THE FEASIBILITY OF SILICA GEL DESICCANT PRODUCTION FROM CORN STALKS

A Research Paper Presented to:

MRS. JOSETTE T. BIYO
Science Research Adviser

in partial fulfillment of the requirements
in Science Research II

By:

Floro, Claribelle
Tianero, Ma. Diarey
So, Marie Angelie

ABSTRACT

This study aimed to produce silica gel desiccant from different proportions of sand and corn stalk ash. Treatment A consisted of 100% commercial silica gel; Treatment B, 25% sand and 75% ash; Treatment C, 50% sand and 50% ash; and Treatment D, 75% sand and 25% ash, with three replications for each treatment. After fusion at 1100°C, sodium silicate was obtained. Sulfuric acid was added to the sodium silicate. After heating and drying of the solution, silica gel was produced.

0.5 g of the experimental silica gel prepared at different treatment combinations were subjected to moisture adsorption capacity test.

Moisture adsorption capacity based on the final readings (80 hrs) revealed that Treatment D showed the highest percentage. With its adsorption capacity equal to 30.93%, it is comparable with Treatment A which has an adsorption capacity of 29.89%. Treatments B and C have lower percentage adsorption capacity which are to 26.44% and 26.58%, respectively.

One-way Analysis of Variance showed that the adsorption capacity of the silica gel in the different treatment groups varied significantly ($P<0.05$). Percent moisture adsorption capacity decreased in the order Treatment A=D>B=C.

Based on the results of the study, the following conclusions were drawn: (1) the use of sand and corn stalk ash as raw materials for the production of silica gel is feasible; (2) sand and corn stalk ash prepared at a 3:1 ratio showed the highest yield and percent moisture adsorption capacity; (3) the adsorption capacity of the 3:1 sand and corn stalk ash mixture is comparable with that of the commercial silica gel.

T20

APPROVAL SHEET

This research paper entitled " The Feasibility of Silica Gel Desiccant Production from Corn Stalks", submitted by Claribelle Floro, Ma. Diarey Tianero, and Marie Angelie So, in partial fulfillment of the requirements for Science Research II, has been examined and recommended for acceptance and approval.

Date	Prof. Josette T. Biyo

This paper is accepted and approved in partial fulfillment for Science Research II.

Date	Prof. Rebecca V. Yandog

ACKNOWLEDGEMENT

Many great people deserve to be acknowledged for their varied contributions in making this research study possible. Warm and special thanks are expressed to :

Mrs. Josette T. Biyo for giving us the intellective suggestions that contributed much to the refinement of the thesis;

Ms. Joy Cordero for sharing to us her expertise in chemical aspects;

Mrs. Leilani Estilo for making the chemicals, experiment, and other apparatus readily available at anytime of our need;

Mrs. Ernanda A. Suavillo and Mrs. Margarita Arnaiz for their valuable commentaries and suggestions that contributed much to the success of this research;

Mrs. Rose Espinosa and Mr.Leo Pedregosa for suggesting the statistical tools to be used in our data analysis;

The PSHS-WVC guards who patiently checked on our safety while working late at night in the research laboratory ;

Mr. R.Cario, Mr. F.Soverano, Mr. R. Cabual and Frederick Bedonia for sharing their expertise in computer aspects.

The Photon class for their various support and encouragement;

Victor Sunio Jr. for his sudden burst of humor that kept us awake while spending our weary hours in the research laboratory;

Alex Rivas, Ralph Bermejo, Jason Brasileno,Bryan Jiz ("Gwapings") for their kind assistance in burning the corn stalks and putting up our display;

To our parents, whose unending love and support gave us inspiration and encouragement to go on when were on the verge of giving up;

God Almighty, the ultimate source of our knowledge, to Him we owe our fervent thanks and praise.

GELIE, YARI, CLARI

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix

APPENDIX G : LIST OF PLATES

Plate

CHAPTER I

INTRODUCTION

A. Background of the Study

Silica gel is used primarily as an adsorbent in desiccation or drying. It is used to dry air and gases in systems that are either static or dynamic with respect to gas movement. Silica gel is generally prepared by acidification of an aqueous silicate solution. The resulting silicic acid forms either a rigid mass or a gelatinous precipitate from which soluble materials are removed by washing with water. The water is finally removed by heating, leaving a glassy, granular solid. For highest activity as desiccant, the gel is not completely dried but is left with small percentage of combined water. When used as a desiccant, silica gel is enclosed in a gelatin capsule (Dimagiba et al. 1994).

Silica gel is in demand and is imported by the country from abroad and, therefore is expensive. In 1987, the Philippines imported 30.9 MT of silica gel with CIF valued at $537,279. In 1988, the importation was 104 MT.

Corn is an annual plant with long narrow leaves. The tassel represents the small male flower and the body ear is the female flower. The kernels are the fruits and seeds. The husk is made of leafy bracts.

The corn plant has a long jointed stalk varying in height from 2 to 20 feet and from one-half inch to 2 inches in diameter. Internally the stalk is composed of fibrovascular bundles scattered in the pith, the spongy tissue that fills the interior of the stalk.

Corn in the Philippines is usually utilized as natural grain for food and feeds. In the 1970's, farmers began to grow more corn upon the encouragement of the government. In 1986, about 30%

of the total farmland was used for their basic food. Production in 1990 was 4.5M MT, compared to 2M MT in 1971.

Corn is grown in abundance in the Visayan Islands and Mindanao. In Region VI, 57,600 MT of corn was produced in 1995; 72,176 MT in 1996; 80,652 MT in 1997; and the latest partial production figure as of 1998 was 77,520 MT (Bureau of Agricultural Statistics, Iloilo City).

Corn stalks are considered wastes by corn producers. Turning these wastes into useful products such as silica gel will not only help eliminate environmental pollution problem but also lessen the country's dependence of imported silica gel.

This prompted the researchers to conduct this study specifically to investigate the moisture adsorption capacity of the experimental silica gel produced and comparing this with the commercial silica gel.

B. Statement of the Problem

Main Problem. Is corn stalk ash a potential raw material for silica gel desiccant production ?

Specific Problems.

1. Is the moisture adsorption capacity of the experimental silica gel comparable to the commercial silica gel?
2. Is the moisture adsorption capacity of the experimental silica gel affected by the different proportions of sand and corn stalk ash used?

C. Objectives of the Study

Main Objective. To produce silica gel from corn stalk ash and sand.

Specific Objectives.

