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Cover. Silkworm and mulberry leaves the basic elements in sericulture, for the production of silk.

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SERICULTURE

Philippine Technology Journal
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New Breeds of Filipino Silkworm Varieties Commercialized [1]

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and Eduardo P. Villanueva[8]

Abstract

A series of periodic silkworm rearings from 1979-1984 were conducted to evaluate the performance of silkworm races for selection of breeds for the production of local hybrids that can yield good quality cocoons and silk. The parameters used were larval duration, larval and pupal weight, hatching ratio, fecundity, moth emergence ratio, mortality percentage and cocoon filature properties. Purification and characterization of the parent lines were done followed by combining ability test and hybridization for F1 hybrid evolution. Field testing of the F1 hybrids conducted in Benguet and Misamis Oriental led to the identification of promising hybrids suited to specific locations capable of producing quality cocoons.

Introduction

Prior to the 1980's, the Philippines was dependent on imported silkworm eggs for its infant sericulture research and development project. Several problems were encountered in the importation of such not only from the economic view but also in the technical aspect such as untimely hatching of silkworm eggs, being unsynchronized with mulberry leaf production plus the risk involved in importing disease-infected silkworm eggs. The struggling crash cocoon production project on the research level did not wane, however. Due to the encouragement given by international sericulture experts that the Philippine climatic conditions favor the success of a silk industry in a commercial scale, silkworm breeding was taken and made part of the research that started in 1979, with the idea of attaining self-reliance and sufficiency of silkworm eggs. With only an initial collection of four silkworm varieties from Japan in 1978, research for the development of Filipino purelines was done. Silkworm varieties from different countries have been added until 1988. These serve as the materials for continuous silkworm breeding that led to the evolution of the first Filipino silkworm breed. The success in breeding was manifested in 1984 when locally-produced F1 silkworm hybrids were utilized by sericulture farmers in the farm level for cocoon production. From then on, the farmers have been supplied by these local hybrids for the expanding cocoon production of the country.

The present scenario of the silk industry in the Philippines as of to date reveals the increasing areas of mulberry plantation and the number of active farmers' associations (23 associations) thus substantially increasing cocoon production. One

[1] Won First Prize, Likha Award for Outstanding Creative Research, 1992 DOST Technology Fair, June 26, 1992;

[2] Author, Senior Science Research Specialist; [3] Co-author, Senior Science Research Specialist, [4] Co-author, Science Research Specialist II; [5] Co-author, Science Research Specialist I; [6] Co-author, Supervising Science Research Specialist; [7] Co-author, Chief, Research and Development Division; and [8] Co-author, Director, Philippine Textile Research Institute, Department of Science and Technology

major factor attributed to this is the intensified transfer of technology on silkworm rearing to the farm level. Silkworm breeding and egg production is an indispensable aspect to the silk industry and without its success, production cannot be attained due to the prohibitive cost of imported silkworm eggs.

This underscores the significance of the breeding work to the over-all development of sericulture/silk industry in the Philippines. However, due to the absence of a sericulture law in the country, the local hybrids that are being used now for commercial cocoon production have not been legally named or patented. With the increasing production of cocoons for raw silk, coupled with the strong support given by the government, some NGO's and private entities, there is a need to formally register and name these silkworm breeds, so much so that these are the first Filipino silkworm breeds in existence throughout the country.

Description of Technology

Success in research and development of Philippine silkworm pure breeds through long and continuous breeding work of the PTRI-SRTD, La Trinidad, Benguet has been manifested by the evolution of purelines now being multiplied and utilized for commercial silkworm hybrid egg production. Four (4) promising hybrids have been commercialized and supplied to various farmer- individual/groups all over the country. These hybrids of bivoltine character produce cocoons that are sought internationally by the silk markets, as well as domestic markets.

From a very little knowledge on sericulture technology, the present manpower of the institute have mastered the skill required in the mass production of silkworm eggs. The technology has also been transferred to and applied by some skilled farmers who rear purelines.

Human resources as well as indigenous materials needed in the silk industry abound in rural areas, not to mention the country's favorable climatic conditions, and for these factors, the growth of sericulture is seen in the rural areas.

The untilled mountain slopes and marginal lands have been utilized for the establishment of mulberry fields that serve to supply the food requirement of the silkworms. The rearing houses and facilities needed in culturing the silkworm larvae have been built and made of locally-available resources such as cogon grasses, wood and iron scraps, bamboo, plastic nets, bamboo slats and baskets. The cost of production have been lowered due to these local materials. With all of the above resources and because of the increasing demand of silk and silk products, locally and abroad, the need for local production of silkworm eggs is a vital key to supply the demand. The PTRI has set up its first Philippine Silkworm Egg Multiplication Center in La Trinidad, Benguet catering to the silkworm egg demands of the farmers and some private corporations now producing cocoons used by local weavers and also exported to Japan. The Silkworm Egg Multiplication Center now utilizes four (4) major silkworm purelines for its commercial egg production. But the breeding process does not stop here. Other hybrids have to be evolved to be added with the main objective of producing more productive, high quality cocoons. A two-year study was made on these yielding three (3) new lines giving promising qualities. Twelve lines including the four major purelines were studied. Twenty one (21) characters were used as parameters in evaluating each line. Three rearings were done in the established rearing periods. At the end of the study a characterization was made identifying these twelve Philippine purelines. The promising lines now serve as parents to new local hybrids for commercial production.

The breeding technology, consists of three (3) interdependent processes, each of which is contributory to the ultimate objective of breeding which is to produce breeds of desirable qualities to improve the quality of cocoon/silk and to improve production. Each process consists of step by step activities that have been modified to suit local conditions and resources available.

Process 1. ***Silkwormbreeding: Evolution and Development of Filipino Purelines***

Breeding is very broad that it involves the whole life cycle of the silkworm, from egg to larvae to pupa and to adult moth, and covering one generation to generation.

The first step taken was the collection of breeding materials, e.g. silkworm varieties. Japanese and Chinese races were collected from Japan, India, and China and kept in germplasm bank.

The second step, the acclimatization of varieties through periodic rearings of silkworms was done generation after generation. The successive rearings from 1980-1984 acclimatized these temperate varieties.

The third step was testing and evaluation. Each variety was tested and evaluated as to their behavior from egg to adult concentrating on economic characters of cocoon quality. These characters are larval duration, mortality, physical appearances of egg, larva, pupa and moth, whole cocoon weight, cocoon shell percentage, number of cocoons/kg., number of cocoons/liter, pupal weight, percentage of moth emergence, life span and shape of cocoons. These are several hereditary traits of the silkworm but only the practical ones were used in relation to silk production.

The fourth step was purification of the lines. After successive rearings and breedings, most of the races showed segregation upon reaching seventh (7th) to tenth (10th) generation. When segregation was observed, line separation was adopted to purify these and this resulted to the development of Filipino purelines. These lines which are pure are now the great-grandparents (breeders stock) or the so-called P3. These are kept and maintained in the germ-plasm bank and are the sources of P2.

The fifth step was pureline maintenance. The maintenance of all these purelines consist of periodic silkworm rearing and crossing within the same race to remain as pure, for example, Lat 1 female is crossed with Lat 1 male.

Table 1 shows the result of the recent periodic rearing of new Filipino pure breeds from 1989-1990. Following the table are the characteristics of these new breeds.

Table 1. Summary of results of study leading to the development of Filipino Bivoltine Silkworm Breeds 1989-1990

	Characteristics	Filipino Bivoltine					Silkworm Breeds					
		Lat 1	Lat 21	Lat 31	Lat 51	IB2P	ST1	B200	B221	B251	IB3	B271	IB1C
1	Hatchability (%)	90.00	76.30	91.20	94.00	96.80	96.60	96.10	85.90	96.00	86.90	98.60	93.60
2	Larval period (day-hours)	26-23	26-18	27-7	26-16	25-0	25-21	26-9	25-23	24-19	24-14	25-16	24-19
3	Missing percentage of young silkworm (%)	17.50	9..70	20.20	19.60	9.80	13.00	13.90	6.30	8.60	10.90	9.30	10.00
4	Missing percentage of grown up silkworm (%)	11.70	9.60	16.40	11.60	5.70	17.80	7.90	10.20	2.40	8.20	6.40	2.70
5	Maximum larval weight (gms)	3.40	3.20	2.60	3.00	3.20	34.00	32.00	3.60	3.60	3.40	3.10	3.30
6	Mounting percentage (%)	86.20	89.10	72.00	85.30	93.40	76.40	90.80	85.80	96.20	89.80	92.50	94.30
7	Cocooning percentage (%)	98.60	97.60	98.90	98.50	98.60	95.00	97.20	95.10	96.00	97.10	98.80	94.90
8	Sound pupa ratio (%)	94.20	96.70	96.70	96.60	98.00	88.10	97.00	93.50	96.40	97.30	97.70	99.00
9	Normal Cocoon percentage (%)	91.90	94.00	92.40	95.60	88.10	89.10	89.50	87.20	91.00	90.30	94.70	92.10
10	No. of cocoons/kg.	603	620	764	684	650	640	653	579	598	596	651	636
11	Single whole cocoon weight (gms)	1.70	1.66	1.47	1.55	1.59	1.59	1.52	1.71	1.65	1.63	1.54	1.65
12	Single shell cocoon weight (mg)	369	371	333	346	347	343	345	391	366	374	347	386
13	Cocoon shell ratio (%)	22.18	22.51	23.05	22.75	21.34	21.00	23.80	23.38	22.41	23.06	22.55	23.55
14	Pupal weight (gms)	1.35	1.09	1.08	1.16	1.22	1.31	1.16	1.33	1.31	1.32	1.22	1.24
15	Length of cocoon filament (m)	1181	1193	1003	1024	1086	1287	841	1051	1058	1077	1081	1081
16	Length of non-breaking cocoon filament -NBLF (gms)	656	660	637	776	794	690	559	635	650	648	706	602
17	Weight of cocoon filament (gm)	36.20	35.10	25.40	31.80	33.80	40.80	33.80	41.00	35.60	35.90	37.00	35.00
18	Size of cocoon filament (denier)	2.49	2.44	2.28	2.70	2.72	2.75	2.89	3.09	2.66	2.67	2.50	2.87
19	Life span (days)	44-46	46-48	45-47	45-47	43-45	43-45	44-46	44-46	42-44	41-43	42-44	41-48
20	Moth emergence (%)	95	98	90	98	96	95	95	94	97	95	98	98
21	Fecundity	569	539	413	479	197	512	414	438	589	469	556	468

Characteristics of Philippine Purelines from Egg to Moth Stages

Lat 1

1. Egg Color : Purple; egg shell - white

2. Newly-hatched larvae: black

3. Molting Colors:

   1st molt - yellow green to brown

   2nd molt - yellow green to quail gray

   3rd molt - yellow green to brown

   4th molt - yellow green to brown

4. Larval Marking:

   Generally normal

   Distinct velvety-like black-brown eyespot with tinge of red.

   Two (2) pairs crescent or moon markings; 1st pair crescent is black-brown and 2nd pair crescent is brown.

   Star marking present on 2 segments, but more prominent just before the candal horn.

   Segmental ring or fold is pinkish.

   Yellow ripener.

5. Body: Slender, yellow tinge

6. Cocoon: White, peanut-shape, wrinkles moderately coarse.

Lat 21

1. Egg Color: Gray, towards purple, white egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - greenish brown

   2nd molt - greenish brown

   3rd molt - brown

   4th molt - brown

4. Larval Marking: Normal marking, 2 pairs black-gray crescent/moon markings with streaks on body, star marking prominent.

   Dark thorax, black eyespot with pink to red line.

   Of all Lat's, it has the most streaks on body and pinkish segmental ring.

   Mature larvae hard to distinguish with yellow tinge that tend to darken.

5. Body: slender

6. Cocoon: White, long and peanut shaped, wrinkles moderately coarse.

Lat 31

1. Egg: Gray to purple; egg shell - white

2. Newly-hatched larvae: black

3. Molting colors: 1st molt - greenish brown

   2nd molt - greenish

   3rd molt - yellow green

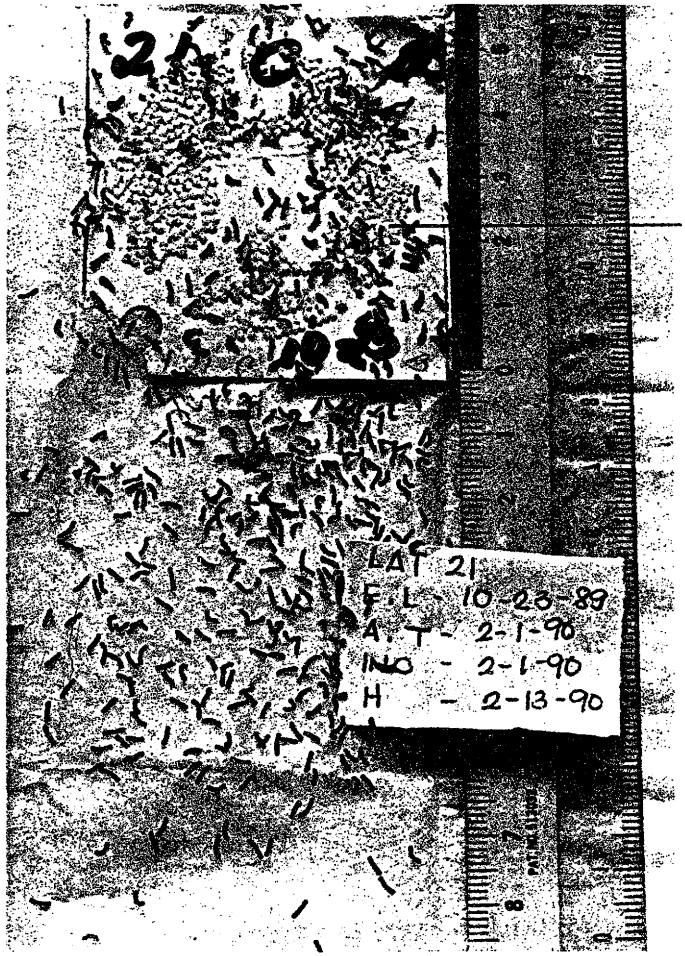
   4th molt - brown

4. Larval marking:

   Normal, 2 pairs black-gray lunar markings. Ash-like thorax. Body with light zebra streaks and star marking. Segmental ring pinkish. Yellow to pink ripener, but hard to distinguish.

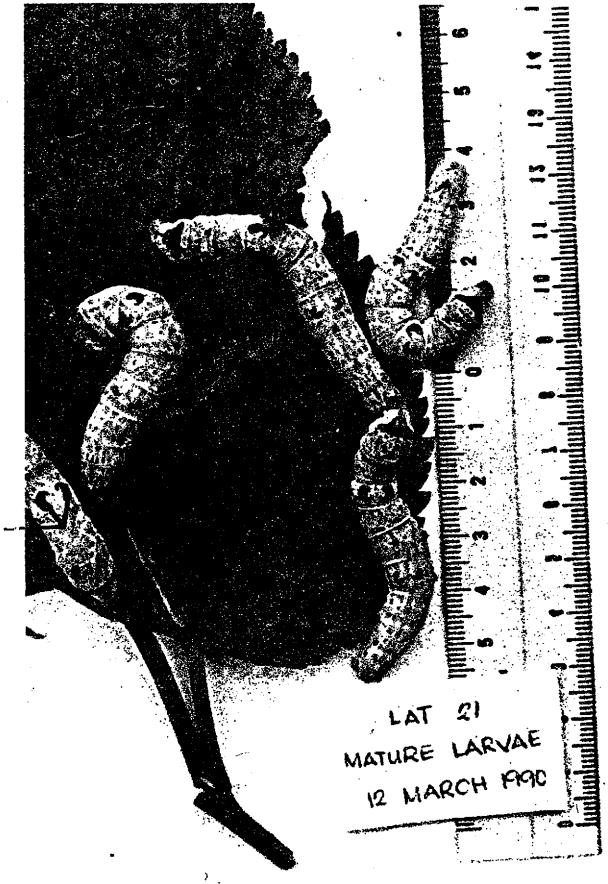
5. Body: slender

6. Cocoon: White, peanut shape, wrinkles moderately coarse.



Egg shell

Lunar/Moon
or crescent mark



LAT 21

Newly-hatched larvae

Mature larvae ready to spin
Cocoons (27 days after hatching)

Lat 51

1. Egg: Purple, white egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - greenish brown

   2nd molt - yellow green

   3rd molt - yellow green

   4th molt - brown

   Newly molted larvae have a scattering behavior.

4. Larval Marking:

   Normal marking, black eyespot with dark pink line. Two pairs of lunar markings, black in crescent spreads towards the center combined with yellow-brown but outline is more dark.

   Second pair of crescent is yellowish.

   Segmental ring is pinkish.

   Yellow ripener.

5. Body: slender

6. Cocoon: white, peanut-shape, wrinkles coarse.

IB2P

1. Egg: Brownish green, yellowish egg shell.

2. Newly-hatched larvae: black ants

3. Molting Color:

   1st molt - whitish gray to brown towards tail

   2nd molt - gray

   3rd molt - dirty white

   4th molt - dirty white

4. Larval Marking:

   Plain with very slight, transparent eyespot and 1 pair lunar markings. Pinkish segmental rings or fold. Mature lunar is yellow.

5. Body: slender

6. Cocoons:

   White, peanut-shape but short, very coarse wrinkles or grains.

ST1

1. Egg: gray, white egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - white thorax, dark brown to grayish brown body

   2nd molt - dark gray with quail marks

   3rd molt - dark brown-black with quail marks

   4th molt - brown

4. Larval Marking:

   Normal marking, black eyespot with pink line. Two (2) pairs lunar marking, 1st pair distinct black-brown outline spreading to center becoming yellowish brown at the center.

