surface of the material to be tested. By comparing the results of different materials by reference to hardness scale, the relative hardness is found; or a better test is by

Density = $\frac{Mass}{Volume}\left(Kg/m^3\right)$

7. Moisture Content

This is the weight (or amount) of water contained in a given sample of groundnut particle recommend at 0.5% M.C express as %. It is calculated thus.

$$\frac{\text{Weight of wet sample – weight of dry sample x 100}}{\text{Weight of dry sample}}$$

8. Plastic limit (PL)

The moisture content at which a board became too dry to be in a plastic condition as determined by the plastic limit test.

9. Curing

This is the process of controlling the rate of water (moisture) lose from fresh particle board. The setting and hardening of stuck (mix) depend on the presence of water. Drying out (or rapid dehydration) if allowed to take place rapidly would result in low strength and brittle board. Method of curing to be adopted depends on the atmospheric conditions of the stacking condition. The lower the temperature, the slower is the rate at which boards harden – if efficient curing method is adopted, the strength of the product in creases resistance to abrasion. Effective curing method is thus most necessary and may last for several days.

ii. **Sawing**

Particle board may be sawed as any other wood product with hand or power tools. For best results sharp high – speed power saws should be used. For high – production work, saws must be carbide – tipped, of a design recommended by the saw manufacturer.

iii. **Machining**

Particleboard may be machined the same way as other wood products. Such operations as shaping, routing and planning give best results if tools are kept sharp. Absence of grain in particleboard allows uniformly fine machining without splintering.

iv. **Sanding**

The quality of particle board is such that surface sanding is not normally required. However, sawed edges, machined surfaces, and surface scratches can be dressed up by normal wood- sanding procedures. Also, precision sanding to close tolerance can be done.

v. **Bending**

Wide dry bends may be made by fastening particle board solidly to curved forms for smaller-radius bends wet the particle board, then bend it over heated forms until dry. Tighter bends without rupturing may be made by slow, deliberate bending. The thinner

the board, the sharper the curve that can be bent. Also, tempered particleboard will bend tighter than the same thickness of non-tempered varieties.

vi. **Drilling**

Particle board may be drilled the same as other wood products. f or best results the fact of the piece should be placed upward and a solid backing used to attain clean edges.

vii. **Gluing**

For gluing particleboard, follow the directions of the glue supplier.

viii. **Applying Particle Board Over Studding**

If nails may show, good results are obtained by spreading adhesive with a knife or gum on the studs and panels, and securing with a minimum of nails or staples. If no nails can be used, contact cement for plastic laminates is excellent. Follow manufacture's instructions for proper application.

ix. **Fastening**

Particle board may be fastened with any of the common wood fasteners, such as nails staples, automatic, nailers, screws bolts, adhesives or rivets.

x. **Nailing Particle Board**

Start at the edge adjoining the previous panel and work across the board to ward the free edge. Use 3d finishing nails (galvanized against preferred) for interiors. As insurance against fiber puffing around nail heads and nail loosening, it is recommended that annular – thread or ring – groove hardboard nails be selected. These nails are designed to be set flush with the work. Allow some freedom of movement between the boards, taking care not to force them tightly together. Space nails 6" on center. Make joints only where solid support is available. For exteriors, at least a 5d galvanized nail (casing or box), a shake nail, or a hardened siding nail should be chosen.

xi. **Staples for Particle Board**

For best result staples with narrow crown and divergent points (branching out in different directions) should be used, along with a hammer – types stapler or air gum. Spacing of 4" or 6" is recommended Length of staples should be at least ½" plus the thickness of the board. The power required varies with the thickness and kind of board.

xii. **Screws and Bolts for Boards**

Any thickness of hardboard may be screwed or bolted to a frame or base after drilling holes large enough to accommodate the shank of the screws or bolts. Also particle board ¼" or thick has excellent screw-holding strength for attaching hinges or other hardware. Drills holes smaller than the screw diameter and use sheet metal screw.

xiii. **Particleboard Joints and Edges**

Joints and edges may be scored, routed, beveled, grooved, or otherwise treated as use requires. Some particleboards are patterned so that their edges will blend into the overall pattern of the board when butted together. If joints are to be hidden, leave a space equal to the thickness of a single nail, then apply tape and joint cement as in normal dry-wall construction. This may be painted or otherwise covered. When joints are exposed, the edge may be beveled or routed. Wood, metal, or plastic battens or inserts may be used to accentuate the joints. Inside corners may be covered with cove molding or may be butted.

vx. **Painting Particle Board**

Particle board will take almost any type of finish. Brush, spray, or roller may be used according to the finish required. Interior-wall

panels require no special sealer. However, if sealer is to be applied, rubber or vinyl-base white are good choices. Wall paints (oil – base flat) require no special sealer. Water – mix sealer may be used as well as standard oil base primers. With enamel finishes, apply a pigmented primer-sealer as the base coat. Enamel under cost may be applied and rubber or vinyl emulsions also. Clear finishes require a recommended non-pigmented sealer. Clear varnish or resin sealers should not be used as a first cost. Best result are obtained with transparent filler-sealer, natural paste wood filer, or clear-drying white vinyl glue. Stain finishes may be obtained with pigmented resin sealers, oil wood stains, colored pasted – wood fillers or stain waxes. These are wipe – on finishes, varnish stains are not recommended. Texture paints or wallpaper may be applied when joints are properly taped and filled **(see table 2.1).**

TABLE 2:1 TYPICAL WORKING CHARACTERISTICS OF MANUFACTURED PARTICLE BOARD

USES	Particle Board 5.63M^3
Bending	Fair
Drilling	Good
Hardness	Medium
Laminating	Good
Nailing	Good
Painting	Unfilled – Fair
Punching	Filled – Good
Routing	Fair
Sanding	Good
Sawing	Good
Screw Holding	Good

2.6 GROUNDNUT SHELL AS FIBROUS RESIDUE

The groundnut is a leguminous plant originated in Brazil and introduced to West Africa by Portuguese traders. The plant germinates in about 5

days after planting. Flowering occurs in one and half months and crop is ready for harvest in 4-5months.