1. To compare the moisture adsorption capacity of the commercial and experimental silica gel.
2. To determine the moisture adsorption capacity of the silica gel produced using different proportions of sand and corn stalk ash.

D. Hypotheses of the Study

Major Hypothesis. Corn stalks ash is a potential raw material for silica gel production.

Minor Hypotheses.

1. The experimental and commercial silica gel have comparable moisture adsorption capacities.

2. There is a significant difference in the moisture adsorption capacity of silica gel produced at different proportions of sand and corn stalk ash.

E. Significance of the Study

This study is beneficial to farmers and others because through the results of the study, awareness of the usefulness of this by-product will be enhanced and therefore eliminate the problem of improper disposal; likewise, this will give light to local manufacturers to venture into silica gel production, thereby minimizing the importation demand of this expensive product and eventually contribute to our country's economic stability.

F. Scope and Limitation

This study is limited to the use of sand and corn stalk ash at different proportions for the production of silica gel. Furthermore, it determines the moisture adsorption capacities of the experimental silica gel produced.

This research was conducted at the Science Research laboratory of Philippine Science High School-Western Visayas, Brgy.Bito-on, Jaro, Iloilo City from June 1997 to November 1998.

G. Definition of Terms

Adsorbent - are substances characterized by their ability to condense, accumulate, and retain molecular or ionic substances over their surfaces.

Ash - the residue remaining after complete combustion.

Anhydrous- free from water; especially water of crystallization.

Caustic Soda - (Sodium Hydroxide) essential to the production of soap, detergents, cleansing compounds, dyes, cosmetics, and pharmaceuticals. It is also necessary in the manufacture of rayon, cellophane, phenol, naphtol, and oxalic acid.

Corn - an annual plant with long narrow leaves. The tassel represents the small flower and the body is the female flower. The kernels are the fruits and seeds. The husk is made of leafy bracts.

Dehumidification- removal of moisture from any substance.

Fusion- the process of combining substances by melting them and using heat.

Porosity - the property of being porous, having pores.

Refrigerants - substance used for obtaining and maintaining a low temperature.

Silica - white or colorless, extremely hard, crystalline silicon dioxide, principal constituent of quartz and sand.

Silica gel - a regenerative adsorbent consisting of amorphous silica. Used for dehumidification, dehydration, air conditioning, drying of compressed air and other gases, and liquids, such as refrigerants and oils containing water in suspension.

Sodium Silicate - Water glass/ soluble glass; crystal-like lumps that range from colorless to white or grayish white and resemble glass but can be dissolved in water to form syrupy liquid; they are beat dissolved by heating with water under pressure.

Sodium Carbonate - (anhydrous) soda ash; Na_2CO_3; washing soda; salt soda; formed by heating sodium hydrogen carbonate, either dry or in solution.

Sulfuric acid - also called Hydrogen sulfate; dense, colorless, oily, corrosive liquid; prepared by the reaction of water with sulfur dioxide.

CHAPTER II

REVIEW OF RELATED LITERATURE

A. The Uses of Corn and Its By-Products

Corn is usually utilized in the Philippines as natural grain for food and feeds. The corn plant is a grass with a fibrous root system, a stout, straight, solid stem (stalk), and large, narrow leaves that are spaced alternately on opposite sides of the stem. At the top of the mature corn plant is the tassel, the male part of the plant.

Further down, the stalk grows one or more spikes which develop into ears. Each one grows out from beneath the base of a leaf, and at first it is completely wrapped in leaves. The spikes bear threadlike filaments which are the female flowers. On the spikes are located the ovules which produce the kernel or the seed.

Corn is grown in all parts of the Philippines, principally in Central Visayas, notably in Cebu, in sections of Mindanao, especially in Davao and Cotabato, and in Cagayan Valley. There are three distinct cropping seasons in the country. The first cropping season is from January to April or May, a second crop may be planted in May or June and harvested in August or September; and the last season is from September or October to December or January.

Over 20 percent of the country's population is dependent on corn as its principal staple food. Corn kernel has the following composition: moisture of 10 to 25 percent (depending upon weather and other conditions under which it was grown); 70 percent starch (carbohydrates); 10 percent gluten (protein); and the remainder is fat and oil; fiber in hull, and minerals.

Corn is also a principal ingredient in the manufacture of commercial livestock feed, and elsewhere, as a raw material in chemical industries. Alcoholic beverages such as beer and bourbon, and industrial alcohol and other chemical products use corn as raw material base. It is also used in a wide range of food products. From the whole kernels, manufacturers make corn meal, breakfast foods, and hominy.

Being the Philippines' second most important food crop - next to rice, the government has given importance to the production of corn in the country. The Department of Agriculture has been implementing a series of national corn production programs since late 1970's. The common objective of these programs was to increase significantly the total corn output by taking advantage of the superior genetic potential of new corn varities (Lales, 1993).

In the Philippines, corn husks, corn stalks, rice hulls, and coconut husks are potential sources of bioenergy or biomass. Biomass generally refers to renewable organic matter, which includes plants and animal matter (wood, microbes, plants, animals, and organic wastes) that can be converted to energy (Cruz, 1992).

The corn plant has a joined stalk varying in height from 2 to 20 feet and from 1/2 inch to 2 inches in diameter. At the base of each stalk section or internode are buds that produce lateral branches called earshoots. Internally, the stalk is composed of fibrovascular bundles scattered in the pith, the spongy tissue that fills the interior of the stalks. Chemical analysis of the stalk showed that it contained 4.1 percent silica (F & F Technology Center).

B. <u>**Production of Silica Gel**</u>

Silica gel is a high purity, chemically inert, amorphous, dehydrated aggregate of SiO polymer. It is derived from sodium silicate, a soluble glass crystal-like lumps that range from colorless to white and can be dissolved in water to form a syrupy liquid, and from Sulfuric acid, a dense, colorless, oily, corrosive liquid. Sodium silicate is used in the production of adhesives, fireboards, insulators, cleansing agents, and fire proofing material for fabrics, textiles and wood. It is made by fusing sodium carbonate and silica (sand) (Chemistry Made Easy).

Silica gel does not have an ordered crystal structure and therefore its pores are not in uniform size. It is used on a large scale as a desiccant at relative humidity approaching 100% adsorption.

The true density of silica gel is 2.2 grams per millimetre (137 pounds per cubic foot), but the porosity of silica gel gives them much lower bulk density of about 0.7 grams per mm and surface area of about 750 square meters per gram or more than 5 acres per pound.