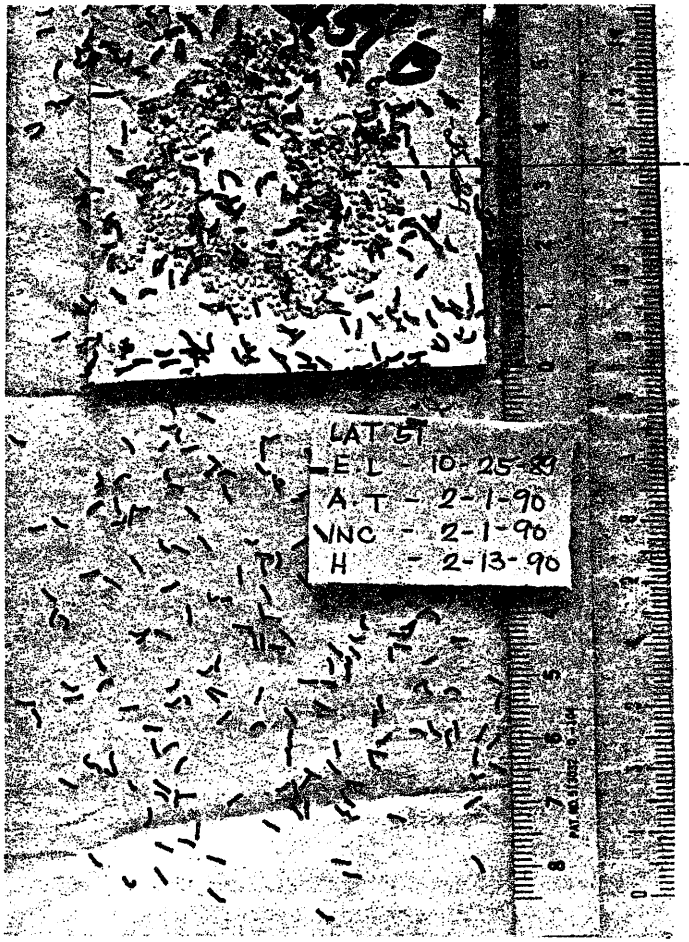
   2nd pair yellowish brown but not so crescent in form, instead appears to be in a "C" form with 3 circles.

   Body is yellowish and segmental rings or fold are pinkish.

   Yellow ripener.

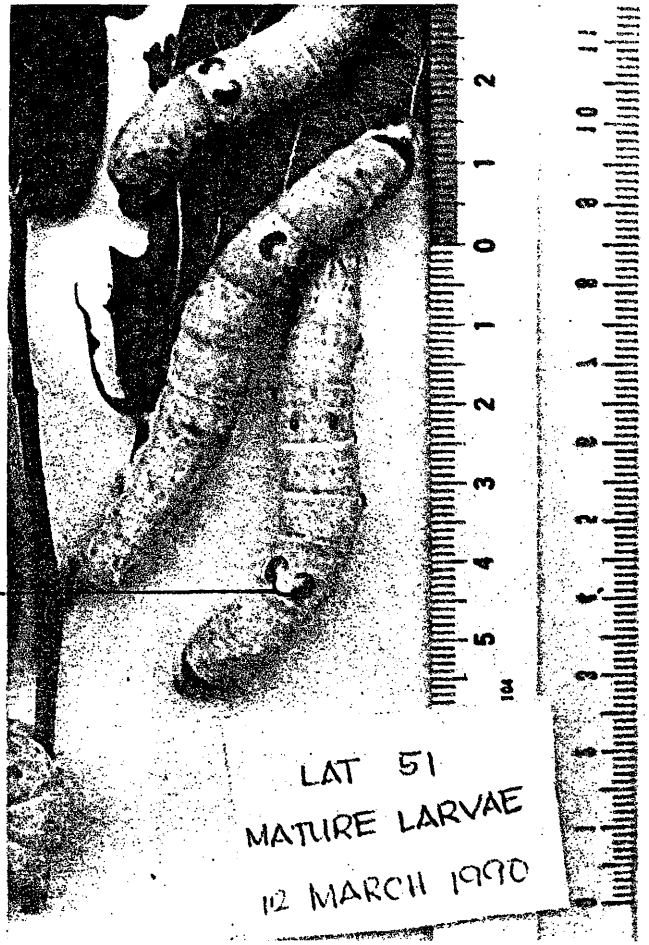
5. Body: thin

6. Cocoon: white, oval, small and moderately coarse grains/wrinkles.



Egg shell

Moon/Lunar
or crescent mark



LAT 51

Mature larvae ready to spin
Cocoons (27 days after hatching)

Newly-hatched larvae

B200

1. Egg: Light greenish, white egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - whitish gray

   2nd molt - light gray to white

   3rd molt - white

   4th molt - white

4. Larval marking:

   Plain with 1 pair crescent faint or light yellow-brown tint. Yellow mature larvae.

5. Body: Rounded, short and stout

6. Cocoon: Round, short, white, coarse wrinkles or grains

B221

1. Egg: light green, yellowish egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - whitish gray

   2nd molt - whitish gray

   3rd molt - white

   4th molt - white

4. Larval Marking:

   Plain, no eyespot, very light transparent 1st lunar markings. White to yellowish segmental rings or folds. Yellow ripener.

5. Body: rounded

6. Cocoon: White, round, short, very coarse wrinkles or grains.

B251

1. Egg: yellow green, yellow egg shell

2. Newly-hatched larvae: black

3. Molting color:

   1st molt - white thorax, gray abdomen

   2nd molt - whitish gray

   3rd molt - whitish gray

   4th molt - white

4. Larval Marking:

   Plain slight 1st pair crescent, pink segmental folds or rings. Yellow ripener.

5. Body: Rounded

6. Cocoon: white, roundish, big with coarse wrinkles or grains.

IB3

1. Egg Color: green, yellowish egg shell

2. Newly-hatched larvae: black

3. Molting Color:

   1st molt - whitish gray

   2nd molt - whitish gray

   3rd molt - white

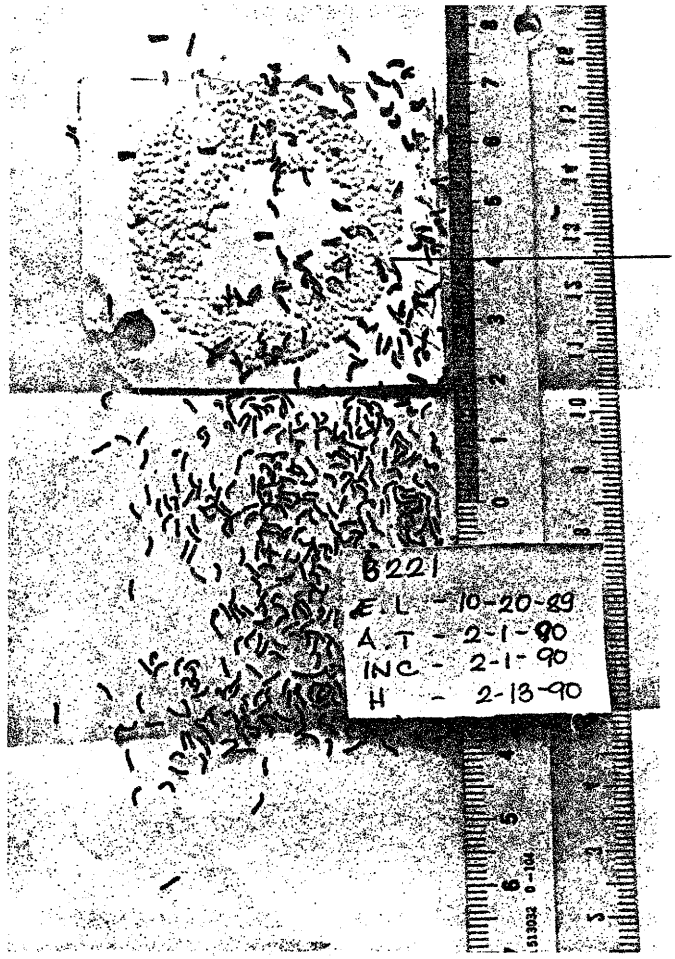
   4th molt - white

4. Larval Marking:

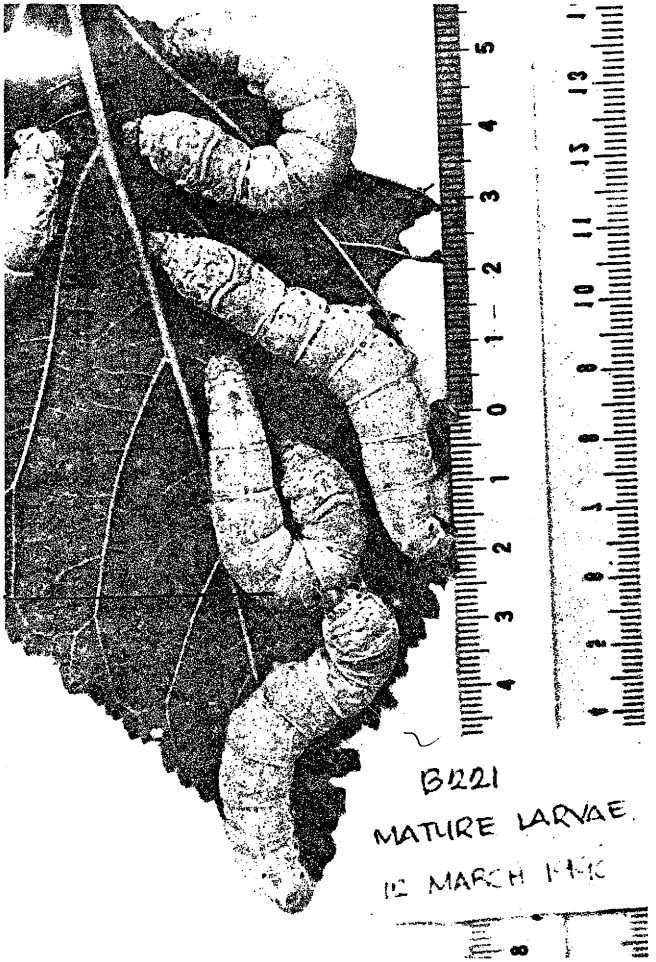
   Plain, transparent segmental ring, distinct transparent 1st pair lunar marking, no 2nd pair. Yellow ripener.

5. Body: Rounded

6. Cocoon: white, roundish, coarse wrinkles or grains

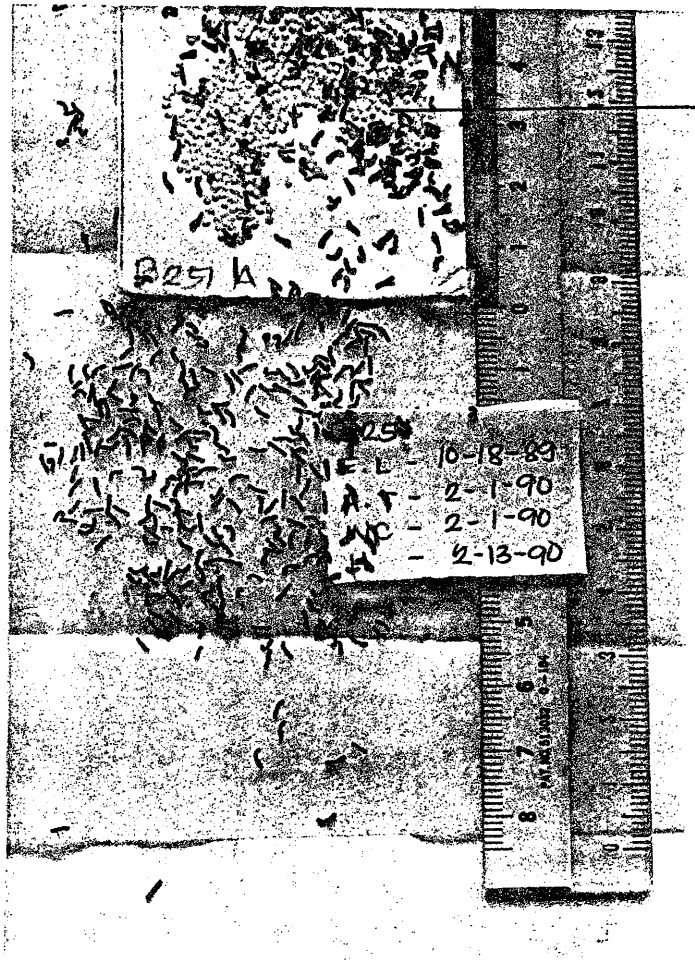


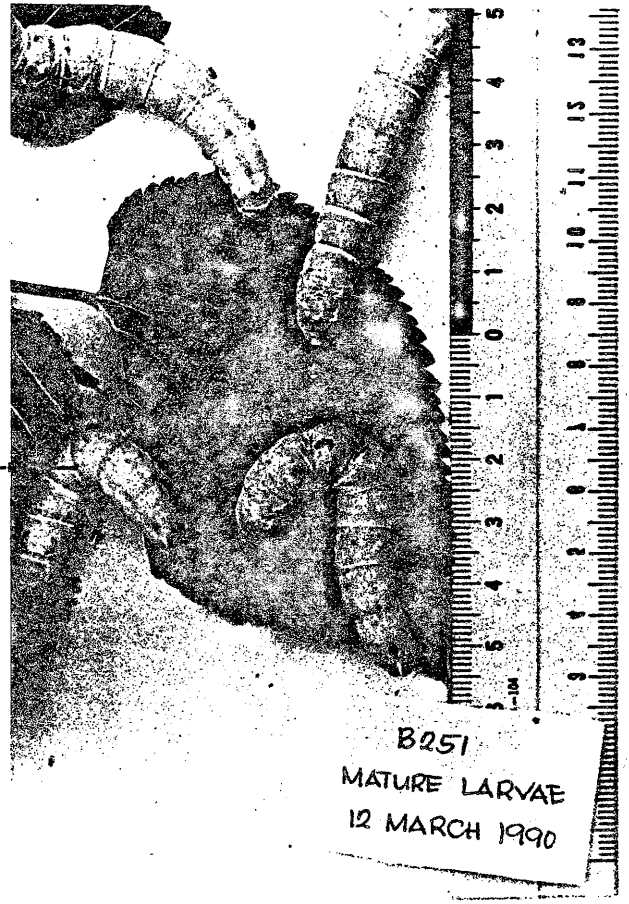
Newly-hatched larvae



LAT 221

Mature larvae
(25 days after hatching)





LAT 251

Newly-hatched larvae

Mature larvae
(25 days after hatching)

B271

1. Egg: dark green, yellow egg shell

2. Newly-hatched larvae: black

3. Molting color:

   1st molt - grayish to brown

   2nd molt - grayish to brown

   3rd molt - white

   4th molt - white

4. Larval Marking:

   Plain with prominent semi-transparent 2nd pair crescent. Slight brownish eyespot. Pinkish segmental ring or fold. Yellow ripener.

5. Body: Slender

6. Cocoon: white, oval, short, fine wrinkles or grains.

IB1C

1. Egg: dark green, yellow egg shell

2. Newly-hatched larvae: black

3. Molting color:

   1st molt - whitish gray

   2nd molt - white

   3rd molt - dirty white

   4th molt - white

4. Larval Marking:

   Plain, thin black eyespot, 2 pairs transparent to gray lunar markings, 1st pair being more prominent than second. Pinkish segmental rings or folds. Yellowish ripener.

5. Body: slender

6. Cocoon: white, roundish, very coarse wrinkles or grains.

Process 2. *Multiplication And Seed Cocoon Production*

From the twenty nine (29) purelines, four (4) were selected for multiplication and serve as grandparents or P2 and cocoons produced in rearing are called foundation stock or hybrid seed. In this second process, the silkworm eggs remain in pure state. Male and female belonging to the same line are crossed or mated and multiplied. This will become the grandparents of the hybrids. The quantity of eggs maintained and multiplied is very dependent on the parent demand which in turn is dependent on the scale of commercial cocoon production. The economic character established from the breeding has to be observed in this process but not as keen as the first process. However, the care and management has to be proper to grow the silkworm healthily and uniformly as this will determine the quality of eggs to be used in the succeeding step.

Resulting from the multiplication of the grandparents or P2 are the parents or P1. The rearing of P1 or parents to produce the seed cocoons (raw material for F1 egg production) can be done by private institutions, government entities or farmers. The production can be done solely from incubation to egg production by a single entity; or it can be done through separate functions wherein incubation until cocoon production is entrusted to the selected farmers or other groups while the breeding and egg production work is done by the government center. The latter method is being adopted at present by the PTRI in cooperation with some farmers and the Benguet State University. This method is beneficial to both parties since the cocoons produced in raising parents command a higher price on the part of the producers while easing the load of the egg producing center. The center derive its income from the sale of the eggs or hybrids after conducting the next process.

Process 3. *Hybridization or Cross-breeding for F1 Hybrids*

Hybrids are produced from the crossing of two or more individuals belonging to different varieties. The breeding of parent stock varieties (purelines) is carried out giving special attention to the ability of the hybrid descendants of the first filial generation (F1). Since the ultimate objective of breeding is to find out breeds producing high quality silk, final evaluation of characteristics is made on their offsprings which are crossbreeds.

Commercial cocoon production use hybrids of the first generation. The reason behind this is that, generally, hybrid silkworm of the first filial generation are superior to those of purelines making rearing management easier and cocoon production more profitable. Crossbreeding between moths belonging to different breeds results in the variation of the hereditary characters of progenies. New forms, different early maturity and higher yield are produced. This hybrid stock displays the phenomenon of increased vigor, known as "heterosis", which is true to living creatures. This phenomenon is usually manifested through the following characteristics: a) large size of larvae, b) robustness, c) shorter larval duration or rearing period, d) high cocoon weight, e) high raw silk percentage, f) greater denier, and g) lesser susceptibility to diseases. Therefore, in hybridization, a careful selection of the parents is made.

Tables 2a and 2b shows the improvement of characteristics after hybridization. Annex 1 illustrates the actual cocoon improvement after hybridization. Following are the considerations in the selection of parents for hybridization:

1. Adequate parents are selected according to different breeding aims. For example, choosing a variety suited to warm climatic conditions or colder climates. 2. Parents should have more good than unfavorable characters. Thus, the good characters of one parent can overcome the defects of the other to a great extent, expressing better characters in their progenies and elimination of defects by selection.

3. Parents that have good combining ability.

4. Parents should be pureline to avoid segregation of characters.

There are several types of hybridization but the single/simple or monohybrid method is practiced. Accompanying flowchart shows the Processes 1-3 applied in breeding and egg production.