The groundnut shells (pods) are considered value less in most part of the world as soon as the seeds are removed from their pods. They are discarded as waste, because of their low nutritive value and high silicon content, which rendered the shell harmful to the digestive and respiratory organs of Human beings and Animal alike. The shells are referred to as fibrous residue and brownish in fibre structure and have a composition of lignin, pectin, pelea and lema which can not be eaten. Lignin is an amorphous material that increases the cellulose fibrils present in the cell walls of the tissues.

The groundnut shell (pods) have its structure build with fibres that give the required strength to be used as raw materials for the production of particle boards.

Lignin is a 3 – dimensional polymer formed from cyclic alcohol to protect cellulose from hydrolysis, but tends to reduce bonding strength in the shells particle mixed with adhesive. The application of great pressure on the mixture or addition of chemicals (Na OH & Na S)into the mixture readily removed lignin presence in the mixture to achieve effective bonding in manufacturing particle board (**Peter, 1985**). **See tables 2.2 and 2.3.**

TABLE 2.2:- PHYSICAL COMPOSITION OF GROUNDNUT SHELL.

PHYSICAL (CONSITUENTS)	COMPOSITION AVERAGE (%)
Cortical layer	24.84
Wood blast	70.35
Pith (spongy tissue)	2.3

TABLE 2.3:- CHEMICAL COMPOSITION OF GROUNDNUT SHELL.

CHEMICAL (CONSTITUENTS)	COMPOSITION AVERAGE (%)
Ash	14.5
Pentosan	20.6
Cellulose	48.5
Carbohydrates	10.0
Lignin	3J.2
Gude Protein	6.5
Fats	3.0
Waste	9.7
Oil	7.2
calcium	45

2.7 SUGAR MOLASSES AS ADHESIVE

Sugar molasses are by – products of Agricultural Plant processing. Sugar molasses is a dark grey, dense and highly viscous liquid that is very

soluble in water. It can have its composition affected by the variety and maturity of the cane used, climatic and soil conditions

Sugar cane molasses is produced when sugar cane is crushed, after shredding the cane stem and washed with water. The aqueous mixture is filtered and the fibrous residue is discarded as waste. The molasses contains over 99% pure sucrose which is a disaccharide with the formula C_{12} H_{22} O_{11} . It can be transformed into two other sugar (glucose and fructosed) by the addition of one molecule of water. This process of hydrolysis is called inversion and can be accomplished by heating a sucrose solution with dilute acid or by action of enzymes; called invert sugar.

Molasses as an industrial raw material is used for the production of edible table sugar, cattle feeds alcohol, yeast, soil stabilizer and plant particle stabilizer. Sugar molasses have the disadvantages of attraction to fungi & termites attack **(Margaret and Brian 1994).**

2.8 TYPES OF ADHESIVE

i. Vegetable-starch adhesive:- Obtained from cassava when peeled and grinded. The grinded cassava is sieved and allowed to settle; it is later decanted and dried to prevent it from bacterial attack. Other adhesives like casein adhesive made from curd of soured mill **(Othmer, 1968)**

ii. Synthetic resin adhesive:- the product is a combination of Urea and phenol formaldehyde, but some moisture is added to the furnished board when powder formaldehyde are used. The resins are by chemical means, suitable in paint and plastic industry.

iii. Gum Resins:- Contained gum, which differs from resin in that it is soluble in water. They include frankincense and myrrh, used in perfume and asafetida (used in medicinal) (**New Standard Encyclopedia, 1986).**

iv. Resin:- any various substances obtained chiefly from plants or made synthetically and used in medicine, perfumes, soap, paints, plastic, wood product, vanishes and other products. Some natural resins ooze from wounds in the back of trees, others are obtained by distilling wood, still others are extracted from. Plants by solvent most of these resin are yellow to brown, translucent, aromatic, solid or semisolid substances that can not be dissolved in water but are soluble in alcohol and many other solvent (**New Standard Encyclopedia, 1980).**

v. Animal Adhesive:- obtained from animal hides, skin and horns by burning them in limited supply of air to form a gelatinous substance. When used as binder, in particle board gives density lower than 600kgm^{-3} (**Othmer, 1968**).

vi. Cement:- This is an in – organic types and made from calcium Trioxocarbonate (v) (Ca CO_3)clay, sand and other materials. When used, it gives a density from about 500 to 800kg/m^3 **(Othmer, 1968).**

Of all classes of adhesive discusses above, only vegetable starch would be compared to the sugar molasses being used for the purpose of the project. Both sugar molasses and vegetable starch are readily available in commercial quantities in Nigeria and processing method is simple and cost less. The residue fibre left over could be used for the manufacturing of paper in the case of sugar cane adhesive.

2.9 FUNCTIONS OF ADHESIVE

Adhesive can be said to be ideal for a particular operation if it has the following characteristics.