Silica gel has valued applications in industries such as decolorization, dehumidification and dehydration, gas adsorption, and air conditioning. It is also used in the drying of compressed air and other gases and liquids such as refrigerants and oil containing water in suspension. It is included in the packaging of electronic devices to adsorb water vapor in the air.

Silica gel is manufactured by precipitation from a solution of sodium silicate. The precipitate is a jelly-like mass, which is washed to remove impurities. The result is a form of hydrated silica, reasonably represented by the formula H_2SiO_3. Hydrated material is then heated to dehydrate it. The resulting silica (SiO_2) can adsorb water equivalent to 40% of its own mass.

In April, 1989 a PCIERD-assisted project on utilization of rice husks for the production of silicate chemicals was started. This project study on the production of silica gel from sodium silicate had the ultimate objective of establishing an economically feasible technology for silica gel production. The Chemicals and Minerals Division, Industrial Technology and Development Institute (CMD, ITDI) established the production steps to encourage local manufacture of silica gel. The processing consists of the following steps : (1) Liquid silica solution was prepared by using sodium silicate with sulfuric acid; (2) the solution was then allowed to set to a rigid all-embracing, clear, and glassy hydrogel; (3) when the gel reached the appropriate mechanical strength, the massive lumps were broken mechanically to about centimeter sized pieces; and (4) the gel was then washed free from impurities, dried, sieved, and activated. The silica gel from this process was a glassy, and granular product.

In 1991, Suavillo, Paramil, and Zalameda conducted a study on the utilization of rice husk ash using the CMD process for the production of silica gel desiccant. Their study revealed that silica gel can be prepared using sodium silicate and sulfuric acid. Sodium silicate was produced from rice husk ash and caustic soda while sulfuric acid was produced from ChemPhil. The following procedures were tried.

In method 1, sulfuric acid was added to cooled sodium silicate. Based on several experiments using method 1, the suitable concentrations for gel formation were 40-45° Be H_2SO_4 or about 49-56% wt. The use of dilute acid yielded opaque jelly-like product. The use of highly concentrated acid produced fine granules of silica gel which were difficult to separate from Na_2SO_4 and precipitated SiO_2. It was observed that stirring to obtain a homogenous mixture could not be employed because SiO_2 precipitate was formed instead of silica gel. Stirring or slow addition of sulfuric acid would result to disruption of the stable Na_2O x SiO_2 solution and subsequent precipitation of SiO_2. The pH of the mixture was not maintained below 3, hence, polymer of H_4SiO_4 was not obtained. One hundred-grams samples of sodium silicate were used in the laboratory preparation of silica gel where 13-18 grams of product were obtained.

In method 2, CO_2 gas was bubbled into sodium silicate prior to acid addition. The silica gel was also separated from large particles of SiO_2 aggregates manually.

In method 3, sodium silicate solution was added to cooled sulfuric acid. The pH of the mixture was maintained below 6. This method was further investigated because it posed lesser problems for scale-up experiments.

Silica gel was best produced at pH 1-3. The results showed that CMD's silica gel, was found comparable to silica gel. According to the researchers, the following activities should be conducted for business opportunities: (1) design and fabrication of suitable equipment for silica gel production , (2) evaluation of process efficiency using the fabricated equipment, and (3) determination of manufacturing cost.

Later in 1993, Gonzales and his group conducted a study on the production of silica gel desiccant from volcanic ash by fusing the ash with sodium carbonate and directly exposing the resulting sodium silicate to hydrochloric acid to produce silica gel.

The latest experimental production of silica gel was in 1994 when a group of students from Philippine Science High School Diliman conducted a research and produced silica gel from geothermal scalings. The research aimed to produce low-cost and efficient desiccant from geothermal scaling. In the preparation of silica gel, the pulverized geothermal scalings were fused with sodium carbonate at 1000° C to obtain sodium silicate. The sodium silicate was added with hydrochloric acid, heated, and dried to produce the silica gel desiccant. The total cost of the experimental desiccant was computed and was found lower than the price of commercial silica gel.

CHAPTER III

METHODOLOGY

A. MATERIALS

Discarded, dried corn stalks
crucible tong
sand
Sulfuric acid
furnace
crucible
beakers
oven
stirring rod
triple beam balance
sieve
air-tight containers
petri dishes
hotplate
graduated cylinder
analytical balance
large can container
reagent bottles

B. PROCEDURE

B.1 Burning of corn stalks

Five kilograms of corn stalks were collected. The stalks were cut and placed in the oven at 90°C for 10 minutes to remove the moisture. The dried stalks were then placed in a large can container and burned.

B.2 Ashing

Thirty grams of the black ash obtained from the burning process was placed in three crucibles. The three crucibles each containing 10 g of black ash was then placed inside the furnace at 600°C for four hours.

B.3 Preparation of sand

350 grams of sand was collected. The sand was sieved to separate fine sand from the coarse one. The coarse sand was discarded.

B.4 Fusion

Three different proportions of sand and corn stalk ash were prepared and replicated. The proportions were 25% sand:75%ash, 50% sand:50%ash, and 75% sand:25% ash. Five grams of

Table 6. Duncan's Multiple Range Test (DMRT) for comparing Moisture Adsorption Capacity of Silica Gel in Different Treatment Levels.

Treatment	Percentage Moisture Adsorption Capacity	[a]Rank [b]
D	30.93	1
A	20.89	2
C	26.58	3
B	26.44	4

[a] :average of the three duplicates

[b] : any two mean connected by the same vertical line are not significantly different at the 1% level of significance.

The data in Table 4 shown that the silica gel in treatment D had the highest percentage moisture adsorption capacity, while that of treatment B had the lowest among the four treatments.

Statistical Analysis (Duncan's Multiple Range Test) of the percentage moisture adsorption capacity of the silica gel at different treatment combinations showed that treatment A (control) and treatment D did not differ significantly with each

each were placed in a crucible and fused at 1100°C for 6 hours. The mixture was then allowed to cool at 20°C.

B.4 Acidification

20 mL of 49-56w/w Sulfuric acid was slowly added to each mixture of ash and sand. The mixtures were then left to stand overnight.

B.5 Decantation

The solid particles were allowed to settle. The liquid was poured out gently from the container without disturbing any sediment.

B.6 Washing with water

The precipitate was washed with distilled water until the washed liquid was colorless and produced no more odor.

The purpose of washing was to remove soluble materials from the precipitate.

B.7 Drying

The liquid in each suspension was removed by decantation. The solid obtained from each were dried with a commercial silica gel at 200°C for 6 hours.