Table 2. Improvement of Races After Hybridization

2a. Comparative Results Between Parents and Offspring
(Hybrid for Baguio-Benguet)

	Parents		Offspring (Hybrid)	
Characters	Lat 21	B221	PTRI SW1	PTRI SW2
Larval duration (days-hours)	26-20	23-07	25-10	24-19
No. of cocoons/kilogram	589	662	563	616
No. of cocoons/liter	120	88	95	101
Weight of cocoons/liter (gms)	182	135	151	173
Whole cocoon weights (gms)	1.500	1.522	1.659	1.757
Cocoon shell weight (mgs)	330	352	390	400
Cocoon shell ratio (%)	21.75	23.46	23.51	23.76
Pupal weight (gms)	1.175	1.180	1.269	1.326

2b. Comparative Results Between Parents and Offspring
(Hybrid for Misamis Oriental)

	Parents		Offspring (Hybrid)	
Characters	Lat 51	B251	PTRI SW3	PTRI SW4
Larval duration (days-hours)	26-15	26-18	25-20	25-18
No. of cocoons/kilogram	705	659	641	624
No. of cocoons/liter	125	88	101	108
Weight of cocoons/liter (gms)	175	151	157	163
Whole cocoon weights (gms)	1.477	1.542	1.672	1.716
Cocoon shell weight (mgs)	345	363	404	406
Cocoon shell ratio (%)	23.48	23.83	24.16	23.67
Pupal weight (gms)	1.133	1.191	1.265	1.300

Breakthrough in Breeding

Following Processes 1-3, breakthrough in breeding work was made in 1982 when PTRI successfully evolved four (4) F1 hybrids. The series of field testing/performance evaluation resulted to the identification of specific hybrids suited to specific locations or local conditions, for example:

Baguio-Benguet Condition

PTRI SW1 = crossbreed of Lat 21 x B221

PTRI SW2 = crossbreed of B221 x Lat 21

Misamis Oriental, Bukidnon Condition

PTRI SW3 = crossbreed of Lat 51 x B251

PTRI SW4 = crossbreed of B251 x Lat 51

The most recent periodic rearings yielded an additional four (4) more new hybrids that show promising qualities and are now the objects for small-scale testing in several sericulture sites in the country. These are the following:

PTRI SW5 = crossbreed of Lat 61 x IB1C

PTRI SW6 = crossbreed of IB1C x Lat 61

PTRI SW7 = crossbreed of Lat 51 x B221

PTRI SW8 = crossbreed of B221 x Lat 51

Application of Technology

The local bivoltine hybrids, to our knowledge, is the first of its kind in the Philippines. Other State Universities and Colleges like UPLB, DMMMSU, and CLSU are also undertaking silkworm breeding but none so far have produced and field-tested bivoltine hybrids of the same quality. The local F1 hybrids are used by the existing sericulture farmer cooperators, some private entrepreneurs and state universities and colleges in the commercial cocoon production. Table 3 gives a list of the existing farmer associations, private companies, state colleges and universities who avail of PTRI F1 hybrid eggs.

Technological Advantage

Increased Production at the Farmer's Level

Due to the silkworm breeding and egg production technology that led to the development of Filipino purelines and hybrids, the cocoon production technology has been commercialized and transferred to the farm level. The technology was therefore instrumental in bringing the sericulture/cocoon production within reach of the small farmers. Data on fresh cocoon production at the farmers' level revealed a tremendous increase from 450 kilos in 1982, to 800 kilos in 1983 to 1.44 MT in 1989 and 1990 respectively.

A Boost for S&T

The successful breeding work and the commercialization of F1 hybrids nurture the development of the industry by ensuring the supply of quality and disease-free silkworm eggs. Likewise, it supports the national sericulture programs of the Comprehensive Technology Transfer & Commercialization (CTTC) Program of the Department of Science and Technology (DOST). Considering that a number of sericulture farmers' associations throughout the country (numbering 23 with 1,150 farmer-members) are presently engaged in cocoon production, then substantial volume of silkworm eggs is required.

Tables 4 and 5 give the potential silkworm egg requirement for Region 1/CAR and Region X respectively.

Economic Advantage

The development and commercialization of silkworm eggs and cocoon production contribute to the government's program on the following;

Self-Reliance and Generation of Foreign Exchange Savings:

The development of local hybrids infuses more dynamism in the current efforts to develop a well-rounded and self-reliant silk industry in the Philippines.

Table 3. List of Existing Farmer Associations/ Private Companies and State Colleges and Universities

I. Morticulture

A. Total Hectarage and Location of Mulberry Plantations

Name of Government & Private Organization/Location	Existing Hectarage of Mulberry	No. of Ha. to be Developed
PTRI station, La Trinidad, Benguet	2	5
PTRI station, Misamis Oriental	3	
Farmer Cooperators in Benguet & Ifugao	154.5	435
Farmer Cooperators in Misamis Oriental	108.19	416.49
Murcia Sericulture Farmers' Association Murcia, Negros Occidental	3	
Silk Mountain Corp., Bukidnon	100	
First Agricultural Research Management, Inc. Bukidnon	1	
Laguna Silk Corp., Luisiana, Laguna	50	
Don Mariano Marcos Memorial State University (DMMMSU), Bacnotan, La Union	2	
Farmer Cooperators of DMMMSU	3	30
Central Luzon State University (CLSU) Munoz, Nueva Ecija	4	
Farmer Cooperators of CLSU	1	
DSAC, Indang, Cavite	1	
Aral-al, La Carlota City, Negros Occ.	1	
Han San Agricultural Company Sitio Maligatong, Baguio District, Davao	15	
A.M. Mata Realty Development Corp. Matina-Pangi, Davao City	2	
University of the Philippines, Los Banos, Laguna	1	
DMMMSU, La Union	1	
Benguet State University, La Trinidad, Benguet	5	
Central Mindanao University, Bukidnon	4	
Misamis Oriental State College of Agriculture and Technology, Claveria, Misamis Oriental	1	
Asia Coat, Bukidnon	3	47
Ateneo de Davao, Sinuda, Bukidnon	1	
Dingle Agricultural College, Iloilo	3	
Panay State Polytechnic College, Mambusao, Capiz	2	
Negros Agricultural College Kabangkalan, Negros Occidental	5	
La Paz Experimental Station, Zamboanga City	2.0	
Sta. Cruz Mission, Lake Sebu, South Cotabato	1.25	
Isabela State University, Cabagan and Echague, Isabela	1.75	
Pangasinan State University, Infanta, Pangasinan	1.25	
Department of Agriculture, Region I	1.0	
FIDA-CAR	1	16
FIDA-Region I	2	8
FIDA-Region IV	8	17
FIDA-Region VI		3
FIDA-Region IX		7.5
FIDA-Region X		2
FIDA-Region XI	3	17
Farmer Cooperators of FIDA, La Union	8	20
Farmer Cooperators of FIDA, Iloilo	10.8	
Individual Farmer Cooperators of PTRI, La Union, Benguet	5	10
Individual Farmer Cooperators of PTRI, Misamis Oriental	9.8	
TOTAL	531.54	1033.99

Table 3. Continued...

B. Name of Farmers' Association/Location	Farmer Member	Existing Has. of Mulberry	No. of Has. to be developed
1 Hinaplanan Sericulture Farmers Association/Hinaplanan, Mis. Or.	35	30.18	2.75
2 Hinaplanan Cocoon Producer's Association Hinaplanan, Misamis Oriental	47	34.00	39.50
3 Lambagohon Farmer's Association Claveria, Misamis Or.	52	21.50	61.50
4 Lanise Sericulture Farmer's Association, Claveria, Mis. Or.	25	7.50	19.00
5 Tribal Agriculture Social Services Program, Madaging, Claveria, Mis. Oriental	36	11.51	24.49
6 Plaridel Farmer's Association, Claveria, Mis. (	44	1.25	42.75
7 San Isidro Cooperative Misamis	25		25.00
8 Patrocinio Farmers Association, Misamis Ori	77	.50	76.50
9 Cabacungan Silk Producers Association, Claveria, Misamis Oriental	14	1.75	12.25
10 Gumaod Farmers Association Claveria Misamis Oriental	13	0.25	12.75
11 Baliwagan United Farmer's Cooperative, Mis.	120		100
12 Kalingagan Cocoon Producer's Association, I	20		
13 Kapangan Sericulture Faremers Association, Kapangan, Benguet	138	66	200
14 Cocoon Growers' Development Cooperative Nangalisam, Tuba, Benguet	43	8	120
15 Baguio-Benguet Sericulture Farmers' Associa Tuba, Benguet	50	7	50
16 Kiangan Farmers' Association, Ifugao	59	59	28
17 Itogon Farmers, Tudin, Itogon	30	10	25
18 Poblacion Kibungan farmers' Association, Be	15	1.5	
19 Basil Tubay Multi-Purpose Farmers Association, Benguet	13		
20 Banangan (Sablan) Multi-Purpose Farmer's Association, Benguet	51	1	
21 Alno Farmer's Associatio, La Trinidad, Bengu	26	2	12
22 Murcia Sericulture Farmers' Association Negros Occidental	36	3	30
23 Individual Farmer Cooperators of:			
a. PTRI, La Trinidad, Benguet	10	5	10
b. PTRI, Region X	1	9.8	
c. DMMMSU	125	3	30
d. CLSU		1	
e. FIDA, La Union		8	20
f. FIDA, Iloilo	45	10.8	
	1150	303.29	931.49

Table 4. Potential Silkworm Egg Requirement of Region 1/CAR

Indicators	1992	Projections Based on CTTC Program 1995	2000
Mulberry areas (ha) of farmers	530	1000	2000
Silkworm eggs requirement (boxes) based on the age of mulberry	3806	30120	72000
Egg production of the Multiplication center per annum	4000	27000	27000
Variance		3120	45000
Number of centers required @ 27,000 boxes capacity		1	3
Expected income generated thru the sale of hybrid silkworm eggs at P 100.00/box	380600	3.01 M	7.2 M
Savings to be incurred by the government in the importation of hybrid silkworm eggs	761200	6.02 M	14.4 M

* as of March 1991

14.60 ha = 3 - yr old & above (8 boxes/ha/a. 6 rearings/ha/a)
44.40 = 2 - yr old (5 boxes/ha. 4 rearings)
34.0 = 1 - yr old (2 boxes/ha, 2 rearings)
41 = below 1 yr (1 box, 1 rearing)

Table 5. Projected Silkworm Egg Requirement of Region X

	Projections Based on CTTC Program		
	1992	1995	2000
Area of Mulberry (ha)			
a. farmers	1070	2500	5000
b. private co.	200	200	300
TOTAL	1270	2700	5300
Silkworm egg requirement (boxes) based on age of mulberry			
a. farmers	4766	62788	178500
b. private co.	7720	9600	14400
TOTAL (boxes/a)	12486	72388	192900
Egg production of center/a	14685	50000	50000
Variance		22388	142900
Number of centers required @ 50,000 boxes, capacity/a center/a		2	4
Expected income generated thru the sale of hybrid silkworm eggs at P 100.00/box	1.25 M	7.24 M	19.29 M
Savings to be incurred by the gov't in the importation of hybrid eggs	2.5 M	14.48 M	38.58 M

The commercialization of hybrids with two (2) Multiplication Centers in PTRI, La Trinidad and PTRI, Misamis Oriental shall make available a total of 77,200 boxes of silkworm egg/s at full production of the two (2) centers, valued at P7,720,000/a or US$ 1,544,000 foreign exchange when imported at US$ 20/box.

Enhancement of Rural Development/Generation of Employment Opportunities

Through the available local hybrids, sericulture and its downstream technology has been promoted and now being practiced mostly in rural areas where labor is much available and where there is vast tracts of land for cultivation. Either as a full-time or part-time job, it can add to the low income thus uplifting the quality of life of the rural folks.

Based on the action plan of the National Sericulture Project under the DOST - CTTC program, the employment generation and potential income of the industry are given in Table 6.

Increased Foreign Earnings for the Government

Cocoons, raw silk, silk fabrics and silk-blended garments are highly priced in the international market. The exportation of any of the above will mean foreign exchange inflow. The foreign market provides unlimited opportunity for silk producing countries and with the phasing out of cocoon production in highly industrialized countries like Korea and Japan, silk production is now focused on tropical countries, the Philippines being one of them.

Utilization of Marginal Lands Contributing to the Improvement of Ecology and Reforestation Program

With the development of sericulture as a rural-based industry, utilization of marginal lands could be tapped as mulberry plantation since mulberry trees grow anywhere. Even mountain ranges and hills could be used for plantation purposes.

The development of Filipino purelines and hybrids from laboratory scale transferred to the field and later to commercial scale application, provide a golden opportunity for the Philippines to fill in the growing world demand for silk. This will then assume a significant role in the government's efforts to alleviate the farmer's plight, transform the rustic scene of the countryside into active economic and industrial centers of activity to become the building blocks of a Newly Industrialized Country.

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Table 6. Employment and Potential Income of the Industry

Employment Generation

Projected Jobs : Sericulture Program
(Full Production of 10,000 ha.)

60,000 - for mulberry farms/moriculture

50,000 - for cocoon production

12,000 - for reeling/filature

122,000 -Total Jobs

Potential Income
(Full Production of 10,000 has.)

Various Stages of Sericulture	*Production/ha.*	*Net Income/ ha/year*	*Estimated Net Income*
I. Cocoon Production	1,833 kg*	P110,000	1.10 B
II. Filature	229 kg	196,000	1.96 B
III. Fabric Production	2,290 mtrs	480,900	4.80 B
Total Potential Income			7.86 B

*** production/ha at 8 rearings/a**

Table 7. Income Generated on Fresh Cocoon Production per Household (4-5 members) on One Hectare

A. Mulberry Production :	
Area of Field	10,000 sq. meters
Distance of planting	1m x 1m
Required no. of trees	10,000 trees

	1st yr	2nd yr	3rd yr	4th yr
Ave. leaf yield/plant every 3 mos.	0.25	0.25	0.5	0.85
Ave. leaf yield/harvest (kgs)	2,500	2,500	5,000	8,500
No. of rearing/year	1	3	4	5
Total leaf yield/yr (kgs)				

B. Cocoon Production	
Ave. no of silkworm egg/box	20,000 eggs
Ave. leaf consumption/worm	0.045kg
Total leaf consumption/box	900 kgs

	1st yr	2nd yr	3rd yr	4th yr
Required no. of egg/boxes/yr	2.7	8.3	22.2	47.2
Less : Mortality	20%	20%	20%	20%
Ave. whole cocoon weight (gms)	1.8	1.8	1.8	1.8
Ave. fresh cocoon yield/box (kg)	25	25	25	25
Total fresh cocoon yield/yr (kg)	67.5	207.5	555	1,180
Cost of fresh cocoon/kg	90	90	90	90
Total production/yr	6,075	18,675	49,950	106,200
Less : Cost of eggs (P100/box)	270	860	2,220	4,720
Income from fresh cocoon/yr	5,805	17,845	47,730	101,480

Once established a mulberry plantation can last up to 20 productive years. Cocoon production rea from year 4 to year 15 with proper field maintenance and rearing management.

Region I/CAR sericulture farmers practice sericulture as a subsidiary source of income, thus they on it. Most of their landholdings are less than a hectare and for the last year's cocoon production pro source of additional income for them. Their work force consists of out-of-school children and non-wor tional income for them. Their work force consists of out-of-school children and non-working parents.

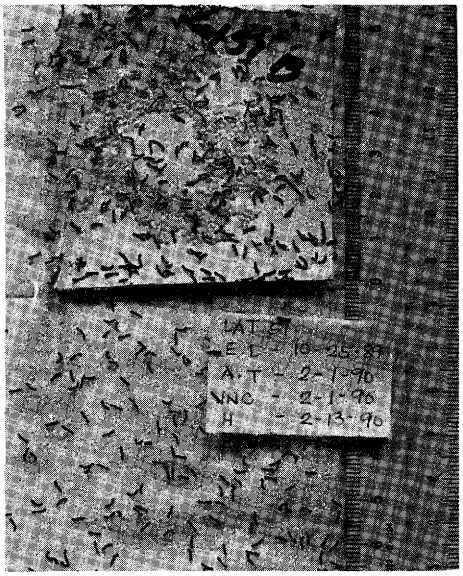

Fig. 1 Japanese parent eggs with newly hatched worms. Japanese parent for PTRI SW3.

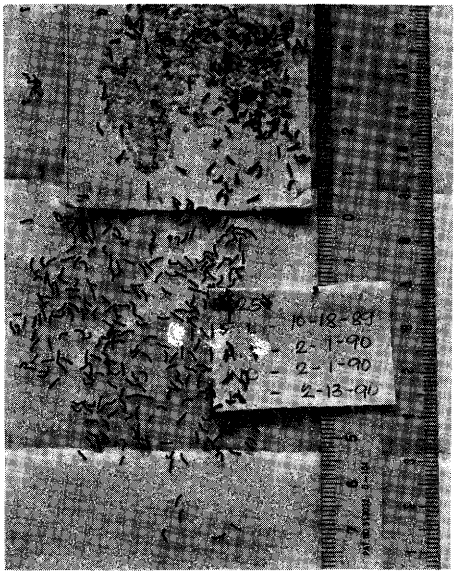

Fig. 2 Chinese parent eggs with newly hatched larvae. Japanese parent for PTRI SW3.

Fig. 3. Japanese parent silkworm larvae, about 28 days old. Japanese parent for PTRI SW3.

Fig. 4. Japanese parent mature larvae, about 26 days old. Japanese parent for PTRI SW3.

Fig. 7. Mulberry tree, food for silkworm.