1. Fast grab attack
2. Dehydration of binding area
3. To be easy to apply and require no special or fixing equipment.
4. To be resistant to creep at high temperature
5. Have low moisture content
6. Resin should be flexible on application

The selection of an adhesive will depend on the following:-

i. Its design life

ii. Loading factors

iii. Effects on near by materials

iv. Economic Factors

v. Heat and Safety factors

There are other things to be considered in the selection of an adhesive. The adhesive must not be toxic to materials chosen. It must not be flammable or toxic and must be available in commercial quantities e.g sugar molasses and vegetable starch. Arabic gum **(Gladius, 1977).**

2.9.1 COMPARISON ON CHEMICAL PROPERTIES OF MOLASSES AND UREAFORMAL DEHYDE USED AS ADHESIVE

(i) Urea formaldehyde:-

A colourless, poisonous gas with a sharp odour. It is very chemically reactive. Urea formaldehyde are the products of urea or melamine with formaldehyde. It is the simplest of the aldehydes (a class of com pounds of hydrogen, carbon and oxygen) formaldehyde is commercially made by oxidation of methanol (methyl alcohol vapour). It

is usually dissolved in water to form an aqueous solution called formatin; in solid form is called paraformeldehyde or paraform.

One of the most important use of formaldehyde is in the manufacture of synthetic resins that are used in adhesives and plastic. Chemical formular of urea formaldehyde is CH_2O. Urea was the first organic compound to be artificially produced from inorganic material. Human body produces urea from the liver and can also be produce from heating solution of ammonium nitrate, and inorganic compound. Chemical formula of urea is $CO(CH_2)_2$.

(ii) Molasses. The molasses is produce from heating extractect solution and raw sugar obtained from cane hybrid. Molasses can be transformed into two other sugar, fructose and glucose.

Molasses belongs to class of food called carbonhydrate, which composed of carbon, hydrogen oxygen and nitrogen as protein. Molasses has a chemical composition of $C_6H_{12}O_6$.

Generally, both urea formaldehyde ($CO(NH_2)_2 + CH_2O$) and molasses ($C_6H_{12}O_6$) belongs to class of compounds of hydrogen, carbon, oxygen, Nitrogen and plant proteins. These adhesives were made by hydrogen from the above compounds.

Molasses and urea formaldehyde are produced through chemical reaction to change its properties to obtain adhesive. e.g. by oxidation of carbon as impurities.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 MATERIAL/EQUIPMENT

The materials and equipment used for the production and characterization of particle board from agricultural by – products are given in (**Table 3.0 and 3.1).**

TABLE 3.0 MATERIALS USED FOR THE PROJECTS.

Materials	Sources	Botanical Name Research Code/ Name	Comment
Groundnut Shell	Minna Gwadabe Market	Arachi hypogaea	Dried and Crushed
Sugar Molasses ($C_{12}H_{22}O_{11}$)	Wuya Village in Bida L.G	Saccharum office- narum	Shredded, wash with water, crushed and sieved
Lime-lome (Citricfrunit) Ca (OH_2)	Minna Central Market	Orombo	Peeled, crushed & sieved.
Water	Civil Lab. FUT Minna	Tap water	Washing items.

TABLE 3.1 EQUIPMENT USED FOR THE PROJECT

MATERIAL	SOURCES	RESEACH CODE
Manual press square shaped steel mould with steel pallet cover and bottom plate size 0.15x0.15x0.025m	Mr Wahid welding w/shop Mx	PR
Electronic weighing balance	Sauter England	Digital Calibration in grammes.
Scoop	Elt England	BS 410/1986
Spatula	Elt England	BS 410/1986
Measuring cylinder	Elt England	BS 410/1986
Cylindrical steel Container size 0.18m^3	Made in Mx	Metal
Grinding machine	China made	-
Mortal and pestle	Made in Mx	Wooden frame
Local sieve	Made in Mx	Wooden frame
Knife	Made in China	Rubber frame

Local stove	Made in China	-
BS Sieve	Elt England	BS410/1986
Milk can	Civil lab	C_1, C_2 & C_3
Oven	Elt England	BS410/1988
Rammer (75kg)	Elt England	BS410/1986
Nails & Screws	Made in Nigeria	37.5mm size
Ordinary Hammer	Made in Nigeria	Wooden frame
Stop clock	England made	-
Hounsfield Tensometer	Hounsfield Ltd England	W4729
Wooden Clamp	England	G245

3.2 PREPARATION OF GROUNDNUT SHELL PARTICLE WITH MOLASSES MAKING AND CURING

The groundnut shell sample used throughout had to under go some form of preparation to obtain shell that is reasonable in its particle size (small chips) and thus useful for the purpose of making particle board. In this instance, the ordinary groundnut pods with seed which I obtained from Gwadebe Market in Minna was air dried by daily spreading it in the sun out of contact with the ground and debric, until suitable dried.

This dried groundnut pods with seed was pounded using pestle and mortar. The seed was sold to Local groundnut seller and the shell was then pounded with mortar and pestle to loosen and breaks into particles (chips, splinter, flakes and saw dusts). These particle where again sun dried for several days, to reduce the moisture content to about 5% M.C. The particles are sieved using sieve size 1.18mm, 1.17mm, 600um. To ensure conformity with the regulated standard of keeping the particles dried to about 5% M.C. An experiment to determine the moisture content of the sample was taken **(See tables 4.0 and 4.1).**

Similarly, sugar cane stick numbering 3 boundle made up of 15 stems, was obtained from Wuya Village in Bida Local Government because of the maturity of cane produced in that Area. The summary of final preparation of these Raw materials were Itemized below.