C. EVALUATION OF THE PRODUCT

C.1 Moisture Adsorption Capacity

After drying, each sample which contains different proportions of corn stalks ash and sand was placed in pre-weighed foil boats for moisture adsorption capacity test. The foil boats each containing 0.5 grams of silica gel, alongside a small container with distilled water were placed inside separate airtight containers. Each foil boat were weighed every 20 hours until there were no more changes in weights from the previous readings. These last readings were recorded as the final weights and the moisture adsorption capacity calculated from the equation,

$$\%\ \text{Moisture Adsorption Capacity} = \frac{\text{Final weight} - \text{Initial weight} \times 100}{\text{Initial weight}}$$

C.2 Statistical Analysis

The results obtained from Moisture Adsorption Capacity Test of silica gel at different treatment combinations were subjected to One-Way Analysis of Variance (ANOVA).

Comparison of Moisture Adsorption Capacities between treatment means was done using the Duncan's Multiple Range Test (DMRT).

were placed inside separate airtight containers. Each foil boat were weighed every 20 hours until there were no more changes in weights from the previous readings. These last readings were recorded as the final weights and the moisture adsorption capacity calculated from the equation,

$$\%\ \text{Moisture Adsorption Capacity} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \times 100$$

C.2 Statistical Analysis

The results obtained from Moisture Adsorption Capacity Test of silica gel at different treatment combinations were subjected to One-Way Analysis of Variance (ANOVA).

Comparison of Moisture Adsorption Capacities between treatment means was done using the Duncan's Multiple Range Test (DMRT).

CHAPTER IV

RESULTS AND DISCUSSION

A. RAW MATERIALS FOR SILICA GEL PRODUCTION

This study aimed to produce silica gel desiccant from different proportions of sand and corn stalk ash. Sand is the source of silica while cornstalk ash is the source of both silica and sodium carbonate (Britannica, 1993). Silica and sodium carbonate were fused at very high temperature of 1,100°C using a furnace to produce sodium silicate which is the main component of silica gel. Sodium silicate was acidified by adding sulfuric acid. It was then washed with distilled water and dehydrated by oven drying at 200°C to form silica gel.

This study showed that burning of one kilogram of dried corn stalks produced an average of 103.2 grams of ash (Table 1).

Table 1. **Amount of ash produced(gms) from burning of one kg of dried corn stalks.**

REPLICATE	ASH PRODUCED(gms)
1	101.50
2	104.50
3	103.60
MEAN	103.20

B. QUALITATIVE OBSERVATIONS OF SODIUM SILICATE

Three different proportions of sand and cornstalk ash were prepared and replicated. The ratios were 25% sand:75% ash; 50% sand:50% ash; and 75% sand:25% ash.

After fusing the mixture of sand and ash at a temperature of 1,100°C, a grayish white, hard, glassy solid substance was formed following the shape of the crucible. It was observed that treatment D (75% sand:25% ash) showed closer arrangement of the identified glassy substance while same substances were arranged further apart in treatment B and C. These substances were identified as water glass or sodium silicate.

C. MOISTURE ADSORPTION CAPACITY

The experimental silica gel produced was subjected to moisture adsorption capacity test. Initial and final weights were recorded every 20 hour interval for a duration of 80 hours, thereafter, adsorption end-point was noticed since there were no more increases in the weights of the different treatments. These data are shown in Table 2.

Table 2. Average weights (gms) of silica gel in each treatment combination of sand and ash at different time intervals. Values are means of three replicates.

Time Intervals (hours)	Mean weights (gms)			
	A Control (commercial gel)	B 25% sand: 75% ash	C 50% sand: 50% ash	D 75% sand: 25% ash
20	0.6378	0.6274	0.6277	0.6466
40	0.6417	0.6287	0.6295	0.6493
60	0.6456	0.6302	0.6311	0.6520
80	0.6494	0.6322	0.6329	0.6547

The percentage moisture adsorption capacity was determined by taking the ratio between the difference of final and initial weight and multiplying it by 100. The average percentage moisture adsorption capacity of each of the different treatment combinations of sand and cornstalk ash is shown in Table 4.

Table 4: Average moisture adsorption capacity of silica gel of each treatment combination at different time intervals.

Time (hrs)	% Moisture Adsorption Capacity			
	A Control Commercial silica gel	B 25% sand: 75% ash	C 50% sand: 50% ash	D 75% sand: 25% ash
20	27.55	25.48	25.55	29.32
40	28.34	25.72	25.89	29.85
60	29.11	26.03	26.23	30.40
80	29.89	26.44	26.58	30.93

The results of the computations for the percentage moisture adsorption capacity based on the final readings (80 hours) revealed that Treatment D (75% sand:25% ash) had an average moisture adsorption capacity of 30.93%; Treatment A (commercial silica gel), 29.89%, treatment B (25% sand:75% ash) and C (50% sand;50% ash), 26.44 and 26.58 respectively. This goes to show that treatment B and C have almost similar moisture adsorption capacity and the lowest compared to the other two treatment combinations. Treatment A is slightly lower, while Treatment D had the highest adsorption capacity.

Table 5. Analysis of Variance (ANOVA) of the Moisture Adsorption Capacity of Silica Gel in Different Treatment Levels.

Source of Variation	Sum of squares	Df	Mean Square	Calculated F	Tabular F	
					.05	0.1
Column means	51.03	3	17.01	36.98 **	3.49	5.95
Error	5.55	12	.46			
Total	56.58	15				

** highly significant at 1% level of significant other. This means that treatment A and D had the same percentage adsorption capacity. The results further showed that the experimental silica gel had comparable percentage moisture adsorption capacity with the commercial silica gel.

D. SODIUM SILICATE YIELD

The sodium silicate produced from the different proportions of sand and corn stalk ash were measured using a topload balance. Yield in each treatment combination is shown in Table 7.

Table 7. Yield obtained (in grams) in each treatment combination based on 5 grams of different proportions of ash and sand mixture.

Treatment	Replicate 1	2	3	Total	Mean
B	4.92	4.89	4.97	14.78	4.93
C	4.94	4.93	4.96	14.83	4.94
D	5.00	4.96	4.98	14.94	4.98

Treatment D (75% sand: 25% ash) gave the highest yield of 4.98 grams per 10 grams sand and ash mixture while treatment B (25% sand:75% ash) had the lowest yield of 4.93 grams per 5 grams of sand and ash mixture.

Results of this study showed that higher percentage of sand promotes a higher yield.

Table 8. Projected sodium silicate yield in each treatment per Kilogram of Ash Sand Mixture.