Fig. 8. Silkworm larvae

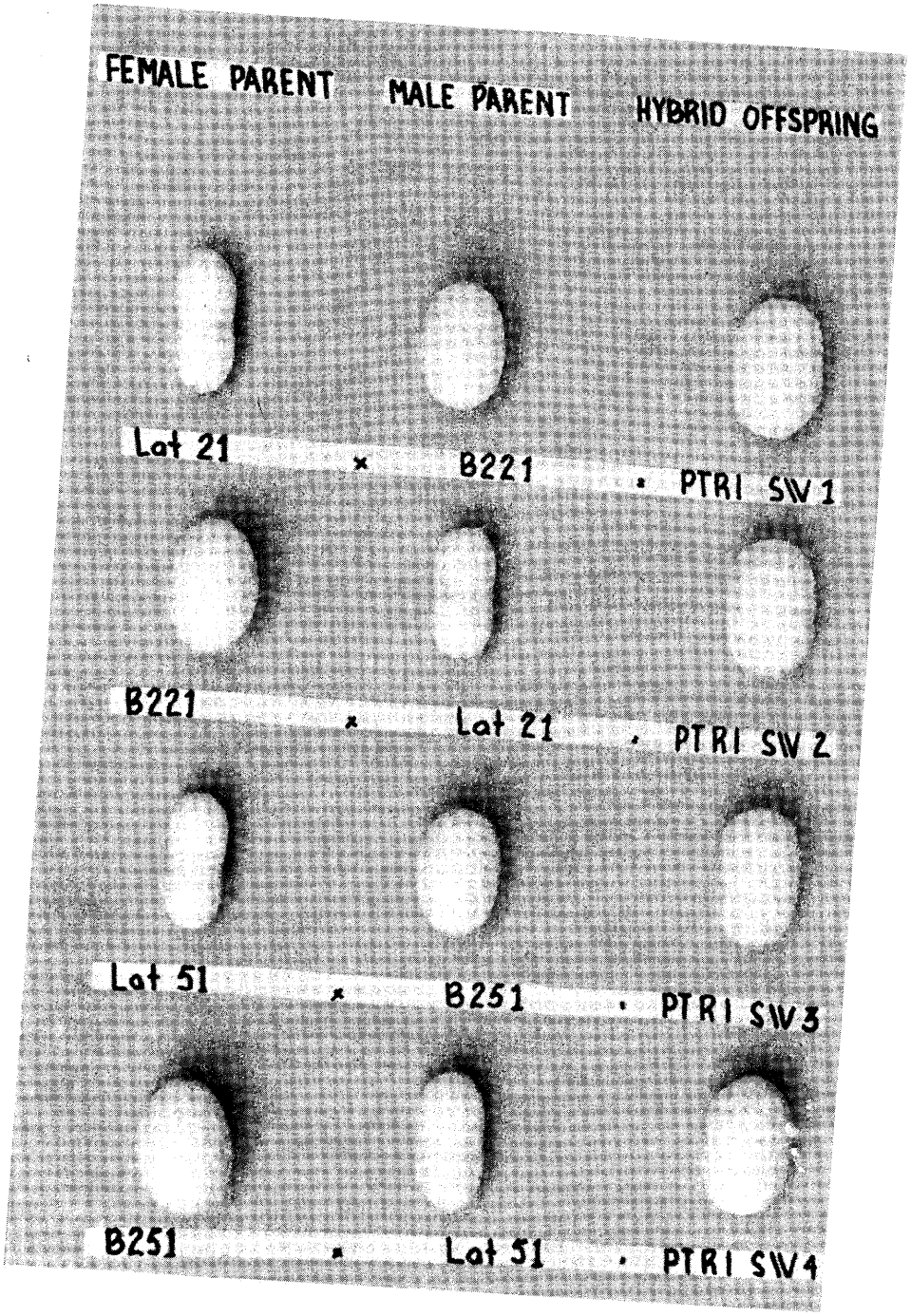

Fig. 9. Actual cocoon improvement after hybridization.

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Piloting of Lumbang Oil for Finishing of Wooden Furniture and Other Products

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Abstract

The successful processing of a finishing material out of lumbang oil in the laboratory showed promises for its utilization and adaptation in the furniture industry. Following the criteria in the selection of cooperators, two proprietors were identified from Angeles City, Pampanga and Metro Manila. The promising two oil formulations, 1:1 and 1:2 by volume ratios of lumbang oil and paint thinner, were prepared and applied on their finished products.

A post assessment was conducted on the previous cooperator in Angeles City, Pampanga, and it was learned that their present job calls for the application of varnish on their product lines. Even if the performance of the lumbang finishing oil has been found acceptable, market demand prevented its application. Likewise, a survey of prospective markets of lumbang finishing oil was also done. A representative of Sta. Ursula, Betis Modern and Antique Furniture Producers Cooperative was interviewed and expressed interest in the finishing oil.

Mr. Venancio Bandoquillo of Amlan, Negros Oriental was identified as the cooperators. However, the project could not be pushed through due to the the cooperator's lack of capital needed in the fabrication of equipment.

Introduction

The Forest Products Research and Development Institute (FPRDI) in cooperation with the Philippine Council for Industry and Enrgy Research and Development (PCIERD), recently conducted a study on the formulation and development of finishes from indigenous agro-forestry products (Moredo and Tavita, 1986). This was in response to the identified need of local furniture and related products industries for relatively low cost finishing materials. Among the formulations subjected to laboratory tests and limited service evaluations, finishing oil processed from lumbang seeds showed the brightest prospects for industrial application. In all the tests conducted, lumbang finishing oil was found to compare very well with a popularly used commercial brand of oil finish. Encouraging laboratory test results, however, were not adequate for product commercialization. Production and performance under a scaled-up operational setting had to be looked into. The successful implementation of this intermediate technology development process was expected to provide local producers witn a profitable option in quality finishing of furniture and related products.

Review of Literature

In order to meet the requirements of local processors, the coating industry has resorted to im-

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portation of raw materials for various types of finishes. Total importation amounted to 16.6 million kg. valued at US$26.7 million in 1988 and increased to 21.5 million kg. valued at US$31.7 million in 1989 (Foreign Trade Statistics, 1988-1989). Shipments of finishing oils to the Philippines amounted to some US$5.3 million in 1989, a 50.02% increase from the 1988 importation of US$2.6 million. The bulk of imporatation was on crude and refined linseed oil, refined palm oil and crude tung oil.

Indigenous substitutes to the imported types of oils can be identified from among the country's rich agro-forestry resources. Lumbang oil, which is obtained from the seeds of lumbang (*Aleurites moluccana*) tree, seemed a promising local material.

Manas (1977) reported that the oil consists of unsaturated fatty acid as oleic acid (16%), linoleic acid (49%), linolenic acid (17%) and others (12%). Its chemical characteristics can be modified to further enhance its suitability as a drying oil in the preparation of clear and pigmented coatings. This can be attained either by isomerization or re-esterification of the highly unsaturated fatty acids (Binlayo et. al., 1981).

Other possible indigenous sources of oil for the coating and furniture industry include baguilambang, dehydrated castor oil, bitaog oil, rubber seed oil and mahogany seed oil. Rubber seed oil consists principally of glycerides of linoleic and oleic acids, very similar to the industrially well-known linseed oil (West and Brown, 1921). Initial results of tests to determine the suitability of mahogany seed oil as a furniture finish showed the oil possesses some characteristics which are comparable to a popularly used brand of finishing oil (Manas, 1985). Soybean oil is another material which can serve the requirements of the local coating industry (Anonymous, 1986). In the foreign scene, the United States Department of Agriculture reported that seed oils from cramble, parsley, cape marigold and Indian Ironwood had been found suitable ingredients in the manufacture of finishing materials (Anonymous, 1963).

There were no previous efforts to utilize lumbang oil as a finishing material for furniture and related products on a pilot-scale. The commercial production of the oil had been reported (Arida, 1982) but the oil was mainly utilized in paint manufacture or as component of some other products like varnish, alkyd resin and printing inks. The Nasipit Lumber Co. also uses lumbang oil for tampering fiber boards.'

It became imperative therefore, to verify in a broader scale the promising results that have been generated from the studies conducted on lumbang finishing oil under laboratory conditions. Before final commercialization, it is worth determining whether the product answers such current requirements for wood finishes as depth and transparency, ability to accomodate many species of wood adaptability for mass production and ability to withstand many years of use (Sta. Ana, 1986). It is also important that economic benefits to technology users be established through pilot-scale testing.

Objectives

The objectives of the study were as follows :

1. To prepare what were found in laboratory tests as the best two formulations of lumbang finishing oil and apply them on furniture or other related products of furniture shops/firms;

2. To evaluate and compare the performance of developed finishing oil formulations on furniture and related products with that of a commercial finishing oil; and

3. To determine the acceptability of finished products by manufacturers and consumers.

Materials and Methodology

For CY 1987 and 1988, the following procedures were followed in conducting the study :

A. Packaging the technology

A brief description and presentation of what the technology is all about was prepared. This serves as a promotional material about the technology.

B. Identification of cooperator

Two cooperating firms, manufacturing furniture and other wooden products were identified in Pampanga and Metro Manila. Criteria in the selection included, 1. being actively engaged in furniture/related products manufacture, 2. availability of utilities, manpower and other services required, 3. readiness to provide fabricated products for testing

purposes, and 4. willingness to adopt the technology, if proven possible, in its production line.

C. Preparation of lumbang finishing oil

Lumbang nuts were placed overnight in an electric oven maintained at 70°C. From the oven, the nuts were immersed immediately in ice-cold water to facilitate cracking of the shell. The kernels were separated from the shell through manual hammering and then sliced into smaller particle size, after which were fed into a manually operated slurry press to extract the oil.

Formulation of lumbang finishing oil

Formulation was based on the 1:1 ratio of oil to paint thinner by volume

The raw lumbang oil was heated to 95°C. At this temperature, 24% lead naphthenate amounting to 1.5% by weight of oil and 6% cobalt naphthenate at 0.5% by weight of oil were added. The mixture was further heated to 180°C for 30 minutes, then cooled to room temperature before the paint thinner was added.

D. Performance evaluation of the finishing oil

1. Application of the oil system

A piece of office table, two rocking chairs and a set of wooden bowls, depending upon the cooperators choice, were selected for finish application. The surfaces were prepared employing an appropriate sanding schedule for the wood species used. The finishing oil was applied by brush, then the wood surfaces were wiped with clean cotton cloth. One to two coats of oil were applied.

2. Performance evaluation

The criteria used in the assessment of applied oils are given below. Performance of commercial oil relative to the applied oils was assessed based on the finisher's experience/views.

a. Driving time. The time required for the finish to dry to touch and to recoat, measured by experienced finishers. This was compared with the drying time of a commercial oil which was 25-35 minutes.

b. Grain-raising property. This refers to the capacity of the finish to raise the grain of the wood observed under a 20% hand lens against a clear white background. Grain-raising can be widespread or excessive to no grain-raising at all. Tolerable or moderated grain raising means that only 11-20% of the section is affected and does not necessitate further sanding of the surface.

c. Brushability. This refers to the ease with which the material can be brushed over the wood surface. Usually, the problem experienced is drag. This was determined likewise by identified experienced finishers.

3. Monitoring performance

The behavior of the applied oil was monitored/evaluated during the the service testing period which lasted from four to six months. Defacement and other physical changes or deteriorations were carefully noted and recorded.

In 1989, and 1990 various lumbang oil producers, lumbang nut dealers, fabricator of equipment were contacted. A post assessment was conducted on the previous cooperator in Angeles City. Likewise, a survey on the possible prospective markets of lumbang finishing oil was also done.

Results and Discussions

A. Technology Package

Please see Appendix A.

B. The Cooperators

Two proprietors/firms served as cooperators for the study. These are the following: Mr. Michael Diangson, owner of Diangson Woodcraft in Angeles City, Pampanga and Mr. Valerio Bituya of Metro Manila. Another two cooperators were identified. They were Ms. Clarita Magat, President of D'OR Designs Inc. in Guadalupe, Makati and Mr. Lorenzo Binuya, General Manager of Tahanang Walang Hagdanan, Inc. in Cainta, Rizal. However, these two cooperators were not considered since they could not assure the researchers if they could try the formulated finishing oil in their line products. They gave as reason for not availing their customer's preference for a certain type of finish which is usually specified in the order.

Mr. Michael Diangson is a single proprietor who started his business of manufacturing wooden ware in 1975. He caters for the local and foreign markets. His raw material is wood particularly acacia and his products are finished with varnish or depending upon the job order.

The other cooperator, Mr. Valerio Bituya, is also a single proprietor, who manufactures mostly modern furnitures for office and household. He started his business in 1952 with an initial capitalization of P10,000. His current capitalization is about P200,000. He employs an average of five persons, meaning he does not maintain a fixed number of workers. He uses the traditional species from lumber yards. The type of finish he applies on his products is dependent upon the job order. He caters too the local market. Problems he encountered are financing and workspace.

Furniture Consumers. Lumbang finishing oil was applied on two rocking chairs presented as souvenirs gifts to two retirees from the Forest Products Research and Development Institute (FPRDI), Engrs. E.U. Mendoza and J.O. Escolano. Both expressed their satisfaction and acceptance in the quality of the finish when their assessment was taken based on appearance and performance in service for a period of six months. Engr. Mendoza particularly cited his preference for the flat finish imparted by the lumbang finishing oil. Both have not observed discolorations/deteriorations or the appearance of molds on the chairs.

C. Performance of the finishing oil

Diangson Woodcraft. The 1:1 finishing oil formulation (1 part oil to 1 part thinner) was applied on a set of wood bowls. The following was the finishing procedure followed: 1. The wooden wares were first sanded with 120 and 150 grit sand papers; 2. Sanding sealer was applied; and 3. The lumbang finishing oil was applied by means of a wiping cloth. Only one coat of the oil was used. Drying time was 15-30 minutes and no grain raising was observed on the wood.

Diangson Woodcraft found the lumbang finishing oil acceptable based on appearance of the finish. From the finisher's view the oils was comparable to the commercial oil in terms of the ease of application, drying time of 15-20 minutes with no grain-raising and free from physical side-effects like itchiness. Presently, the firm utilizes cooking oil to finish their wood products and consequently, formation of molds during packaging posed a problem for the firm. Mr. Diangson expressed his willingness to use the lumbang finishing oil in commercial quantity.

Mr. Valerio Bituya. The 1:1 oil formulation was applied on a piece of office table. The table was first sanded with 80 and 400 grits sand paper. This was followed by the application of lumbang finishing oil using the brush and wiped with cloth. Two coats of the oil were used. The drying time of the lumbang oil was 25-30 minutes. Grain-raising was found to be tolerable and no physical side-effect was observed during application.

Mr. Bituya expressed his satisfaction on the finish quality imparted by lumbang oil. He noted that it was comparable with the commercial finishing oil. His firm was willing to use the product if commercialized, and was optimistic that furniture makers will accept it.

D. Activities conducted as recommended during the FPRDI-In-House Evaluation last CY 1988:

The following lumbang oil producers and lumbang nut dealers were contacted:

Lumbang oil producers:

1. Cosmos Lumbang Oil Factory
2. Columbia Paint and Varnish Co.
3. Mayon Industrial Corporation
4. Pacific Paint and Oil Manufacturing Co.
5. Po Man Hing Oil Factory
6. Finch Products Incorporation
7. Elizalde Paint Factory
8. Nasipit Lumber Co., Inc.

The first seven (7) companies have stopped producing lumbang oil accordingly, for lack of lumbang nuts. Their equipment in extraction were sold as

scrap. The lumbang oil, produced by Nasipit Lumber is just enough for their own consumption.

Lumbang nuts and other seed dealers :

1. Department of Natural Resourves

2. Ecosystems Research and Development Bureau

3. Manila Seedling Bank

4. Rayos Marketing

5. Makinabang Enterprises

Only Makinabang Enterprises could assure the supply of lumbang nuts of 5 tons per month at P15 per kilo.

In 1989, the Agricultural Mechanization Development Program of UPLB was contacted; re: design and fabrication of seed crusher and oil expeller. The cost of oil expeller and seed crusher is P12,000 and P8,000 respectively, excluding cost of fabrication which is 100% based on raw material cost.

Likewise, details of the concept of the technology was presented to Nasipit Lumber Company, Inc. (NALCO), Binondo, Metro Manila. NALCO agreed to cooperate with FPRDI in production trial run of lumbang oil using its existing facilities and resources. Through this, NALCO will be able to know the yield in terms of profitability and test the viability. An assurance was made that the technology will be adopted if found successful. However, some problems were met which hamper the production trial run. This included the unstable peace and order situation in Agusan del Sur.

A post assessment was also conducted on the previous cooperator in Angeles City, Pampanga. The post assessment was done on August 17-18, 1989, It was learned that their present job order calls for the application of varnish on their product lines. There was no demand for wooden wares finished with oil at present. It was suggested that the best market for finishing oil is the furniture industry. The trend now in the said industry is the "antique look" which needs/requires oil finish.

Since Region III is well known as the Furniture Center of the Philippines, a survey of prospective markets of lumbang finishing oil was also done. A representative of Sta. Ursula, Betis Modern and Antique Furniture Producers Cooperative was interviewed. He expressed interest in the finishing oil. He promised to inform the members of the cooperative regarding the benefits using oil finish to be one of the prospective market outlets of the finishing oil. A separate detailed report was made regarding this.

Efforts to get NALCO as the cooperator was not intensified due to the unavoidable circumstances beyond the researchers' and coordinator's control. Instead, identification of new cooperators was intensified in 1990. These were the following :

1. Mr. Venancio S. Bandoquillo

Mr. Bandoquillo is a degree holder in Business Administration; 71 years old; protestant; and married. The cooperator's major source of income is farming, and secondary is the SSS Pension. He is also a life corporate member of YMCA.

Mr. Bandoquillo started planting lumbang trees in 1964 with an initial capital investment of P20,000. The plantation is located in Mabinay, Negros Oriental which is 70 kilometers away from Amlan, Negros Oriental. A total of 10-20 tons of lumbang seeds could be collected from his plantation yearly. However, Mr. Bandoquillo could buy an additional 30 tons of lumbang nuts yearly from other towns of Negros Oriental. Previously, lumbang nuts are sold at P4,500-P5,000/ton.

The details of the piloting and investment cost of putting up a small capacity plant on production of lumbang finishing oil were presented. Mr. Bandoquillo is very receptive to the technology. He could provide the site or location of the project, raw materials like lumbang nuts; manpower and utilities. However, his main problem is on the financial aspect of buying or fabricating an equipment.