1. The shells are sun dried for several days to facilitate pounding and sieving.

2. The shells are subjected to manual pounding using mortar and pestle to reduce its sizes into flakes, chips, splinters and saw dust; referred to as particles of groundnut shell.

3. The particle are sieved using British standard sieve (a set of 7 sieves) to determine and use in the mix, single size distribution of

groundnut particle sample to form an homogeneous or the same consistency mix. The particles that retained in sieve size 1.18mm,1.17mm and 600um was chosen; because the finer the particles size the better in quality of the particle board produced.

4. The retained particles sizes were sun dry for several days to reduce the moisture content to about 5%.

5. Moisture content test was conducted in the to laboratory to keep the particles below or within 5% M.C.

6. Sugars cane (stems) were shredded and washed before breaking into smaller sticks and crushed using grinding machine and local sieve to retain all the sugar fibre residue for disposal and using the extracted sugar liquid in the production of particle board.

7. The groundnut particles sizes are weighed using Electronic sauter balance into 3 (three) separate samples ("A" "B" "C") each weighing 0.27kg respectively.

8. The steel mould was greased with oil on sides, bottom, surface and cover to reduce frictional resistance created during forming operation.

9. The pale, brown, aqueous mixture (raw sugar) was filtered and heated for 20min. A volume of lime solution (10ml). Was added to raw sugar as calcium hydroxide to remove the impurities in the sugar solution. The scum so formed concentrated the juice to thick syrup, while the impurities were evaporated into atmosphere and the remaining viscous liquid was referred to as molasses.

Note:-Colouring and anti –fungal agents are not added to the solution due to scope of the laboratory works.

3.3 MANUFACTURING PROCESS OF PARTILCE BOARD

A giving sample "A" weighed 0.27kilogrammes of groundnut particles was poured freely into open steel container in damped condition. A liquid molasses in hot condition was added to the groundnut particles and mixed thoroughly for about 5 minutes to form a thick slurry called "stuck". These loose but damped mattress of particle was forced to achieve reasonable workability for easy compaction. The stuck (mixture) was then forced into an oiled mould of internal size 0.15m x 0.15m x 0.025m thick. The board was shaped to required size as the stuck was compacted several times using 75kg standard rammer on top of steel pallet cover in 25 strokes, to achieved a pressure of 33333.3 N/m^2 to satisfy the British standard (BS) 2604 part 2 code of manufacturing particle board and plywood. The formed sample was then left to dry under atmospheric

condition for several days. The mould are removed, 2 hours after placing and compacting processes. The same procedure was repeated for samples "B" and "C" respectively. **(See figure 4)**.

3.3.1 CONDITIONING (CURING)

The particleboard was produced after mixing and compacting to desired pressure of 33333.3N/m^2. The steel mould was removed leaving behind the formed board to dry in open air and at room temperature for several days. The purpose of the conditioning is to equalize the moisture content through out the board and to minimize war page that maight otherwise occur, due to uneven shrinkages.

3.3.2 CHARACTERIZATION OF THE BOARD

The board produced had attained the recommended pressure of 33333.3N/m^2 and lower density range of 350kg/m^3 – 1400kg/m^3 as compare to the recent origin of the low-density particle boards. The standard used in this work is that of plywood and other wood- based panels by the FAO (1963).the standard is based mainly on experience in the flax shivers for the production of these types of board. To determine the efficiency of the boards made from the groundnut shell and molasses. It is also necessary to established the minimum standard of blending and tensile strength in particular and other properties in general was specified in BS 26604 part 2 1970.

3.3.3 OBSERVATIONS OF FORMED BOARD

In this project, 3 (three) formulations of the particle board produced denoted as A,B, & C, using different sizes of groundnut shell particles (1.18mm, 1.17mm, & 600um) respectively and producing different finish products in times of smoothness and texture. The curing arrangement are describe below.

i. particle boards "A" and "B" were left to age at room temperature (27°C) for 24 hours to set, after which it was trimmed and shaped using spatula. The board were then conditioned at the same room temperature for several days.

ii. particle board "C" was left to set for 24 hours, after which it was put directly into the oven at controlled temperature of 150°C for 16 hours. The oven was then switched off and allowed to cool for 2 hours. It was observed that board "C" had burnt traces on all the 6 faces of the particle board (cube). The result signifies a very rapid dehydration of board "C", largely due to high temperature and resultant warpage, and uneven shrinkages on surfaces of the board. Similarly, board "A" and "B" had proper drying at control room temperature. On conclusion, I suggest oven drying at control temperature of 100^0c to achieve efficient curing without crack or warpage condition.

CHAPTER FOUR

4.0 LABORATORY EXPERIMENT / TESTS, RESULTS AND DISCUSSION.

This research work is based on scientific methodology as such, several laboratory experiments and tests were conducted using the experimental variables to obtain the results which are analyzed here.

The experiments were conducted mostly on the groundnut particle's sample in order to determine the moisture content by reducing it to as lower as 5%. To analyze the particle size distribution and achieve homogenous mix, and to verify its suitability or otherwise. The experimental tests procedures, observations and results are as recorded as follows.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

DEPARTMENT OF AGRIC. ENGINEERING

MATERIALS TESTING LABORATORY

PERCENTAGE MOISTURE CONTENTS DETERMINATION

JOB:- ON PROJECT RESEARCH

TITLE :- SIEVE ANALYSIS OF GROUNDNUT SHELL PARTICLES

AIM:- To determine the particle size distribution of groundnut shell sample with intention of choosing less medium, Medium & finest particles for the production of particle Boards British standard sieve (to BS 410)

APPARATUS:-Electronic sauter balance (accurate to 0.01 degree) a Mechanical shack.