Treatment	Projected Yield in grams
B(25%sand:75%ash)	989
C(50%sand:50%ash)	988
D(75%sand:25%ash)	996

From this study, it can be projected that one kilogram of corn stalk ash and sand mixtures at different proportions, can produce sodium silicate ranging from 988-996 gms (Table 8).

E. SILICA GEL YIELD

Silica gel produced from the different treatment proportions were weighed using a top load balance. Yield in each treatment proportion is shown in Table 9.

Table 9. Silica gel yield in each treatment per 5 grams of sand and corn stalk ash mixture.

Treatment	1	2	3	Total	Mean
B(25 :75)	4.63	4.56	4.64	13.82	4.60
C(50: 50)	4.62	4.61	4.63	13.86	4.62
D(75 :25)	4.75	4.64	4.65	14.04	4.68

Treatment D (75% sand : 25% ash) showed the highest average yield of 4.68 grams per 5 grams of sand and corn stalk ash mixture while treatment B(25% sand : 75% ash) had the lowest yield of 4.60 grams per 5 grams of sand and ash mixture.

This study showed that per 5 grams of sand and ash mixture, silica gel ranging from 4.60 grams - 4.68 grams can be produced.

Collection of corn stalks

↓

Burning of corn stalks

↓

Ashing

↓

Collection of Sand

↓

Fusion at 1100° C

↓

Addition of 49-56% w/w H_2SO_4

↓

Decantation

↓

Washing with distilled water

↓

Decantation

↓

Drying at 200° C

↓

Evaluation of Product
(Moisture Adsorption Capacity Test)

↓

Statistical Analysis

Figure 2. FLOWCHART OF METHODOLOGY

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF SIGNIFICANT FINDINGS

The main purpose of this study was to produce silica gel from corn stalk ash and sand at different treatment combinations. It also aimed to determine the moisture adsorption capacity of the experimental silica gel produced and to compare their moisture adsorption capacity with that of the commercial silica gel.

Specifically , this study sought to answer the following questions :

1. Is silica gel produced from corn stalks ash and sand capable of desiccation?
2. Is the moisture adsorption capacity of the experimental silica gel comparable to the commercial silica gel?
3. Is the moisture adsorption capacity of the experimental silica gel affected by

the different proportions of sand and corn stalk ash used?

The significant findings of this study are summarized as follows:

i. After fusion of different proportions of corn stalk ash and sand mixtures at 1100°C for 6 hours, Sodium Silicate with impurities was produced.

ii. The product produced was then processed into silica gel and was proven to be capable of desiccation.

iii. Further analysis of the results revealed that treatment A (commercial silica gel) and treatment D(75%sand, 25%ash) did not differ significantly with each other. The results further show that the experimental silica gel had comparable percentage moisture adsorption capacity with the commercial silica gel.

iv. Results of the moisture adsorption capacity test revealed that treatment D has an average moisture adsorption capacity of 30.93%; treatment A, 29.89%; treatment B and C, 26.44 and 26.58, respectively.

B. CONCLUSIONS

Based on the results of this study, the following conclusions were drawn:

i. Silica gel produced from corn stalk ash and sand is capable of desiccation.

ii. Different treatment proportions showed different moisture adsorption capacities.

iii. The experimental silica gel, specifically, treatment D(75% sand, 25% ash) showed better adsorption capacity among the other treatments and is comparable with the commercial silica gel in terms of adsorption performance.

C. RECOMMENDATIONS

Based on the findings and conclusions of this study, the researchers strongly recommend the following:

i. The use of 75% sand and 25% corn stalks ash mixture for the production of silica gel.

ii. The fabrication of suitable equipment for silica gel production for business purposes.

iii. Further study on the use of other raw materials for the production of silica gel.

iv. Innovate a simplified, less laborious method/procedures for silica gel production.

LITERATURE CITED

Cruz, I.E. 1992. Agricultural and Forestry waste Utilization for energy, Philippine technology Journal. 17(3) : 3-4.

Dimagiba, R.M., Ferolino, L.E., Ocampo, P.M. 1994 Production of silica gel desiccant from geothermal scalings, BatoBalani. 14(4) : 16-19.

Encyclopedia Britannica. Sodium Carbonate, Encylopedia Britannica, Inc. , U.S.A. vol 5 :297, 21:301,1 : 273.

Lales, J.S. 1996. Improved Cultural Practices for Corn Production, Philippine Technology Journal. 21(1) : 43-44.

Suavillo, E.A., Paramil , Zalameda, U.O. 1991. Production of Silica Gel Desiccant from CMD Processed Rice Husk Ash. Philippine Journal of Science. 120 (3) : 279-335.

Young People Science Encyclopedia. Corn, Young People Science Encylopedia, U.S.A. vol 5,pp 449.

-APPENDICES-

APPENDIX A

Result of Chemical Analysis of Crop Residues (dry matter basis)

Result of chemical analysis of crop residues (dry matter basis)

Type of Residue	N	P	K	Ca	Mg	SiO_2	Fe	Mn	Zn
	---	---	---	%	---	---	---	ppm	---
Rice Straw	0.66	0.07	0.93	0.29	0.64	4.9	427	365	67
Rice Hull	0.49	0.05	0.49	0.06	0.04	12.7	173	109	36
Corn Stalks	.081	0.15	1.42	0.24	0.30	4.1	186	38	30
Sorghum Stalks	0.74	0.10	1.41	0.35	0.28	3.9	260	28	34
Soybean sterns	1.42	0.12	1.04	1.30	0.62	2.9	562	35	27
Peanut Hull	0.70	0.12	0.46	0.48	0.15	1.8	388	45	18
Bark	1.33	0.07	0.60	1.44	0.20	1.2	999	259	41

Source : Food and Fertilizer Technology center
Extension Bulletin no. 315

APPENDIX B

WEIGHTS OF SILICA GEL FROM DIFFERENT TREATMENT COMBINATIONS WHEN SUBJECTED FOR MOISTURE ADSORPTION CAPACITY TEST(MACT)

Table A: Weights of Silica Gel from Different Treatment Combinations when subjected for MACT.