2. Mr. Bonifacio P. Fernandez

Mr. Fernandez is a degree holder in Bachelor of Laws; 51 years old, Roman Catholic, and married to Belinda CM Fernandez with three children (one boy and 2 girls), and a resident of Toril, Davao City. His major source of income is from his business and salary. The cooperator's secondary source of income is as FGU Underwritter. He is also a member of some professional and business organizations.

Presently, he is engaged in manufacturing granulated cocoshell charcoal which was exported to the United Kingdom and Japan. The charcoal fines are being utilized in manufacturing briquettes.

The technology package and the lay-out of equipment; re: small scale lumbang oil processing plant were presented to Mr. Fernandez. He opted for a bigger production facility and suggested the design of two oil expellers with a capacity of 20,000 and 10,000 kilos of lumbang meat per day. The oil expeller should be at least three units or three series with one unit of seed crusher.

Prices of lumbang meat in Toril, Davao City were as follows :

a. Below 100 sacks - P4.50/kilo

b. Above 100 sacks - P4.00/kilo

He is receptive to the technology however, he would like first to see the design and costs of the oil expeller before going into the business.

An investment cost for a small-scale finishing oil processing plant was also prepared as shown in Appendix C.

One highlight of the accomplishments was the approval of the patent application of the technology by the Patent Examiner of Bureau of the Patents Trade Marks and Technology Transfer in March, 1990.

Problems/Recommendations

Problems which included lack of market demand for oil finished products, inadequate funds for investment and peace and order affected the successful implementation of the study.

While Mr. Venancio Bandoquillo, the latest potential cooperator, possessed the raw materials required, he could not go into the venture due to the lack of capital needed for equipment fabrication. On the other hand, those approved by having the money ready for investment just can not find a sustained supply of raw materials.

The piloting study may not have provided the needed quantified data expected of it. Nevertheless, the potential for the adoption of the technology is considered high based on the reactions of those to whom the technology was promoted. It is therefore, proper that a continuous process of promotion be undertaken to bring the industrial adoption of this technology into a successful conclusion.

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Appendix A

A. Technology Package

A description of the technology was prepared and shown as follows:

Name of Technology : Lumbang Finishing Oil for Furniture

Year Developed : 1985

Source of Technology: Furniture Program, PWPC, FPRDI

The technology deals with the extraction of oil from lumbang nuts. First, the shells of lumbang seeds were cracked using the hot and cold process developed at the laboratory. The nuts were placed overnight in an electric oven maintained at 70oC. From the oven, the seeds were immediately immersed in ice-cold water. Final separation of the kernels from the shells was done by manual pounding with a hammer. Kernels were reduced to smaller sizes and fed into a slurry press to extracts the oil.

The two formulations found most promising in the laboratory investigations of Moredo and Tavita, 1986 were prepared. These were the 1:1 and 1:2 by volume ratios of lumbang oil and paint thinner. For each formulation, the raw lumbang oil was heated to 95oC. At this temperature, 24% lead naphthenate at 1.54% by weight oil and 6% cobalt naphthenate at 0.5% by weight of oil were added.

The formulated oils were applied on wooden products and method of application was similar to presently used commercial formulations.

Outstanding/Unique Features of the Technology:

1. Indigenous source
2. Import substitute
3. Simplicity in processing
4. Lower cost compared to commercial brands
5. Higher success factor to practical applications
    a. Formulated oil dry fast
    b. Good brushability
    c. Low-grain raising characteristics
    d. High coverage ratio
    e. Good resistance to household liquids and hot and cold water

Functional Capability of the Technology

Test conducted on the laboratory scale showed very promising results. Generally, properties/characteristics (drying time, brushability, grain-raising, consumption pattern, resistance to household liquids and hot and cold water) of the formulated finishing oil compared well with or surpassed those of a widely used commercial oil system.

Service performance evaluation resulted in very encouraging feedbacks.

One manufacturer labelled the finish as "Classy".

Resource Requirements:

1. Raw Materials

   a. Lumbang nuts @ P8.00/kg at gathering point

   b. Paint thinner @ P45.00/4-liter can

   c. 6% cobalt naphthenate @ P50.00/kg.

   d. 24% lead naphthenate @ P40.00/kg.

2. Equipment

   a. Press, manually operated with provision for mechanized operation

   b. Suitable weighing balance

3. Supplies

   Laboratory glasswares

4. Production costs

   Production cost for the lumbang finishing oil in P148.40 per 4-li. based on prices prevailing CY 1988.

5. Returns

   No study was made to determine returns.

Uses of the Technology

The technology holds bright prospects for application in cottage, small and medium-scale furniture and related products industry. Formulated finishing oil may be used with expected success on wooden products and no restriction is imposed on its applicability on other materials like bamboo, rattan and coconut and buri lumber.

Status of the Technology

Extensive laboratory tests have been conducted to determine the suitability of the lumbang oil-based finish formulation for furniture products. A limited scale service performance evaluation in cooperation with existing woodworking shops in Isabela also has been made. Findings from series of tests are encouraging enough for the generated technology to be recommended for piloting study which has been proposed for implementation for CY 1987.

Appendix B

I. GENERAL INFORMATION

1. Name of Firm :
2. Address :
3. Name of Proprietor
4. Contact Person :
5. Type of Activity
   ——— Manufacturing only
   ——— Manufacturing and Trading
6. Year Established :
7. Type of Organization :
   ——— Single Proprietorship
   ——— Partnership
   ——— Corporation

II. PRODUCTION ASPECTS

1. Raw Materials (Wood)
   a. Sources :
   b. Kind of Materials
   c. Type of Finishes
2. Type of Furniture/Wood Products
3. Market Outlet
   ——— Local
   ——— Export
4. Average volume of furniture produced/types
   ——— Weekly

III. ASSESSMENT OF LUMBANG OIL FINISHES

1. Sanding Schedule
2. Methods application
   a. brush
   b. spray
   c. others
3 Consumption
   a. No. of coats
4. Drying time
5. Other observations
   a. grain raising property
   b. onset of biodeterioration
   c. appearance (glossiness - gloss, satin, matt)
6. Ease of application
   a. brushability
7. Physical side-effects
   a. itchy
8. Comments/Suggestions

SMALL-SCALE LUMBANG FINISHING OIL PROCESSING PLANT
INVESTMENT COST

A. Fixed Cost :			
1. Land 200 sq m @ P300.00/sq m		60,000	
2. Building To house plant set-up raw materials storage product storage, living quarters and office; 110 sq m @ P2,500.00/sq m		275,000	
3. Equipment and Accessories			
3.1 Seed crusher		16,000	
3.2 Oil expeller		24,000	
3.3 Perforated screen with frame		5,000	
3.4 Mixing tank, stainless steel		18,000	
3.5 Filtering device		18,000	
3.6 Oil receiver		5,000	
	Total	86,000	
Total for Fixed Costs			421,000

B. Production Costs:		
1. Raw Materials		
1.1 Lumbang nuts	8.00/k	
1.2 Paint thinner	50.00/k	
1.3 6% Cobalt napthenate	60.00/k	
1.4 24% Lead napthenate	50.00/k	
2. Raw material requirements/month = (26 working days) 200-liter capacity per day	122,357.30	
2.1 Lumbang nuts 1.87 k/L x P8.00/kg x 200 L/day x 26 days/mo =	77,792.00	
2.2 Paint thinner 0.66 L/L x P50.00/4 L x 200 L/day x 26 days/mo =	42,900.00	
2.3 Cobalt napthenate 0.001525 k/L x P60.00/k x 200 L/day x 26 days/mo =	475.8	
2.4 24% Lead napthenate 0.004575 k/L x P50.00/k x 200 L/day x 26 days/mo =	1,189.50	
Sub-total	122,357.30	

3. Labor Cost/Month			
3.1 Direct		13,520.00	
6 Operators. laborers @ P70.000/day x 26 days & 1 foreman @ P100/day x 26 days			
3.2 Indirect		3,000.00	
	Sub-total	16,520.00	
4. Utilities/month			
4.1 Electricity			
6 HP x 0.746 kW/HP x 8 Hrs/day x 26 days x P 2.50/kw		2,372.52	
4.2 Water			
1/2 cu m/day x 26 days x 4.79/cu m		62.4	
	Sub-total	2,434.92	
5. Procurement cost, other supplies/month			
5.1 Containers (4-L cans)			
200 L/day x 1/4 x P5.00/can x 26 days		6,500.00	
5.2 Labels			
P0.50/label (can) x 50 cans x 26 days		650	
	Sub-total	7,150.00	
Total for Production Costs			148,417.22
Total for Fixed Production Costs			569,417.22

C. Production Capacity

200 liters/day or 5,200 liters/month

D. Selling Price

P37.10/liter

CHEMISTRY

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Characterization and Utilization of the Gel and Gum-Forming Compounds in Coconut Water

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Abstract

Coconut water from the Department of Horticulture (UPLB) and from the local market were used in the study. Carbohydrate analysis of coconut water at different stages decreases with maturity while dissolved polysaccharides increases.

A susbstance with the property of a gum was isolated from the liquid endosperm of mature coconuts (9-12 months old). The coconut water was concentrated to 1/5 of its orginial volume and the gummy material was precipitated by the addition of 95% ethanol. The white precipitate that was obtained by alcohol precipitation was freeze-dried and characterized.

Qualitative analysis of the isolate showed the presence of carbohydrates, reducing sugars and protein. Solubility tests of the isolate showed its solubility in water, 5% HCl, 5% H_2SO_4 & 10% H_3PO_4 but a white gelatinous precipitate was obtained with 5% NaOH, 5% $NaHCO_3$, 1.0M HCl & 0.1M NaCl. Solutions of the isolate were further added with different test reagents for gum identification and characterization. Precipitation reaction showed some similarities with gum tragacanth, arabic and locus bean gum.

Viscosity determination gave values relatively lower than that of commercial gums. Chemical characterization of the isolate revealed 26.43% total sugars, 14.33% reducing sugar and 12.10% non reducing sugars, 14.33% reducing sugar and 12.10% non reducing sugars, 1.47% protein and 32.57% ash. Carbohydrate analysis by HPLC showed that glucose, galactose, mannose & fructose are present with a relative galactose:mannose ratio of approximately 1:2. Two peaks in the chromatogram were not identified. Same peaks were obtained for the hydrolyzed and unhydrolyzed isolate from 6 month old coconut water. A major peak in extract A was not identified which is possibly that of an oligosaccharide.

The results of the experiment suggest that a gummy substance which could be of industrial importance is present in the coconut water of mature coconuts.

Introduction

The Philippines is one of the world's largest coconut producing country. Among the commercial palm, coconut is by far the most important and most useful. Aside from its various uses such as oil for cooking and detergent, copra for fertilizer and animal feeds, shell for household u ensils and charcoal, the palm itself is considered an ornamental plant. Indeed coconut has so many uses that is often called the tree of life. Utilization of the useful constituents of the coconut and its by-products should be

maximized and one of this area is the utilization of the coconut liquid endosperm, because of all parts of the coconut, the water is the least utilized.

Production of nata de coco is booming nowadays and one of the by-products of this industry is coconut water. Although coconut water has been found to have various uses, these can not absorb the annual production in the country. Excessive production and disposal of coconut water is a big problem encountered nowadays especially from the dessicated coconut industry.

Coconut water as a waste product has many uses. In animal breeding, it was reported (Clamohoy, 1962) that water from young coconut can be used as diluent for boar semen for artificial insemination. The percentage of alanine, arginine, cystine and serine in the protein of coconut water are reported to be higher than those in cow's milk. For this reason, coconut water is used for infant feeding. The water especially of the young nut is used as beverage in the Philippines.

In rubber industry, it was reported the acid coconut water has been used for latex coagulation. According to the Rubber Institute of Malaysia, the acid water from one coconut will coagulate three-fourth pound of rubber.

In plant nutrition, it is used as a medium for slaking of lime to form a sludge because of its high potash content. The sludge can be applied directly to coconut palm as fertilizer.

Coconut water has also medicinal value. Due to its high content of saline and albumin, it is said to check cholera, destroy intestinal worm and relieve stomach ache.

Coconut water has also been used as a media for the growth of microorganisms. It is also very useful in tissue culture experiments because of its content of growth hormone. Volatile fatty acids are also reported to be produced from coconut water. Coconut water is also an excellent media for the production of nata de coco, a native delicacy and an agent imparting body and velvety texture to ice cream. Coconut water, after fermentation and acidification, could also be used for the production of vinegar. It is also used for the production of yeast, alcohol and wine.

The idea of extracting a gel or gum-forming compounds from coconut water came from the observation that when coconut water is concentrated or evaporated, a thick gummy syrup is obtained. Likewise, the substance which is recovered when the cream is recovered fro m the coconut juice also forms a gel. The substances that are responsible for the formation of coconut jelly are presumably the water-soluble polysacchharides. A large number of gel-forming polysaccharides are known and their chemistry studied but those in coconut water has not yet been identified.

A few research workers mentioned the presence of certain substance in coconut water which they called gum, but failed to give its characteristics and identity. Indian workers reported that 100 cc of fresh coconut water from India contain 0.56 g gum. Child & Nathaniel (1947) failed to identify the 1-2% organic solids other than sugar in coconut water of which gum may be one of these organic solids.

A preliminary study on the separation and characterization of a gummy substance from coconut water based on its physico-chemical properties was done by an undergraduate thesis student in 1972 (San Pedro, E.L. 1972). She obtained a gray substance with the properties of a gum by precipitation, but no studies have been reported yet on the identification and detailed characterization of this gummy substance from coconut water. However, chemical characterization has been made on the water soluble (Samont, 1988) and water insoluble residues of coconut endosperm (Hagenmaier et. al., 1976). The water soluble polysaccharides of the endosperm, primarily galactomannans, were reported to contain a mannose:galactose ratio of about 2.9 while the insoluble residue contained primarily mannose (74%) and glucose after complete acid hydrolysis. Galactommannans and cellulose were present in the endosperm at all stages of maturity but mannose increase with degree of maturation (Balasubramanian, 1976), while the water soluble galactomannan decrease with maturity.

Structural studies have been made on the water-soluble galactomannan (Rao et. al., 1961) and alkali-soluble fraction from unripe endosperm (Kooiman, 1971). According to these workers, the two galactomannans have different structures. The water-soluble form studied by Rao et.al., (1961) apparently has a main chain of galactose and mannose residue and galactosyl branch. This is different

from the alkali-soluble form studied by Kooiman (1971) which has a 1-4 mannan chain substituted by galactosyl residues typical of most seed galactomannan. The presence of mannan in the coconut meat was also indicated from the results of enzymatic hydrolysis of coconut meat products (Alacantara et.al., 1978).

Gums are used in industry refer to plant materials anderivatives which are dispersible in hot or cold water to produce viscous mixtures or solutions. Included in this category are the water-soluble or water-swellable or derivaties of cellulose and starch and other modified polysaccharides which are insoluble in the natural form.

Most gums are polysaccharides and those that are naturally occurring gum polysaccharides used in food can be classed as seed gums, plant exudate gum or seaweed gum. Gums are used in a wide range of specific functions and food application is shown in Table 1. The general function of gums can be attributed to their major properties - gelling and thickening.

The importance of gum in industry specifically in the food industry can not be overlooked. Because of the vast uses of gums, it might be worth looking into other sources of edible gum. Coconut water is an excellent possible source of the gummy material because of its availability, and it might be possible to substitute this gummy material because of its availability, and it might be possible to substitute this gummy material in food preparation in place of the commercially available gums.

Objectives

The overall objective of this study is to extract and characterize the gummy substance found in coconut liquid endosperm.

The specific objectives are :

1. To determine the carbohydrate profile of the coconut liquid endosperm

2. To try various procedures for the maximum release of the gummy materials

3. To characterize the gummy compound.

Methodology

A. Collection and concentration of coconut water

Samples of coconut water for preliminary analysis were collected from newly opened coconut (6-12 months old) obtained from the Department of Horticulture. Succeeding samples were collected from the local market. The coconut water is filtered through a thick cotton wad to remove suspended impurities and to drain off any coconut meat particles. The clean coconut water is then concentrated by several methods (boiling with stirring, sun drying and rotary evaporation) prior to extraction of the gummy material.

B. Extraction of the gummy substance

Various solvents like acetic acid, butanol, ethanol, NaCl and heating were tried as precipitating agents. The optimum coconut water solvent ratio was also determined.

C. Qualitative analysis of the isolate

a. Qualitative test for carbohydrates was done by using the Molisch test

b. Benedict's test was used for testing the presence of reducing sugars

c. Ninhydrin test was used for testing for the presence of protein

d. Reaction with various tests reagents.

Aqueous solutions of the isolate together with standard gums were added with different test reagents. Established methods for the qualitative identification of the gum was used (Ewart and Chapman, 1952). The method used classifies the gum on the basis of physical characteristics or appearance of precipitate.

D. Viscosity determination

Viscosities of aqueous solutions of the isolate were determined using an Ostwald-Fenske viscometer. The effect of varying the temperature on the viscosities of the aqueous solutions of the isolate was also determined.

E. Characterization of the Coconut Water and Gum Isolate.

1. Total Soluble Sugars (Yoshida et.al., 1972)

One ml. of the coconut water was mixed with 0.1 ml distilled water. The mixture was placed in an ice bath after 5 minutes, with an aqueous solution of the isolate.

2. Total Reducing Sugar (Boril et.al., 1952)

One ml. of suitablity diluted coconut water and aqueous solution of the isolate were mixed with DNS (dinitrosalicyclic acid) reagent. The tubes were covered with marble and heated in a boiling water bath, then cooled to room temperature. Absorbance was read at 540 nm.

3. Total Hydrolyzable Polysaccharide (Dawson et.al., 1969)

The total hydrolyzable polysaccharide was determined according to the procedure of Dawson et al (1969). The sample was mixed with 10 ml of 1.0 N H_2SO_4 and refluxed for 2.5 hrs in a boiling water bath. The diluted hydrolyzate was then analyzed for total sugar by the anthrone method.

4. Total non-reducing sugar

Total non-reducing sugars were determined as a difference between total soluble sugars and total reducing sugar.

5. Soluble Protein

Total soluble protein was determined by the Lowry method using the Folin-Ciocalteau reagent.