PROCEDURE:-Each of the seven sieve was weighted empty using the electronic. Sauter balance. 2000g of the Grinded groundnut shell particle is poured through the top sieve and the set was placed and secured to the mechanical shaker where it was shaken for 10 minutes. The sieve are arranged in decreasing order of sizes such as, 2.36mm, 1.18mm, 1.17mm 600 um, 300um, 150um, 75um and the bottom pan were each weighed with their contents and the results were as shows in the table below.

TABLE 4.0 SIEVE ANALYSIS DATA.

BS/SIEVE MESH SIZE		% SIEVE	% RETAIN	% PASSING	
BS/SIEVE MESH SIZE	WT. OF SIEVE (g)	WT. of SIEVE + SAMPLE (g)	WT. of retained sample (g)	% RETAINED	COMMULATIVE % RETAINED
2.36MM	395.7	510.0	114.3	11.43	11.43
1.17MM	424.5	326.0	345.2	12.30	21.42
1.18MM	371.6	990.4	618.8	61.88	73.31
600UM	320.4	463.5	143.1	14.31	87.62
300UM	292.7	425.5	133.8	13.38	101.00
150UM	274.8	410.1	135.3	13.53	114.53
75UM	263.7	369.0	105.3	10.53	125.06
Bottom pan	**448.8**	**596.3**	**147.5**	**14.75**	**1000.00**

512.95

Fine ness Moduluss = $\frac{Cumulative\ \%}{100}$

$$= \frac{512.95}{100} = 5.13\%$$

PRECAUTIONS

1. The sample was dried sufficiently in order to reduced the moisture content to about 5%.

2. Reading were made immediately and recorded.
3. During pounding, care was taken to avoid crushing the particles but rather to loosen them.
4. The sample was allowed to settle after shaking so as to avoid losses to the atmosphere.
5. I took great care to avoid computational error.

USES OF THIS TEST

The test is very important in terms of separating the grinded shells into flakes, chips and sawdust. Hence the determination of the suitability or other wise of the grinded groundnut shell. For a particular purpose. The test had help in choosing size 1.18mm 1.17mm & 600um of the grinded sample; to be used as a homogeneous particles for the production of particle board.

LIMITATION:-

The test is limited to sample retained in sieve 1.18mm 1.17mm & 600um graphical representation of the % passing on particle size was not necessary.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

DEPARTMENT OF AGRIC. ENGINEERING

MATERIALS TESTING LABORATORY

PERCENTAGE MOISTURE CONTENTS DETERMINATION

JOB:- ON PROJECT RESEARCH

TITLE:- MOISTURE CONTENT DETERMINATION

AIM:- To determine the percentage moisture content of the experimental samples of groundnut particle.

APPARATUS:-The dry sample of groundnut particle was scooped a bit and put into the container whose empty weight as (WI) had been determined. The mass in gramme of wet sample and the container was obtained and recorded as (W_2). This was put into the oven and left there to dry at temperature of about 105°C. the dry weight of the container plus sample was weighed and recorded as (W_3). Using these data, the percentage moisture content was calculated according to **BS 1377 of 1975 pages 17** for each sample thus.

$$\frac{W_2 - W_3}{W_3 - W_1} \times \frac{100}{1}$$

PRECAUTIONS:-

1. The container had to be cleaned with neat dry cloth.

2. The container and H_3 content was not allowed to come into contact with moisture before or during weighing
3. The dried sample was allowed to cool down before taking the weight.
4. Result were carefully collected and as fast as possible as shown in **Table 4.1**

TABLE 4.1 MOISTURE CONTENT

% Moisture Content	TEST 1 (can. No1)	TEST 2 (Can. No.2)
Weight of container $(W^1)g$	24.55	20.22
Weight of wet sample + container (W^2) g	40.80	43.58
Weight of Dried sample + container $(W^3)g$	40.05	42.53
Weight of moisture $(w_2 - w_3)g$	0.75	1.05
Weight of Dried sample $(w_3 - w_1)g$	15.5	22.31
Moisture Contents, $W = \frac{W_2 - W_3}{W_3 - W_1} \times 100$	4.84	4.71

USES OF THIS TEST

The amount of water presents in the dried groundnut particle should not be more than 5% moisture content. The present of moisture above this limit greatly affects the strength of the particle board to be produced.

4.1 PARTICLE BOARD DENSITY

Table (4.2) shown the result of mechanical test carried out on the particle board produced using groundnut particle of different sizes such as 1.18mm, 1.17mm and 600um. The mix composition can be seen in table (4.2) with its various densities recommended in BS 2604. part 2 (1970) for lower value of 350kg/m^3 – 1400kg kg/m^3 the result also shows different values of densities for different sizes of particle used in the sample produced.

4.2 BOARD TENSILE STRENGTH

Table 4.2 shows the tensile strength of board produced from groundnut/ molasses the results indicate a relative good / high tensile strength and varies inversely with their densities.

4.3 OPTIMUM CONCENTRATION OF THE MOLASSES.

The molasses concentration proved to give a good retention as a resin adhesive. It was also observed that a good gel formation is obtainable at

recommended PH value, when calcium hydroxide was added.