Time	A(control)			B(25%sand,75% ash)			C(50%sand,50%ash)			D(75%sand,25%ash)		
(hrs)	REPLICATE			REPLICATE			REPLICATE			REPLICATE		
	1	2	3	1	2	3	1	2	3	1	2	3
20	.6402	.6396	.6335	.6282	.6249	.6291	.6281	.6302	.6249	.6432	.6515	.6451
40	.6435	.6431	.6385	.6295	.6258	.6309	.6293	.6326	.6265	.6454	.6543	.6481
60	.6467	.6466	.6434	.6309	.6267	.6329	.6304	.6350	.6280	.6477	.6571	.6512
80	.6499	.6501	.6483	.6342	.6276	.6348	.6316	.6375	.6296	.6499	.6598	.6543

APPENDIX C

Percent Moisture Adsorption Capacity of Silica Gel from Different Treatment Combinations.

Table B. Percent Moisture Adsorption Capacity of Silica Gel from different treatment combinations.

Time(hrs)	A(control)			B: 25% sand 75% ash			C:50% sand 50% ash			D: 75%sand 25% ash		
	REPLICATE			REPLICATE			REPLICATE			REPLICATE		
	1	2	3	1	2	3	1	2	3	1	2	3
20	28.04	27.92	26.70	25.64	24.98	25.82	25.62	26.04	24.98	28.64	30.30	29.02
40	28.70	28.62	27.70	25.90	25.16	26.18	25.86	26.52	25.30	29.08	30.86	29.62
60	29.34	29.32	28.68	26.18	25.34	26.58	26.08	27.00	25.60	29.54	31.42	30.24
80	29.98	30.02	29.66	26.84	25.52	26.96	26.32	27.50	25.92	29.98	31.96	30.86

APPENDIX D

Computations for Analysis of Variance (ANOVA) for the Moisture Adsorption Capacity at Different Treatment Combinations

The total variation or the total sum of squares (TSS) is computed by getting the sum of each entry minus the correction term , $\frac{(\Sigma x^2)}{N}$.

Where x refers to the value of each entry and N to the total number of items or entreies.

The total sum of squares for Table is computed as follows :

$$TSS = \Sigma x^2 - \frac{\Sigma x^2}{N}$$

$$= 12340.98 - \underline{(443.24)^2}$$

$$= 12340.98 - 12284.40$$

$$= 56.58$$

The between- column variance or between-column sum of squares (SS_b) is of the sum of the squares of of column sums, minus the correction term, where r refers to the number of rows.

$$SS_b = \frac{1}{\text{no. of forms}} (\text{ sum of each column})^2 - \frac{(\Sigma x)^2}{N}$$

$$SS_b = \frac{1}{r} \Sigma (xij)^2 - \frac{(\Sigma x)^2}{N}$$

$= \frac{1}{4}(13199.71 + 10753.69 + 10868.06 + 14520.25) - 12335.43 - 12284.40$

$= 51.03$

The within- column variance or within-column sum of squares is the difference between the total sum of squares and the between column sum of squares.

SSw = TSS – SSb

= 56.58 – 51.03

SSw = 5.55

APPENDIX E

Compilations for Duncan's Multiple Range Test (DMRT) for Comparing Moisture Adsorption Capacity of Silica Gel at Different Treatment Combination

Refer to Table 4

The least significant range for the p means, and is denoted by Rp, where

$$R_p = r_p \cdot S_{\bar{x}} = r_p \sqrt{\frac{s^2}{n}}$$

A	B	C	D
29.89	26.44	26.58	30.93

Increasing order of magnitude of sample means

B	C	A	D
26.44	26.58	29.89	30.93

From the mean square (s^2) of the Analysis of Variance in Table 3 at 5% level of significance with 12 degrees of freedom, the error mean is .46.

From Table of Significant Studentized Ranges for 5% and 1% Level New Multiple Range Test obtain the value of r_p with 12 degrees of freedom, for p = 2,3,4,5

Compute for Rp_1 by using:

$$R_{p_1} = r_{p_1} \sqrt{\frac{s^2}{n}}$$

Where: Rp = least significant range

s^2 = mean square

n = no. of samples

r_p = least significant studentized range

$$R_{p_1} = r_{p_1}\sqrt{\frac{(.46)}{4}}$$
$$= r_{p_1}\,(.34)$$
$$= (r_{p_1})(3.06)(.34)$$
$$= 1.04$$

Results of Computations:

p	2	3	4	5
r_p	3.06	3.21	3.30	3.35
Rp	1.04	1.09	1.12	1.14

Comparison of the least significant ranges with the differences in ordered means:

1. Since D - A = 1.04 = R_2 = 1.04, we conclude that D and A are equal.
2. Since D - C = 4.35 > R_3 = 1.09, we conclude that D is significantly larger than C.
3. Since A - C = 3.31 > R_2 = 1.04, we conclude that A is significantly larger than C.
4. Since A - B = 3.45 > R_3 = 1.09, we conclude that A is significantly larger than B.
5. Since C - B = .14 < R_2 = 1.04, we conclude that C and B are not significantly different.

REGIONAL CALIBRATION AND TESTING CENTER
Magsaysay Village
La Paz, Iloilo City
Tel. No. (033) 320-0093
Fuentes-Delgado Sts.
Iloilo City
Tel. No. (033) 338-0776

TEST REPORT

Request Reference No.	:	01-99-025 TC
Date Requested	:	January 12, 1999
Date Reported	:	January 19, 1999
Sample Submitted as	:	Corn Stalk Ash
Sample Submitted by	:	Claribelle V. Floro Philippine Science High School Brgy. Bito-on, Jaro, Iloilo City

REPORT:

	$\%_{w/w}$
Silica, SiO_2	**45.1**

Test Method: Gravimetry

REMARKS:

This report is based on sample received by this Office and is of no value for advertising purposes or sales promotions nor as basis for Tariff or Customs Classification of imported commodities.

This report may not be reproduced, except in full, without written approval from the Department of Science and Technology Region VI.