6. Carbohydrate Analysis by HPLC

The extract was dissolved and hydrolyzed in a 1% H_2SO_4 acid solution for 2 hrs. The hydrolyzate was neutralized, filtered and analyzed by HPLC for its component sugars. The standards used were glucuronic acid, glucose, galactose, mannose, fructose, arabinose and sorbitol because these are the sugars reported to be present in coconut endosperms.

The standard gums were also hydrolyzed and its component sugars were determined by HPLC.

Results and Discussion

Qualitative Test of the Coconut Water

The Coconut water sample gave positive test for carbohydrate as indicated by the formation of a red ring at the point of contact between the sample and the reagent. Benedicts reagents also gave positive result for reducing sugars while ninhydrin solution gave a blue to dark violet color indicative of the presence of proteins.

Carbohydrate Analysis and Total Soluble Protein of Coconut Water

Results of carbohydrate analysis and total soluble protein of coconut water at different stages of development is shown in table 2. Total reducing sugars decreased with maturity from 22.13 mg/ml at 6 months to 4.15 mg/ml at 12 months. There is no definite trend with respect to non-reducing sugars. Total soluble sugar also decreased with maturity from 41.95 mg/ml at 6 months to 20.51 mg/ml at 12 months. Total hydrolyzable carbohydrates, on the other hand. increases with maturity from 0.27 mg/ml at 6 months to 6.56 mg/ml at 12 months. Total carbohydrates present in coconut water decreases with maturity.

Concentration of the Coconut Water

Of the three methods used for concentration of coconut water (heating at 60$C with stirring, sun-drying and reduced pressure distillation), reduced pressure distillation was chosen since it gave a white precipitate after precipitation, while heating up to 60$ with stirring gave a yellowish to light brown precipitate. Sun-drying gave a similar results with reduced pressure distillation, but the method is very dependent on the elements and prone to contamination and fermentation. Samples concentrated by reverse osmosis was also tried bu the method is very dependent on the elements and prone to contamination and fermentation. Samples concentrated by reverse osmosis was also tried but upon extraction the resulting precipitate was yellowish. Color is great importance in the commercial value of gums. A strong preference is always given for light colored gum.

Based from the above experiment, concentration of the coconut water at three stages of development were accomplished using reduced pressure distillation to the extent of 20% of its original vol-

ume. This is the best concentration that gave a white precipitate. A more concentrated coconut water gave a mixture of viscous yellow liquid and white precipitate upon addition of ethanol. It is very hard to separate the liquid from the precipitate.

Extraction of the Gummy Substance

The gummy substance present in coconut water was extracted using 95% ethanol, with additional heating, with NaCl addition and using acetic acid as precipitating agent. A white precipitate was obtained upon addition of 95% ethanol. With additional heating, the product becomes syrupy and thick, while with the addition of NaCl, coagulation was induced but a very hygroscopic precipitate was obtained. With acetic acid, no precipitation was obtained unless ethanol is added.

Ethanol was then used as precipitating agent and the optimum coconut water:alcohol ratio was found to be 1:4 (v/v). For both samples 9-12 months (A) and 6-month (B), a white precipitate was obtained. THe isolate was freeze-dried and a white powder was obtained. The isolate was (Table 3) obtained by alcohol precipitation is 0.71 gm/100 ml for the 12-mo. sample. 0.76 g/100 ml for the 9 month old sample and 2.29 g/100 ml for the 6 month old sample. Since the yield of precipitate is very similar for the 12 month and 9 month old samples, the coconut water samples used thereon are grouped into two only, one is a coconut water sample coming from 6-7 month old nut while water from 9-12 month old nuts were combined. Succeeding coconut water samples for the extraction of the gummy material were obtained from the public market which is essentially a mixture of coconut water coming from 9-12 month old nuts.

Description of the Isolated Precipitate

The isolate was also noted to have a sweet taste and odor. These properties of color and odor are important in the selection of gums for food preparation. Furthermore, the isolate was observed to be hygroscopic. Gums are reported to be hygroscopic and will absorb moisture and become soft in a humid atmosphere. The extract from 6-month old nuts appear to be pastelike rather than powdery. It is more hygroscopipc and absorbs moisture from the atmosphere easily giving a thick viscous fluid. The paste-like substance can also be precipitated from the water of matured nuts at 10% concentration of the original volume.

Qualitative Analysis of Isolate

To have an idea of the chemical nature of gel-forming substance, it was again qualitatively analyzed for carbohydrate, reducing sugars, and protein. Results of the chemical test all showed positive results for reducing sugars, carbohydrate and protein. Since coconut water also showed positive test for reducing sugars, it shows that reducing sugars also indicate that both carbohydrate and protein are included in the ethanol precipitate.

Characterization of the Isolate

1. Solubility characteristics

The manner in which gum dissolved or dispersed in water is an initial screening test which may offer a quick clue to the identity of the gum. Ewart and Chapman (1952) found that the way in which gums disperse in water after being wetted with alcohol is a valuble aid in the identity of an unknown sample. For example, gum arabic dissolves easily in water, while tragacanth and karaya swell to give viscous, stringy dispersions. The dispersion in water of some alcohol wetted gums commonly found in food preparation are shown in Table 4. Meanwhile, extract B from coconut water dissolved easily while extract A was observed to disperse and dissolve slowly in cold water forming a suspension. Insoluble particle settle on standing which upon heating, swelling and thickening of the mixture was observed.

Furthermore, the isolate was tested for its solubility in several organic and inorganic solvents at 29°C (Table 5). Results showed that it was only soluble in aqueous solution of 5% HCl, 5% H_2SO_4, 10% H_3PO_4, 5% NaOH, 5% $NaHCO_3$, 1.0M NaCl, and 0.1 M NaCl. Like gum arabic, the gel forming compound from coconut water was completely insoluble in most of the organic solvents.

Solubility behavior of substance with different solvents will give information on its functional group and molecular weight. Solubility of the isolate in water but insolubility in either suggest that the gel - forming substance from coconut water are polyfunctional compounds. Insolubility of the isolate in choloroform and benzene and solubility in water further confirms its polar nature. Meanwhile, with 5% NaOH, 5% $NaHCO_3$ and 1M NaCl, it was noted that gelatinous white precipitate settle on standing. It has been reported that polysaccharides maybe

precipitated as the salt of the cation of the solvent electrolyte. The polysaccharide is then obtained as the salth of the inorganic cation.

2. Behavior of the isolate with some reagents

Early work on the qualitative identification of gum classifies gum on the basis of physical characteristics or appearances of precipitate with several test reagents. Table 6 shows the reaction of standard gums and that of the coconut water isolate using various test reagents. With lead acetate, gum arabic, tragacanth and locust bean gum precipitated. An aqueous solution of the isolate gave a voluminous precipitate with the addition of NH_4OH. Like gum arabic, tragacanth and locust bean fum, a yellow precipitate was observed when the solution was reacted with KOH. Of the gums tested, the isolate gave a reaction close to that of gum tragacanth, arabic and locust bean gum. Tragacanth is reported to contain L-fucose, D-xylose, Galacturonic acid, L-arabinose and D-galactose. Gum arabic on the other hand, contains D-glucuronic acid, D-galactose, L-arabinose, rhamnose (mixed Ca, Mg, & K salts). Locuse bean gum on the other hand contains mannose and galactose. The small amount of precipitate with $CaCl_2$ may indicate that the polysaccharide form an insoluble salt with the cation in alkaline solution. It has been reported that many acidic polysaccharide form insoluble salts with polyvalent cations in acidic, neutral or mildly alkaline solution (Pittet, 1965). Additional tests have to be made to really identify the gum. Furthermore, purification of the isolate may change its behavior with test reagents.

3. Viscosity Determination

Table 7 showed the viscosities of some commercial gums and that of extract A. The viscosities of the isolate increased with increaisng concentration at 29$C but was relatively lower than the reported viscositis of other gums. The viscosity of the isolate also increased with increasing temperature. The relatively lower viscosity of the sample may be due to the presence of high amount of reducing sugar and impurities which may not ne gum or polysaccharide in nature. Wherease most gums form highly viscous solutions at low concentrations of about 1-5%, gum arabice is also unique in that it is extremely soluble and not bery viscous at low concentration. The ability to form highly concentrated solution is responsible for the excellent stabilizing and emulsifying properties of gum arabic when incorporated with large amount of insoluble materials. This property may hold ture for the extract from coconut water. Moreover, in general, the low viscosity of natural gums are more stable that the high viscosity types.

4. Chemical Characterization of the Isolate

Table 8 shows the result of carbohydrate analysis of the isolate. Total sugar amounts to 26.43% total sugar of which 14.34% is non reducing. A relatively high amount of ash is present in the sample indicating the presence of high amounts of minerals.

5. Monosaccharide Analysis

The gummy material isolated from the 6 months and 9-12 month old coconut water were hydrolyzed and analyzed for sugar composition by HPLC. Figure 1 shows the HPLC chromatogram of sample A (9-12 mos.) and sample B (g months), while Figure 2 shows the chromatogram for the mixed standard sugars used. The standard sugars consisting of glucose, and possibly a mixture of galactose, mannose and fructose were identified in the chromatograms of Samples A & B. Sugars in the sample hydrolyzate were identified by comparing its retention time with that of the standard sugar. Spiking was also done to confirm the identities of the sugars. The first peak in sample A, though unidentified at this point is also observed in the hydrolyzate of the other gums tested like gum acacia, tragacanth, carageenan, gelatin and agar. This peak is probably that of an oligosaccharide which is not easily hydrolyzed. This particular sugar is much greater in sample A than in B and this could be responsible for the formation of the gel or gum of the extract as in other commercially marketed gums.

The chromatogram of gum tragacanth in Figure 3 shows the presence of glucose, galactose, mannose and possibly arabinose. Gum acacia reveals the presence of arabinose and possibly galactose and mannose and 2 unidentified peaks. Cargeenan (Figure 4) shows the presence of galactose, trace of glucose and at least 2 unidentified peaks. Agar shows the presence of galactose and 3 unidentified peaks in each of the gums at this point that the unidentified first major peak in sample A.

Del Rosario et al (1984) reported the HPLC chromatogram of coconut water concentrated by reverse osmosis and identified the first peak in the

chromatogram to be that of oligosaccharides or soluble polysaccharides. Results of our analysis showed that total soluble polysaccharides increases with maturity.

The chromatograms of unhydrolyzed samples (Figure 5) of extract A & B, i.e., their solutions in water, were also taken and compared with those of their hydrolyzates. It was observed that sample B dissolved completely in water while A was only partially soluble. As can be seen in Figure 5, the chromatogram of sample B, both hydrolyzed and unhydrolyzed, match each other, i.e. all the peaks of the hydrolyzed sample are also present in the hydrolyzed sample in similar proportions. These sugars are probably present as such in the isolate and any oligo- or polysaccharides present were not really hydrolyzed by the conditions used. The chromatogram of extract A, on the other hand, shows that although both peaks are present, they are not in similar proportion. In the chromatogram of the hydrolyzate, the first peak is much greater in height than the second peak while in the chromatogram of the unhydrolyzed sample it is shorter in height than the second peak. It is possible that extract A probably contains insoluble polysaccharides, thus the increase in height of the first peak. HPLC results show that glucose, mannose, galactose and fructose are present with a relative galactose:mannose ratio of 1:2.

Results of HPLC have to be confirmed since no internal standard was included in the sample and quantitation of the sugars present was not made.

Summary and Conclusion

Carbohydrate analysis of coconut water at different stages of maturity was carried out. Analysis of reducing sugars decreases with maturity while dissolved polysaccharides increases.

A substance with the property of a gum was isolated from the liquid endosperm of mature coconuts (9-12 months old). The coconut water was concentrated to 1/5 of its original volume and the gummy material was precipitated by addition of 95% ethanol. The white precipitate that was obtained by alcohol precipitation was freeze-dried and characterized.

Qualitative analysis of isolate showed the presence of carbohydrates, reducing sugars and protein. Solubility tests were also carried out and the isolate was found to be soluble in water, 5% HCl, 5% H_2SO_4, & 10% H_3PO_4 but a white gelatinose precipitate was obtained with 5% NaOH, 5% $NaHCO_3$, 1.0M HCl & 0.1M NaCl. Solutions of the isolate were further added with different test reagents for gum identification and characterization. Precipitation reaction showed some similarities with gum tragacanth, arabic locust bean gum.

Viscosity determination gave values relatively lower than that of commercial gums. Chemical characterization of the isolate revealed 26.43% total sugars, 14.33% reducing sugar and 12.10 % non-reducing sugars, 1.47% protein and 32.57% ash. Carbohydrate analysis by HPLC showed that glucose, galactose, mannose and fructose are present with a relative galactose:mannos ratio of approximately 1:2. Two peaks in the chromatogram were not identified. Same peaks were obtained for the hydrolyzed and unhydrolyzed isolate from 6 month old coconut water. A major peak in extract A was not identified which is possibly that of an oligosaccharide.

The results of the experiment suggest that a gummy substance which could be of industrial importance is present in the coconut water of mature coconuts.

Table 1. Uses of Gums (1,2)

Function	Application
In Food Products	
Adhesive	Bakery glaze
Binding agent	Sausages
Bulking agent	Dietetic food
Crystallization inhibition	Ice cream, sugar syrup
Clarifying agent	Beer, wine
Cloud agent	Fruit juice
Coating agent	Confectionery
Emulsifier	Salad dressing
Encapsulating agent	Powdered fixed flavor
Film former	Sausage casings, protective coating
Flocculating agent	Wine
Foam stabilizer	Whipped toppings, beer
Gelling agent	Puddings, dessert
Mold release agent	Gum drop, jelly, candies
Stabilizer	Beer, mayonnaise
Suspending agent	Processed meats
Swelling agent	Cheese, frozen foods
Thickening agent	Jam, pie fillings, sauces, gravies
Whipping agent	Toppings, icings
In Cosmetics and Pharmaceuticals	
Thickener	Toothpaste, lotion and cream
Stabilizer	Lotion and cream
Binder	Compressed tablets
In Paper Industry	
Wet end additive	Fiber bonding in paper making
In Tobacco Industry	
Binder	Production of reconstituted tobacco
In Mining Industry	
Auxiliary agent	Froth flotation of potash
Settling agent	Concentrated ores and tailings
Filter aid	Flocculation of small particles
Water treatment	Settling of solid impurities
In Textile Industry	Sizing agent
In Oil-drilling Industry	Drilling and additive
In Explosives	Production of water resistant ammonium nitrate sticks

(1) Glicksman M. 1969

(2) Whistler R. L. and J.N. Bemiller, 1973

Table 2. Carbohydrate Analysis and Total Soluble Protein of Coconut Water Different Stages of Development

	Age of Coconut (months)		
	6-8	9-10	11-12 mos
Total Reducing Sugar	22.13	12.23	4.15
Non-reducing Sugar	19.82	22.33	16.36
Total Soluble Sugar	41.95	34.56	20.51
Total Hydrolyzable Carbohydrates	0.27	1.24	6.56
Total Carbohydrates	42.22	35.8	27.07
Total Soluble Protein (ug/ml)	674.93	797.88	1,075.32

** Average of 3 trials*

Table 3. Yield of ethanol extract from concentrated coconut water

Age (months)	Weight of isolate (g/100 ml)
6	2.29
9	0.76
12	0.71

Table 4. Solubility of Dispersion in water of some alcohol wetted gums

Gum	Manner of Dispersal in water
Alginate	Dissolves slowly in cold water or quickly on heating to form viscous solution.
Carageenan	Dissolves slowly in cold water, rapidly on heating to form viscous solution.
Agar	Swells in cold water, dissolves on heating, gels on cooling
Tragacanth	Swells to form viscous dispersion in hot or cold water but does not form true solution.
Locust bean	Forms viscous suspension but not a true solution
Karaya	Forms viscous suspension. Insoluble particles settle on standing.
Arabic	Dissolves in cold water to form a clear slightly viscous solution
Starch	Disperses on heating.
Extract A (9-12 months)	Disperse and dissolve slowly in cold water forming a suspension. Insoluble particles settle on standing which swells and thickens upon heating.
Extract B (6 months)	Dissolves easily in cold water.

Table 5. Solubility properties of the Isolate at 29°C (Extract A)

Test Solvent	Observation
Petroleum ether	insoluble
Acetone	insoluble
Chloroform	insoluble
Benzene	insoluble
Methanol	insoluble
Butanol	jnsoluble
Isopropanol	insoluble
Ethanol	insoluble
5% HCl	soluble
5% H2SO4	soluble
10 % H3PO4	soluble
5% NaOH	soluble, white gelatinous precipitate which settle on standing
5% NaHCO3	soluble, white gelatinous which settle on standing.
1M NaCl	soluble, gelatinous precipitate settle on standing.
0.1 M NaCl	soluble
Water	soluble

Table 6. Reactions of Standard Gums and Gum Isolate with Test Reagents

Gums	Reagents Used						
	1/5 vol. CaCl2	10% KOH	0.1M Ba(OH)2	1 M Ba(OH)2 (+5 min. standing)	1 ml lead acetate	1 ml. Pb(Ch3COO)2 (+NH4OH)	C2H5OH +2-3 drops NaCl
Tragacanth	-	intense yellow soln	turned slighly cloudy	slightly cloudy ppt on standing	flocculent ppt.	flocculent ppt.	voluminous ppt jelly like
Agar	-	-	-	-	-	gels	fine floculent ppt
Starch	-	-	turned slightly cloudy clearly on heating and cloudy on cooling	immediate precipitation	-	precipitate	opaque floculent ppt
Arabic	-	faint yellow tinge	-	-	immediate precipitation	-	fine opaque non-settling ppt.
Gelatin	-	-	-	-	-	-	fine floculent ppt coagulated
Carageenan	-	-	"gels"/cloudy viscous gels	gels (transparent)	gels (white)	-	-
Locust bean	-	slightly flocullent precipitate	-	-	small amount of ppt	opaque gel	voluminous ppt.
White Ethanol Extract A	very small amount of ppt standing	cloudly soln then turned yellowish intensity inc w/ heating	very small amount of ppt on heating	formation of white ppt on standing	slightly cloudy	immediate precipitation	voluminous ppt.
Yellow Ethanol Extract B	small amount of fine ppt./ gels when NH4OH was added	slightly yellow lq; precipitates upon heating	turned cloudy yellow lq. +precipitate on heating	immediate precipitation	immediate precipitation	voluminous precipitate	voluminous ppt.