4.4 NAIL/SCREW WITHDRAWAL TEST

Dry particle board "C" of size 0.15m x 0.15m x 0.025m was placed on the bench and gripped with clamp. A roofing nail was driven into the dried particle board "C" to a depth of 15mm, using hammer. Hounsfield Tenso meter was attached to the roofing nail through the instrument's hook. Readings, calibrated in Newtons (N) (from 0 – 250N) was attached to the instrument to record the force at which the roofing nail will be removed from the dried particle board. A withdrawal force (N) was activated by the instrument when operated. The roofing nail was removed when the readings was at 185N.

The nailing test shows that the particle board satisfied the minimum holding force of not less than 178N to be recognized as standard; as specified by **(F.A.O., 1963).**

TABLE 4.2 SUMMARY OF COMPARATIVE MATERIAL COMPOSITION & TEST RESULTS

Material Composition	Types Of Resin Binder	Volume of G/Nut Shells Particle (ML)	Weight of Formed Board After Curing (Kg)	Density (Kg/m^3)	Grade of Particle Board	Pressure (N/m^2)	Comments on Bonding Properties of Molasses	Date Of Manufacture	Curing condition	General Remarks or comments
Sample "A" 100% G/nut shell of particle Size (1.18mm)	Molasses	400	0.70936	1261.1	Low density	33333.3	High	5/05/04	Room Temperature of 27^0c	Slow dehydration
Sample "B" 100% G/nut shells of particle size (1.17mm)	Molasses	400	0.71944	1281	Low density	33333.3	High	6/05/04	Room Temperature of 27^0c	Slow dehydration
Sample "C" 100% G/nut shells particle size (600um)	Molasses	400	0.70072	1245.7	Low density	33333.3	High	4/05/04	Oven dry at 150^0c	Rapid dehydration occurrence of burning and warpage

4.5 POSSIBLE FACTORS LEADING TO THE LOSS IN STRENGTH OF THE PARTICLE BOARD

Several factors may have been responsible for the loss in strength of the particle board manufactured, using molasses to particles of groundnut shell such as.

1. MOULD USED:- The mould used is made up of steel. The application of pressure on the sample in the steel mould may cause expansion on the joints and that produces different sizes of board and since the strength is a function of the application of load to the cross sectional area, the variation in shape maight have contributed significantly to adversely reduce the strength of the board manufacture.
2. DRYING EFFECTS:- I discovered that the drier the board, the higher is the strength However, the very dense molasses which appeared oily, coupled with the oiled surfaces of the board made it extremely difficult for the board to dry fast this maight have been responsible for the gummy surfaced during drying. When sample was oven dry there was a significant difference interms of cracks occurrence, war page and burning effects on sample surfaces than the sample that was air dry for several days at room temperature.

3. ACID CONTENT:- The presence of acid (bitter lemon) possibly used during the production of molasses to remove the impurities in place of calcium hydroxide (bleaching of sugar) might have reacted negatively in the mix with groundnut particle to reduce the strength of "molasses – groundnut shell" particle boards.

4. PARTICLE SIZS:- The choice of different sizes of grinded particle of groundnut such as 1-18mm, 1.17mm & 600um may greatly affects the density and strength of the board produced. Nothing that, the smaller the particle sizes, the more the effectiveness of the binder as it penetrates into the intercedes of the bulk of the particles.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

This project was conducted to improve environmental management by recycling of agricultural by – products so as to produce useful item like particle board of low density; by the used of manual steel mould to interpret the functions of the hydraulic hot press machine presently being practiced in the building industries; using molasses as binder. From the results, the following conclusions can be deduced.

Low – density particle boards was produced by manual press method using pressure of 33333.3 N/m^2 and the board so manufactured possessed properties that compared favourable with that of the literature reports.

Molasses in sugar can be used in place of synthetic resin as a binder to some agricultural by – products to formulate particle boards.

Most of the strengths properties increased linearly with board densities this information is important when considering process design for selecting the types of agricultural by – products for particle boards development.

Groundnut shell produces the best quality board irrespective of the binder used. The mixed proportion of components produced properties that proved comparable and even superior to some pure component.

It is important to conclude that from the density of the sample calculated; the board shows comparable resistance to bending after conditioning.

The board formed can be use in the following areas:-

1. *Floor underpayment:*- panels specially engineered for floor underlayment, to serve as underlay for carpets or resilient floors coverings.
2. *Acoustic paneling:*- Low density boards could be used in the construction and building of sound proof houses, auditorium e.t.c (madoux 1963).
3. *Insulator* :- Due to the nature of their structural formulation and low – density, these kind of boards could be used as lagging in heating materials and in electronic casing to regulate the heat maintained within the surroundings of the electronics (Chittenden, 1971).
4. *General furniture low:* – density boards are widely used in place of woods to reduce costs, weight of material used, described as light furniture, like T.V cabinet, wardrobe, shelves e.t.c.

5.2 RECOMMENDATION.

Based on the results of this project, the following recommendations can be made for future works. More research work is needed in the areas of formulation and processing of molasses in the binding of particle board by adding ant fungal (pesticides) and dehydrates to prevent the attack by rodents and to rapidly removed the excess molasses to ensure adequate strength, disability and rapid dryings. The design and fabrication of a local recycling particle board plant is highly recommended able, since all the raw materials required (agricultural by products) and molasses can be obtained locally and cheaply.

There is the need to increase the tonnage and plant sizes of the hydraulic press machines; currently in use in Nigeria which will invariable augment the production of particle board in large commercial quantities in Nigeria building industries.

This research would be in complete without highlighting some of the major problems encountered in the course of executing this research works, to aid further researchers who may wish to do further research work into the use of molasses as stabilizing agent in the manufacture of particle board".