MARGARITA T. ARNAIZ
Analyst

Attested:

ZINNIA P. TERUEL
Regional Director

- PLATES -

Plate 1. Collection of corn stalk

Plate 2. Burning of Corn Stalk

Plate 7. Acidification

Plate 8. Decantation

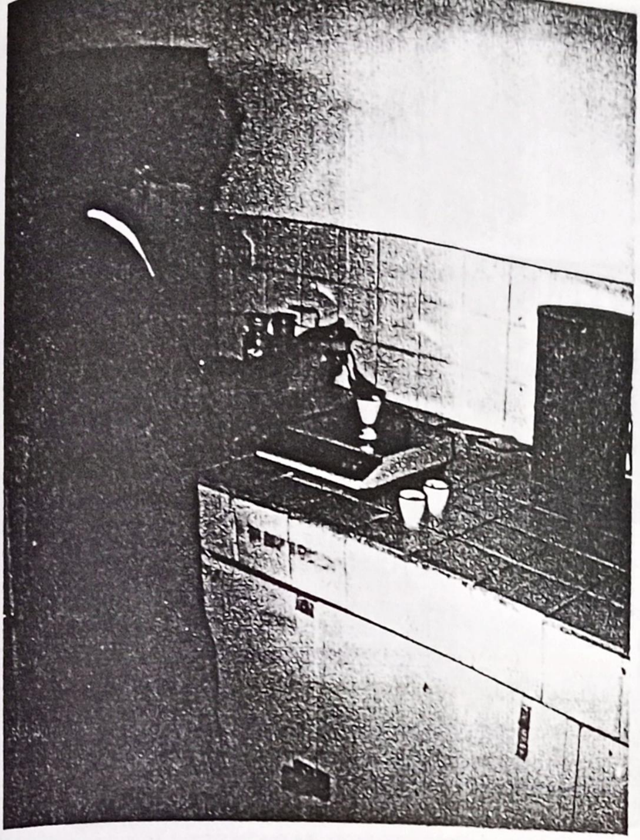

Plate 3. Ashing

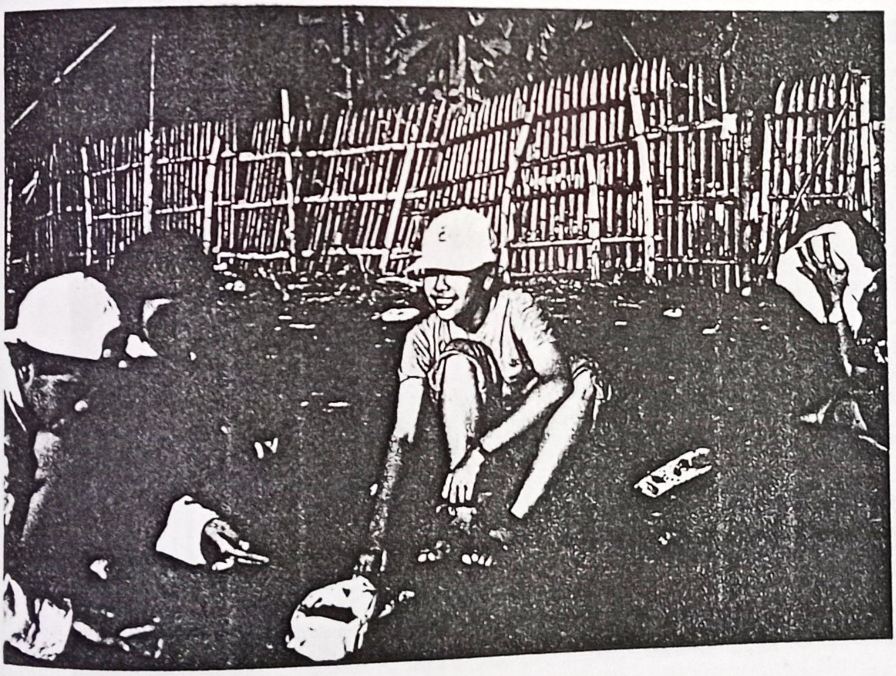

Plate 4. Collection of Sand

T20

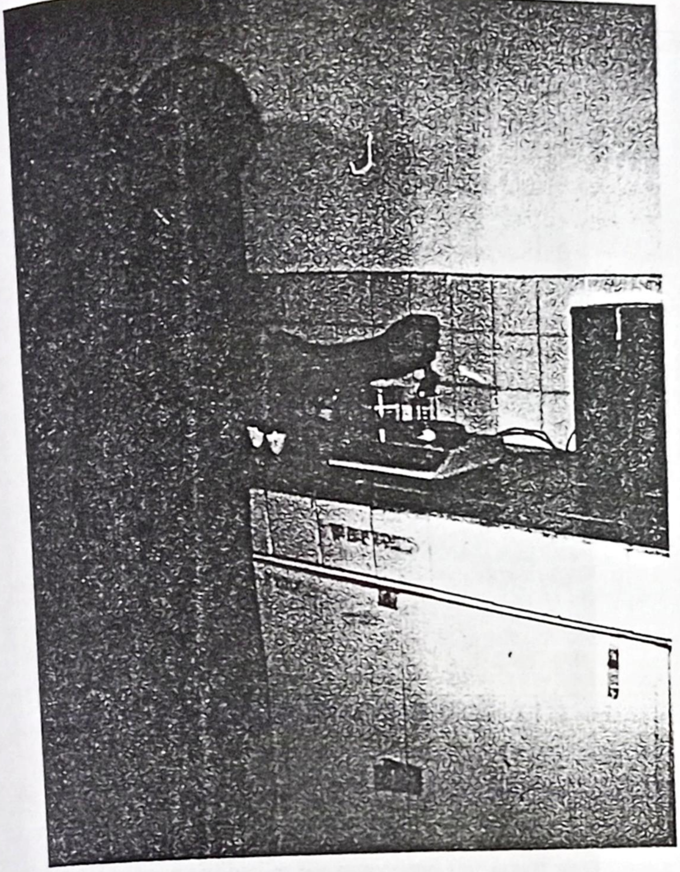