** 8.25 g sample/50 ml solution were used except in the case of agar, gelatin and starch wherein smaller amount were used to prevent undesirble gelation. Three ml aliquots were used for the determination.*

Table 7. Relative viscosities (cps) of some commercial gum and that of Extract A

Concentration (ppm)	Extract B	Guar gum	Gum arabic	Gum tragacanth	Locust Bean
100	-	0.995	-	54	28.5
300	0.49	-	-	906	1114
500	0.557	1.557	-	10605	8260
1000	0.882	2.567	-	44275	39660
1500	1.025	-	-	111000	121000
2000	1.144	-	-	183500	-
3000	1.387	-	7	-	-

Table 8. Chemical characterization of the isolate (Extract A).

Components	Percent
Total sugar	26.43
Reducing sugar	14.33
Non-reducing sugar	12.10
Total soluble protein	1.47
Ash	32.57

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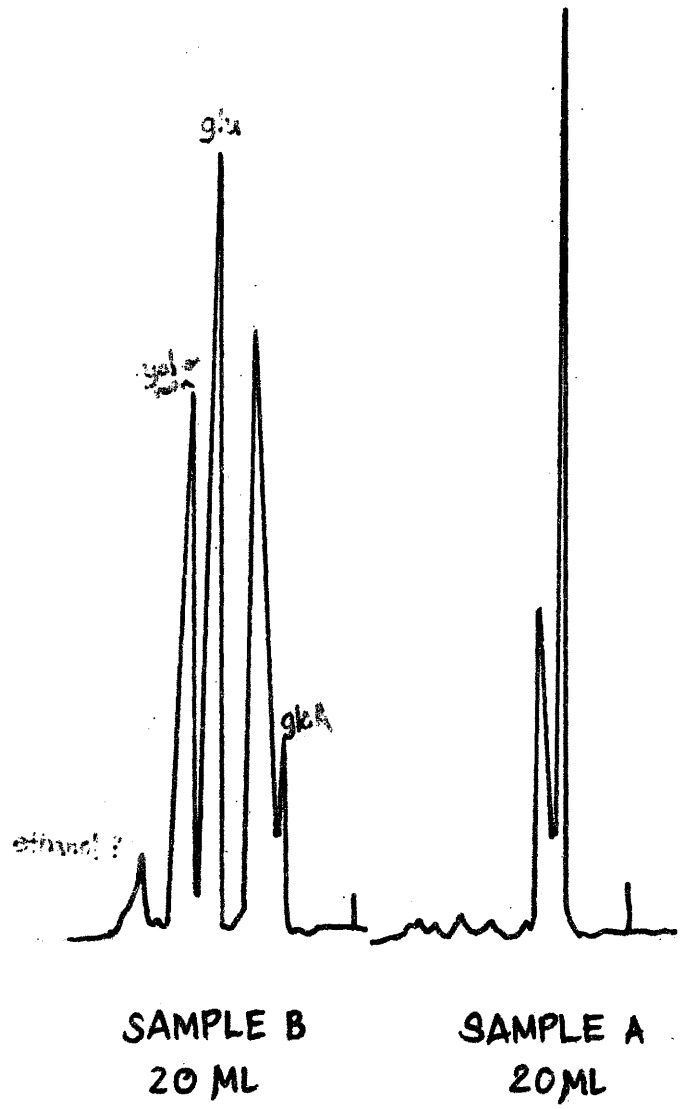

Figure 1. HPLC chromatogram of hydrolyzed extract from coconut water; Chart speed: 12.5/60 cm/min; flow rate: 0.5 ml/min; attenuation: 16X; column: sugarpak; temperature: 90°C; Mobile phase: water.

1 Glucuronic Acid

2 Glucose

3 Galactose & Mannose

4 Fructose

5 Arabinose

6 Sorbitol

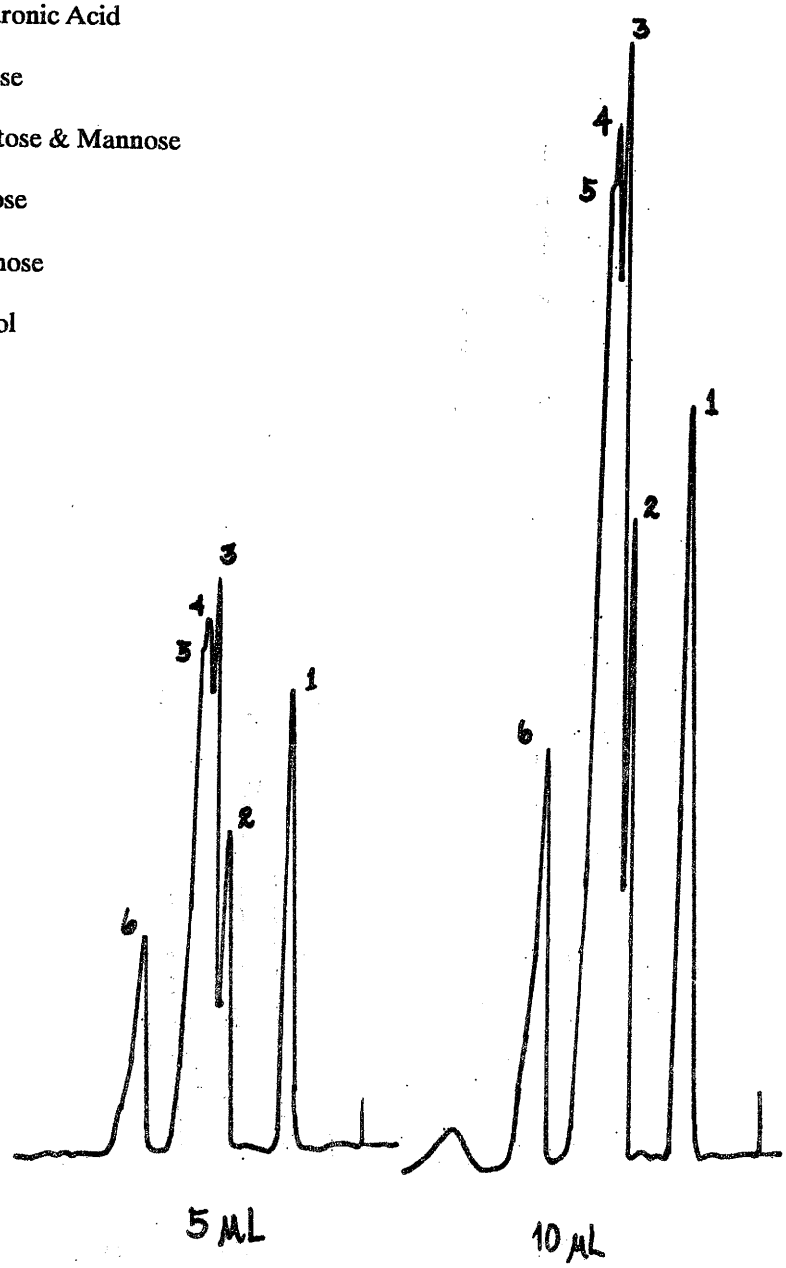

Figure 2. HPLC chromatogram of mixed standards: (1) glucuronic acid, (2) glucose, (3) galactose and mannose, (4) fructose, (5) arabinose, (6) sorbitol; Chart speed: 12.5/60 cm/min; flow rate: 0.5 ml/min; attenuation: 16X; column: sugarpak; temperature: 90°C; mobile phase: water.

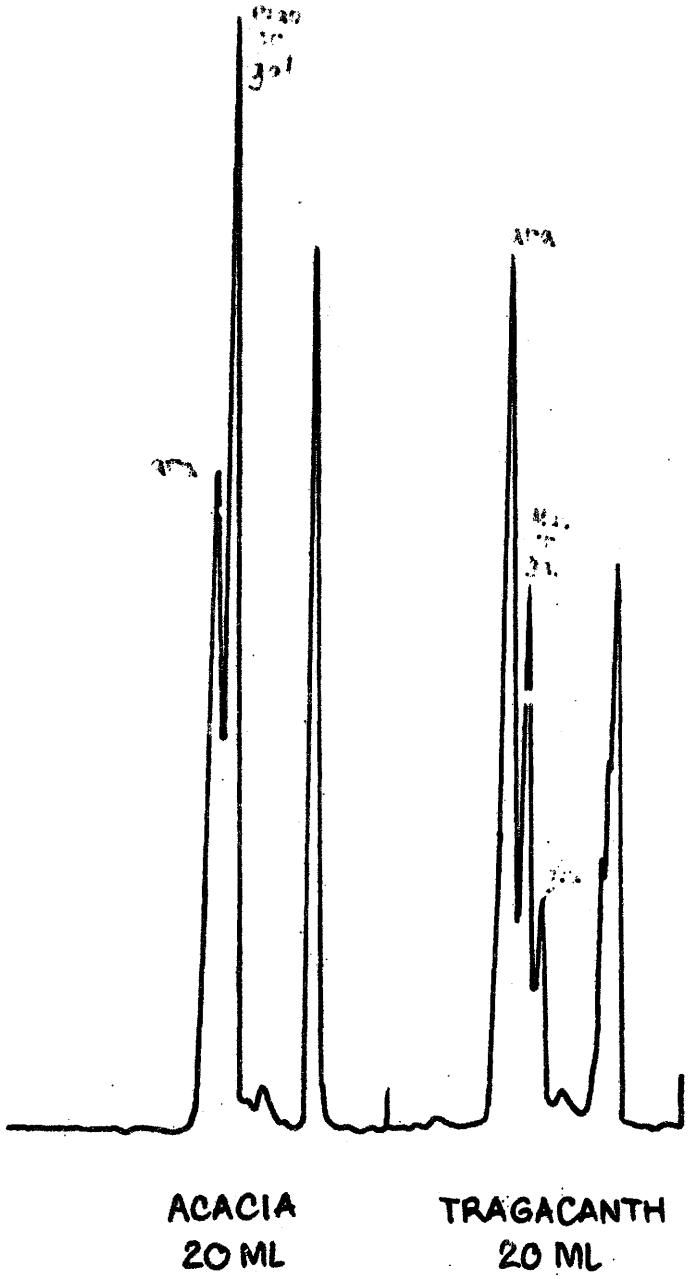

Figure 3. HPLC chromatogram of commercial gums; Chart speed: 12.5/60 cm/min; flow rate: 0.5 ml/min; attenuation: 16X; column: sugarpak; temperature: 90°C; mobile phase: water.

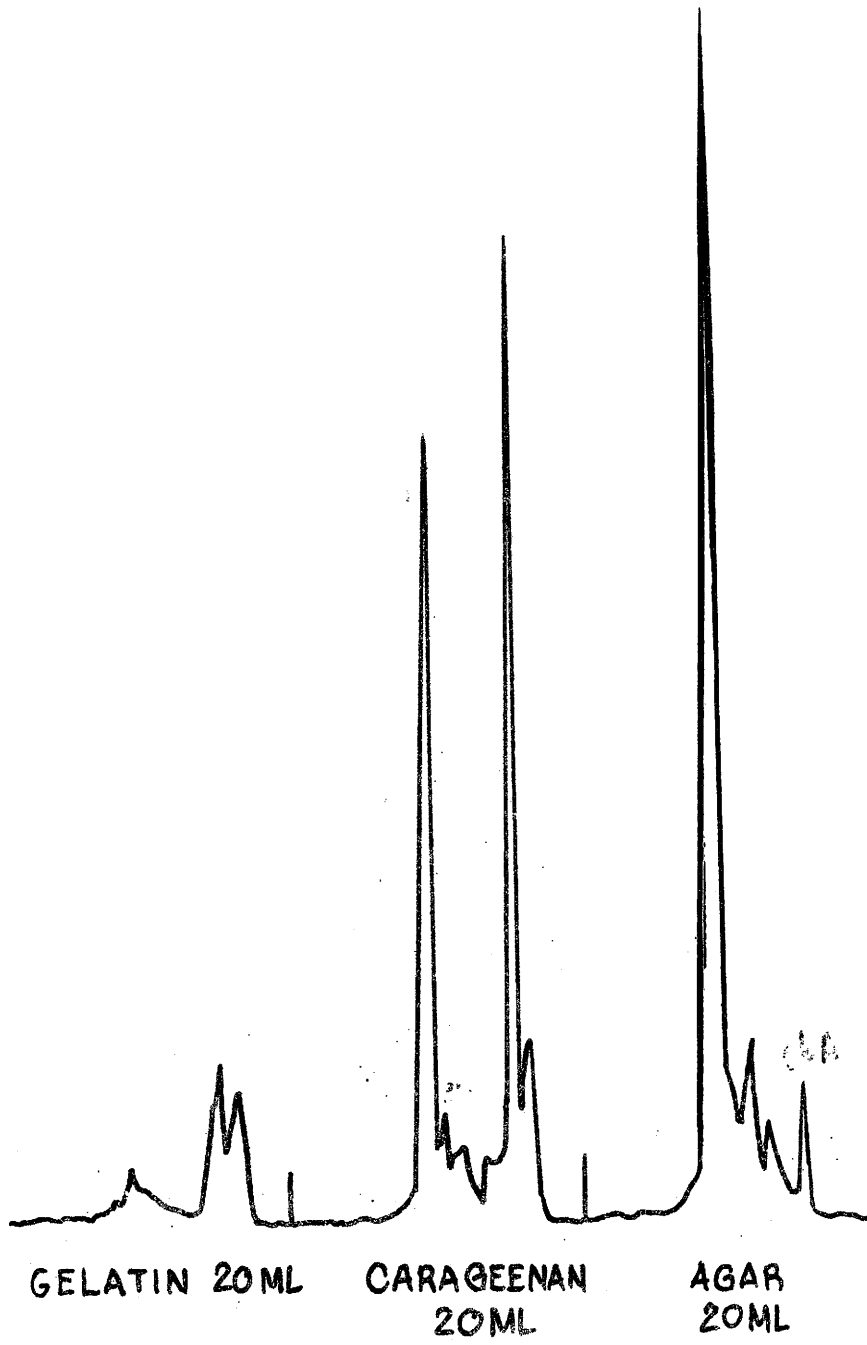

Figure 4. HPLC chromatogram of commercial gums; Chart speed: 12.5/60 cm/min; flow rate: 0.5 ml/min; attenuation: 16X; column: sugarpak; temperature: 90°C; mobile phase: water.

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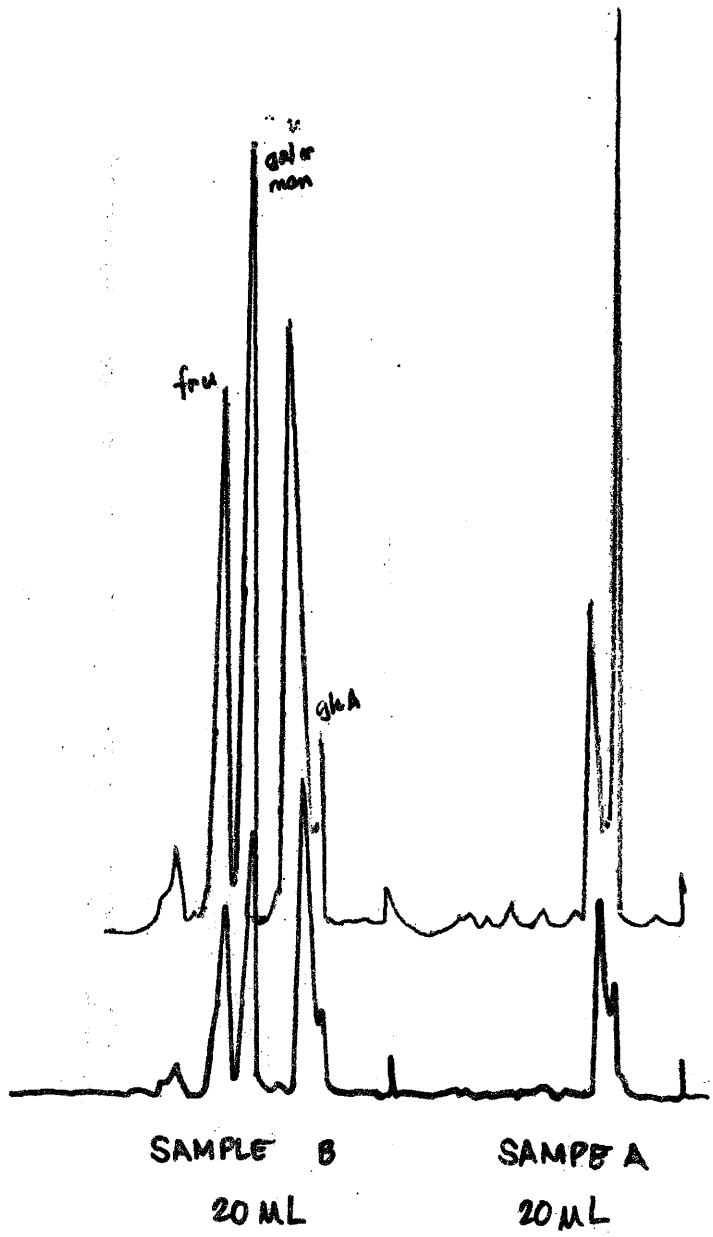

Figure 5. HPLC chromatogram of coconut water extract: (**) hydrolyzed, (***) unhydrolyzed; Chart speed: 12.5/60 cm/min; flow rate: 0.5 ml/min; attenuation: 16X; column: sugarpak; temperature: 90°C; mobile phase: water.

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Charcoal and Activated Charcoal from Coconut Husks

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Introduction

Region IV is one of the coconut growing regions of the Philippines. Coconut husks which are on of the by-products of copra production is underutilized. Only about one percent goes to coir fiber extraction.

Activated carbon has varied commercial applications. The prospects of coconut husk activated carbon for specifica applications are the main concern of this study.

Carbon, prior to activation contains hydrogen in the form of hydrocarbon chains and rings attached to border atoms of the hexagon plates. Much of this is removed during activation at temperatures below 950°C.