THEY INCLUDES:-

1. *Obtaining the Needed Research Materials (raw materials).*

   The two principal materials ie molasses and groundnut shells where the first major obstacles in terms of traveling to Wuya Village in Bida Local Government of Niger State, where I obtained 3 boundless (set of 15 canes) of brown saccharum sugar cane. These canes had to be cut into smaller pieces and transported to Minna. The choice of Wuya village's sugar cane was that, the cane hybrids was build to resist "mosaic diseases". That attacks the leaves & stem of the cane. While the groundnut shell was available in every home including dustbins. The cost of transporting the sugar cane from Wuya to Minna was another up hill task. Coupled with the prevailing situation regarding full priced increase and situation where I was busy looking for a material many considered a waste (groundnut shell).

2. *Curing Problems*

   The particleboard produced was allow to air dry at room temperature. Curing of sample (board) take several days to dry; in some cases up to one month; due to high viscosity of the molasses solution. Improvement of molasses in terms of injecting dehydrator

agent into the solution would greatly make the molasses to be acceptable to the researcher.

3. *Physical Energy Demand.*

The demand of this project on ones physical energy was quite high. These were in the areas of making journeys, lifting of heavy weights, pounding of dried shell, sieving, drying and compaction. It is not something that a lazy person can undertake successfully.

4. *Time Constraints.*

One of the salient factors but vital and high in demand by this research work was time factor. The ability to keep to schedule is very important and this was very difficult in an academic environment where one was expected to combine both and succeed in all.

5. *Preparation of material*

In the preparation of raw material, such as sugar molasses and groundnut shell, difficulties are encountered in preparing the cane, such as cutting, shredding, washing cutting to pieces grinding sieving, Heating to about 105°C ___ 150°C and mixing together. Flies and ants are always around me flying and getting in to the sugar solution. More so, pounding of these groundnut shell was an

uphill task. I had to employ the services of my wife and her two sisters in the preparation. On the contrary, the shell and sugar are very much available but difficult to prepare.

Having over came all hindrances in the process of conducting these. Research, I therefore make the following recommendations based on my findings to ensure efficient waste management from the Agricultural by – product.

1. Environmental waste, generated from groundnut shells (pods) could provide a reliable sources of raw materials for building industries in the production of particle board, chip board, and ceiling board e.t.c
2. Molasses and groundnut shell particle boards met the specified lower densities of 1261kg/m^3, 128kg/m^3 & 146 kg/m^3.
3. In the mixing operation, I was convinced that molasses had a binding effect on groundnut shell particle but difficult to cure due to low dehydration of binding area. It will be worth while to research further so as to determine resin binding used to hold loose or compressible plant particle in cheek during manufacturing process.

4. The establishing of building industries in the country that would utilize the waste generated from Agricultural by – products to reduce cost of production presently experienced in some building industries in the country largely due to importation of some of their basic raw materials.

5. A further studies on other environmental waste in Agricultural – by product such as palm canal shell, rice Husk & maize cobs. e. t. c.

6. The Molasses should be improved upon, to effectively replace the use of synthetic resin adhesive (urea formaldehyde) presently imported into our country for the manufacturing of particle board, chip board and ceiling boards.

7. Curing of particle board by oven drying should be encourage at 100^0C.

APPENDICES

CALCULATIONS

To calculate the density of dried particle board based on the weight of the cured board per unit volume.

$$\text{Density} = \frac{mass}{volume}$$

Weight of particle board "A" = 0.70936kg

Volume of particle board "A" = 0.15x 0.15 x 0.025

$= 5.0625 \times 10^{-04}$

(1) Density of particle board (A) = $\frac{0.70936}{5.625x10^{-04}} = 1261.1kg/m^3$

(2) Density of particle board (B) = $\frac{0.71944}{5.625x10^{-04}} = 1281kg/m^3$

(3) Density of particle board (C) = $\frac{0.70072}{5.625x10^{-04}} = 1245.72kg/m^3$

COMPACTION

Using 75kg standard Rammer, falling at a distance of 0.4m on iron mould pallet to compact particle board mixture. The force of application can be computed as:- Force of application = mass (kg) x Acceleration due to gravity = 75 x 10 = 750N

PRESSURE

Pressure = $\frac{Force}{Area}$ (N/m^2)

$$= \frac{750}{0.15x0.15} = 33333.3N/m^2$$

MIX PROPOSITION (BATCHING BY VOLUME)

The mix ratio of groundnut shell particles and molasses using the proportion below to avoid unnecessary wastages.