Plate 5. Preparation of Sodium Silicate

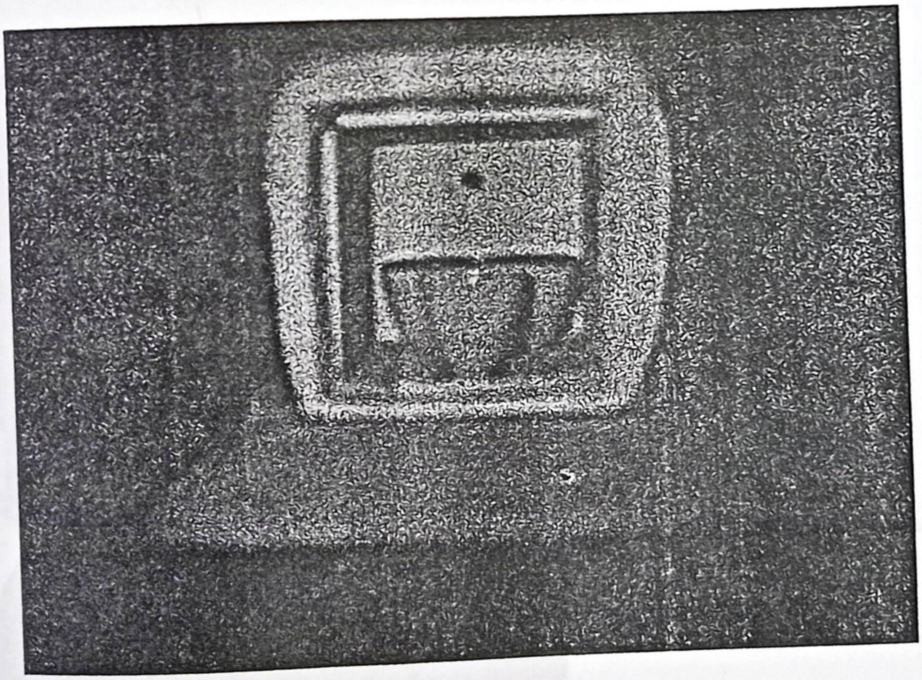

Plate 6. Fusion

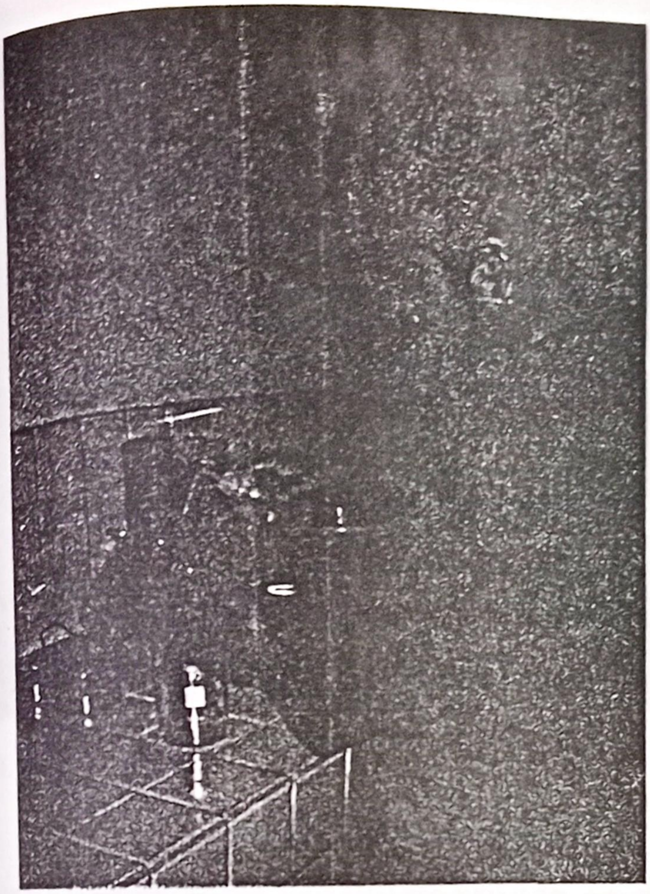

Plate 9. Washing with water

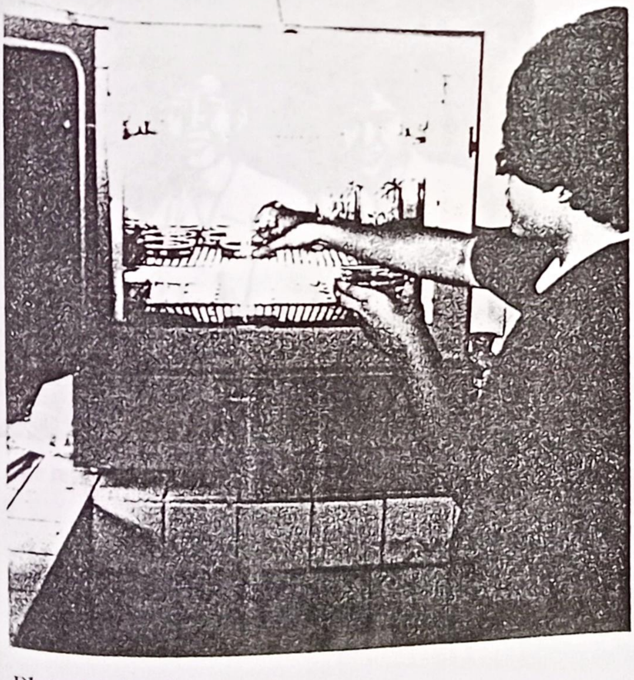

Plate 10. Drying

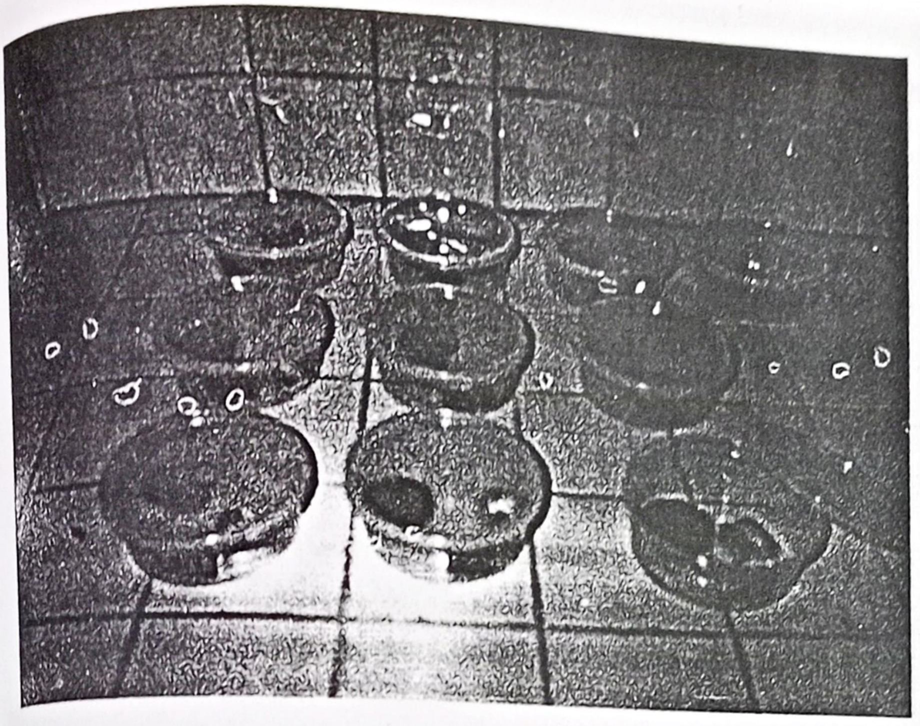

Plate 11. Testing for Moisture Adsorption Capacity

Plate 12. The researchers