Resin molasses in volume denoted as R = 400mL = 0.4 litres

Volume of groundnut shell particles (G) = $5.625 \times 10^{-04} m^3$

Note 1litre = 1000mL

Ratio of P/G = $\frac{0.4}{5.625x10^{-04}m^3}$

$$\frac{R}{G} = 711.1$$

To find R = 711.1G

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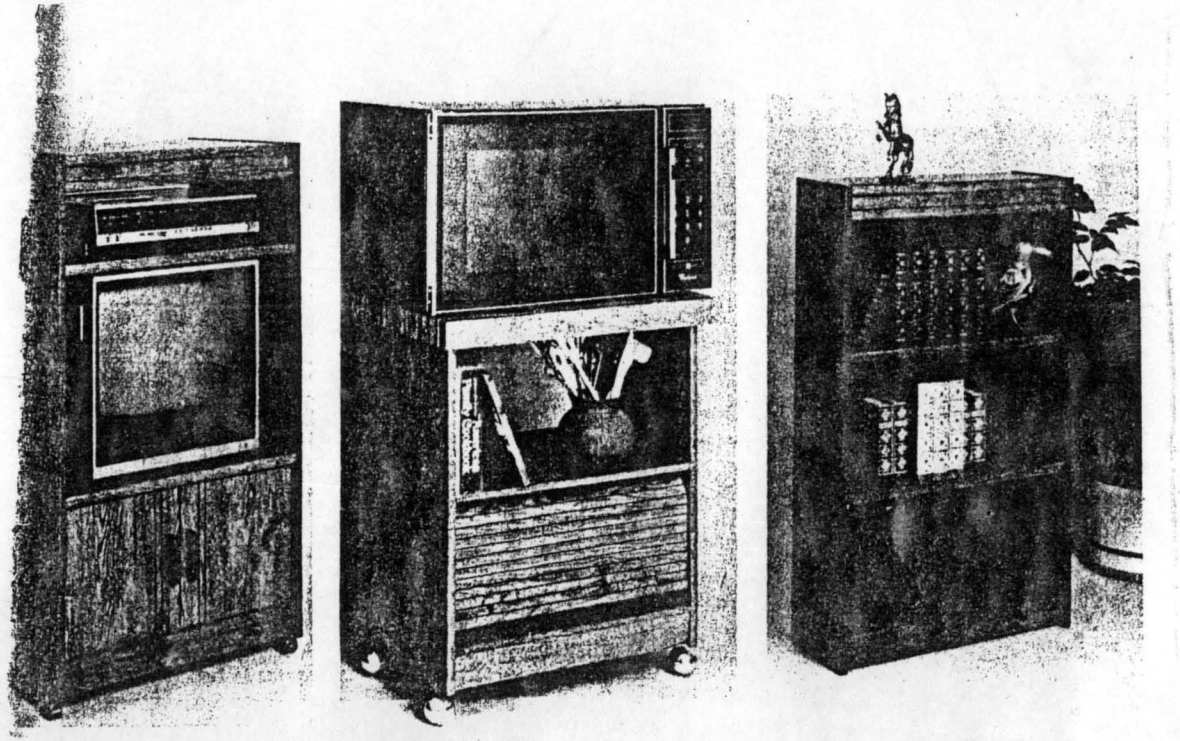
Madoux E.A (1963) properties of particle boards "Quarterly bulletin, Belgium, (FOA) PP 74 – 80.

Fig (1) SHOWS COMMON USES OF PARTICEE BOARD

SOURCES:- JOHN I.F (1982), CABINET MAKING & MILL WORK PP 138



ANDARD SHEET OF TYPICAL PARTICLE BOARD STACKED, AND
SPRAYED WITH COLOURED PRESERVATIVES

SOURCES:- JOHN I.F. (1982), CABINET MAKING & MILL WORK PP 131

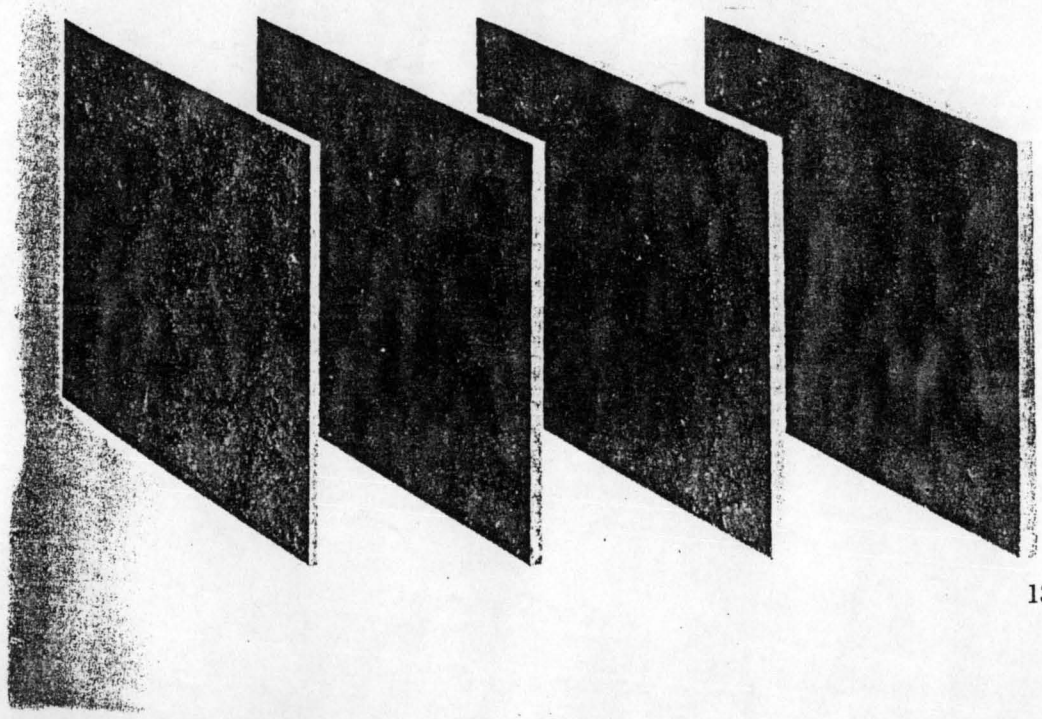


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FIG 3:- MOLASSES PRODUCTION (DIAGRAMATIC)

SOURCES:- ONYEMA S. D (1996) JOURNAL ON SAVANNA SUGAR COMPANY.