The ability of ordinary charcoal to absorb gases and impurities is greatly diminished by the presence of high-boiling hydrocarbon tars adhering to the carbon. Much of the hydrocarbon is removed by processes known as activation. By activation, a vast network of capillaries created increases and improved the adsoprtive power of the charcoal.

Activated carbon has a wide range of uses :

a. Liquid purification which employs low density, finely ground soft charcoals; and

b. Gas and vapor adsoprtion for which high density hard types are preffered.

Yanai (1962), in a laboratory study applying steam activation to charcoal from a mixed-waste wood, found that yield and hardness were inversely proportionate to the degree of activation. Mixing soft and hard charcoals accelerated activation. Different materials and activation techniques influence the properties of the activated carbon. In highly specialized processes, activated carbon from one particular type of material and activation techniques may be the only accepted medium. For each use, a carbon must be with the desirable structural properties and the peculiar affinity, for the adsoprtion of the impurities found in the material to be treated (Steam, 1956).

Materials and Methods

A. Materials

1. Coconut husks were collected from San Pablo City and vicinity. These materials were sun-dried to desired moisture content (16%) prior to carbonization.

2. 0.2 N Iodine - potassium iodide solution. Iodine solution was prepared by dissolving in boiled distilled water the required amount of analytical grade resublimed iodide crystals and analytical grade potassium iodide crystals (20 g/l).

3. 0.1 N Sodium thiosulfate solution. Thiosulfate solution was prepared from analytical grade sodium thiosulfate crystals dissolved in boiled distilled water and standardized against analytical grade potassium iodate.

B. Methods

1. Carbonization. The coconut husk (11.5 kg) was carbonized in a kilm made of (200 li) drum, as

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shown in Figure 1. The carbonization time was 1 hour and 30 minutes. The temperature of carbonization was 130°C to 140°C.

2. Proximate Chemical Analysis. Ground charcoal samples were passed through a 70-mesh sieve and the coarser particles were analyzed for moisture, volatile matter, ash and fixed carbon using the methods suggested by Moore and Beglinger (1961).

3. Activation

a. Zinc Chloride Activation Process

Ground charcoal samples from coconut husk were activated.

Concentrated zinc-chloride solution was mixed with charcoal in the proportion of 1:10. The mixtures were boiled for 30 minutes, 1 hour, 1 1/2 hours, cooled and filtered, charcoal was placed in a crucible with fitted cover and heated in a muffle furnace at 700°C in the absence of air for 30 minutes, 1 hour and 1-1/2 hours, after which the product was washed with distilled water to remove the zinc chloride which could be reused.

b. Steam Activation Process

The weighed ground charcoal passing through No. 70 U.S. standard mesh sieve was placed in a muffle furnace. Activation was carried out with the use of steam at temperature of 800°C to 1,000°C for 10 minutes as shown in Figure 2.

c. Iodine Adsorption Determination

The acitivated-chjarcoal samples were dried ovenight at 105°C. Their iodide-adsorption values were determined according to the procedures described by Fanega et.al. (1963).

d. Tests for the Industrial Application of Activated Coconut Husk Charcoals

A series of duplicate determination were carried out for the test.

Water purification. Samples of varying weights (0.05, 0.10. 0.50. and 1.0 gm) of activated charcoal were ground into a thin paste in mortar and pestle with a small portion form one liter of pond water. The paste was transferred into an Erlenmeyer flask and the remaining liter of pond water was added. The flask was shaken for 10 minutes and water filtered twice through the same muslin cloth to remove all traces of carbon.

The purity of the treated water was measure by determining the pH. The results obtained were compared with those of untreated pond water, tap water, and distilled water.

e. Treatment of Sugarcane Basi

Sugarcane basi, the famous Ilocano wine from sugarcane, obtained from Pangasinan, was treated with the activated charcoal.

Variable weights of activated coconut husk activated charcoal, 0.10, 0.25 and 0.5 grams were made into a thin paste in a mortar and pestle. This was gradually diluted with portions of 40 ml sample of sugarcane basi. The remaining parts of the sample were quickly added and the solution placed in a 250 ml Erlenmeyer flask, fitted with a rubber stopper. The flask was shaken for 30 minutes, and the solution was filtered twice through a filter paper to make certain that all traces of carbon were removed.

A "permanganate test" was carried out to measure the amounts of reducing compounds present in untreated and treated samples. This consist in bringing a 50 ml sample to 180°C in a Nessler tube and adding 1 ml of standard potassium pemanganate solution. The time from the addition of the permanganate until solution turned from pink to yellow was the permanganate time.

Results and Discussion

Results

Results of the proximate chemical analysis of the raw materials and the corresponing activated charcoals produced are presented in Table 1. Results are based on oven-dry samples.

For purposes of comparison, data on the iodine adsorptivities of activated charcoal produced by experimental zinc chloride and steam activation processes and commercial active carbon are given in Table 2.

Table I Proximate chemical analyses of coconut husk charcoal and activated charcoals

Sample	Proximate Chemical Analysis			
	Moisture %	Volatile Matter Content %	Ash %	Fixed Carbon Content %
Coconut husk Charcoal	11.25	9.44	9.78	81.28
Activated Charcoal				
A1 (a)	10.15	12.89	7.54	79.56
A2	9.29	20.36	9.36	70.27
A3	13.42	9.96	6.15	83.88
B1 (b)	12.43	7.34	8.89	83.76
B2	10.78	8.13	8.21	83.65
B3	11.25	8.31	9.68	82.00
C1 (c)	10.69	9.98	7.47	82.54
C2	11.61	9.64	10.03	80.32
C3	13.06	7.54	4.86	87.60
SAC (d)	11.14	9.90	7.59	82.50
Commercial active content	-	8.00	6.40	85.60

(a) Boiling with ZnCl2 for 20 min. and heating time of 30 min. (A1), 1 hr (A2) and 1-1/2 hrs (A3).

(b) Boiling with ZnCl2 for 1 hr and heating time of 30 min (B1), 1 hr (B2) and 1-1/2 hrs (B3).

(c) Boiling with ZnCl2 for 1-1/2 hrs and heating time of 30 min (C1), 1 hr (C2) and 1-1/2 hrs (C3).

(d) Steam activation for 10 min at 800-900°C.

Table 2. Comparative iodine adsorption values of experimental activated

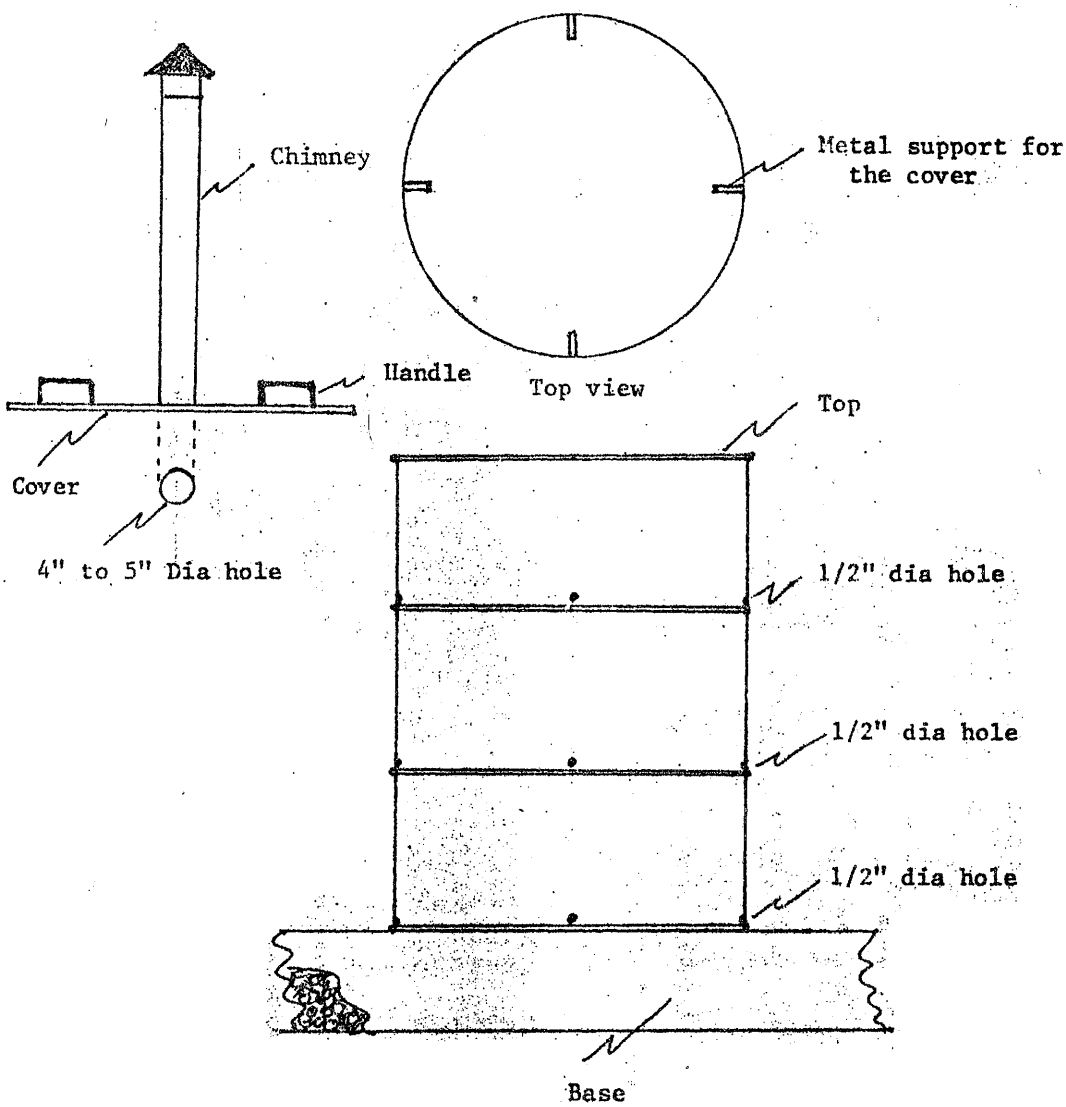
	Approximate Charcoal Weights (gms)	Iodine Adsorptivity(a) (gm/ml)
Coconut	0.10	1,133.80
Husk activated	0.25	975.6
Charcoal(b)	0.50	927.7
(ZnCl2 method)	0.75	566.8
	1.00	497.1
Coconut husk	0.10	865.7
Activated charcoal	0.25	636.0
(Steam activation)	0.50	609.5
	0.75	562.8
	1.00	367.5
Commercial active	0.10	868.1
Carbon	0.25	619.1
	0.50	546.9
	0.75	489.3
	1.00	443.2
Decolorizing carbon	0.10	871.2
	0.25	600.1
	0.50	530.4
	0.75	460.3

(a) Figures represent ml of 0.2N absorbed per gram of the charcoal.
(b) Boiling with ZnCl2 for 1 hr and heating for 1-1/2 hrs.

Table 3. pH of Treated Water

Charcoal Weights (gms)	pH ZnCl2-activated Coconut husk Charcoal	pH Steam-activated Coconut husk Charcoal
0.05	6.8	6.8
0.10	7.0	7.2
0.50	7.7	7.8
1.00	7.9	7.9

	pH
Distilled water	7.0
Tap Water	6.5
Untreated pond water	6.5



Specification:

Drum Diameter = 23"
Drum Height = 35"
Drum Thickness = 1/8"
No. of Air Holes = 12 holes (1/2" dia)

Figure 1. Kiln used in the production of the coconut husk charcoal (FPRDI Model).

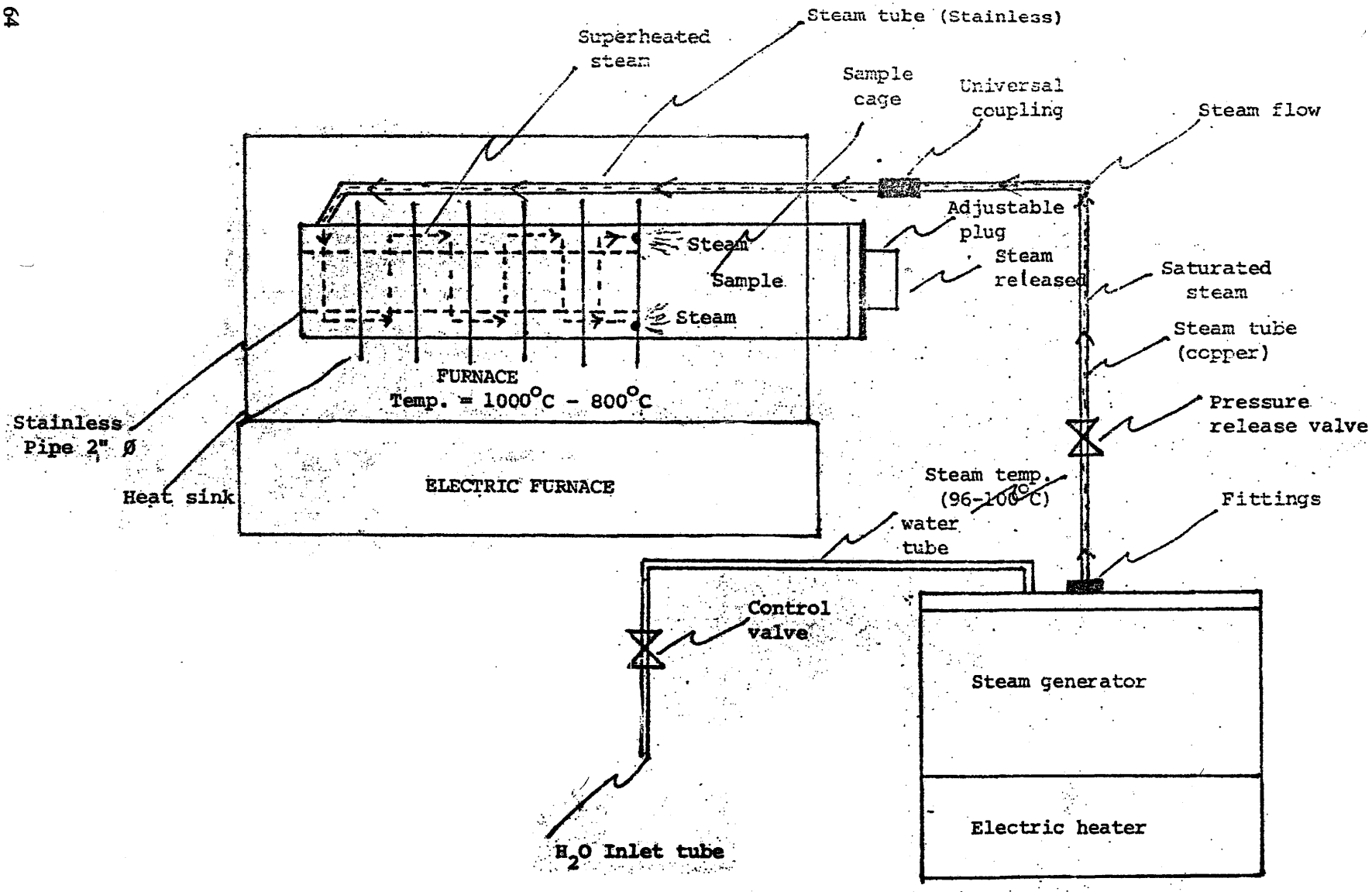


Figure 2. Schematic diagram of the set-up used for steam activation of charcoal.

Discussion

The unusual action of activated charcoal is mainly due to its selective affinity for particular substance; these substances are adsorbed on the surface of the charcoal. The external, visible surface can be increased by making the charcoal particles very small; the ratio of surface to volume becomes considerably increased. The exposed surface area may be even more greatly enlarged by creating internal pores and fissures.

Zinc-chloride activated carbon from coconut husk gave higher iodine values. The iodine adsorptivities of steam activated carbon are comparable with that of commercial active and decolorizing carbon.

The choice of iodine as test adsorbate was based on the conclusion of Chaney and co-workers (1978) that "whenever the substance to be adsorbed are of molecular dimensions, we may expect the retentivity or activity (as represented by iodine number) to be a true index of the performance of any carbon". They observed that the decolorizing power of active carbons tested for sugar solutions increased with iodine activity. Furthermore, it has been shown that the color removal by vegetable carbons from sugar and molasses solutions followed the Freundlich equation (Sanders, 1978).

Puri and Singh (1981) found that part of the iodine removed by charcoal from aqueous solution was converted to HI, the corresponding amount of oxygen being chemisorb by charcoal from aqueous and non-aqueous solutions had been studied by Tovbin and Tovbin (1981). They observed that the rate of adsorption was proportional to the adsorbability of iodine from a given solvent and independent of the intensity of stirring.

In water purification, the pH of treated water was compared with those of ordinary distilled water and tap water from the faucet. The pH is directly related with ions and other impurities present in the water. From the results (Table 3), it is evident that both zinc-chloride activated and steam activated coconut husk charcoals produced water much purer that tap water and pond water by absorbing the impurities. This can be made a cheap method of water purification in the rural areas. In boiler-water industries, the same method avoids any possible corrosion or scales in the boiler plant.

The taste preference indicated that the treatment of sugarcane basi with activated coconut husk charcoal removed the undesirable raw-whisky taste.

It is interesting to note that the taste preference and the desirable effects of aging on whiskies are not yet completely understood. Some theories hold for low fusel oil, aldehydes, and acid values; others consider the relative amounts of all materials more important than the absolute values of each. On this basis, it may be of interest to consider the action of activated coconut husk charcoal as substitute for part of the aging time in the whisky industry, as well as a possible means for the reduction of impurities in the manufacture of industrial alcohol.

Conclusions

Within the content of the study, the following conclusions may be drawn:

1. Charcoals obtained from coconut husk are good sources of activated carbon; and

2. Zinc-chloride and steam activated carbon from coconut husk may possibly be used industrially in water purification and treatment of sugarcane basi.

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The Allium fistulosum as a Biological Monitoring System : Its Response to Potassium Bromate (KBrO3)

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Introduction

Plants are becoming more and more important in environemtnal monitoring. Plants have a significant advantage vis-a-vis measuring gauges. According to Soja (Anonymous, 1994), the concentration values of individual trace cases normally do not allow reliable conclusions on the actual stress reactions of man, flora and fauna. He said that these can only be observed at living organisms.

Some plants provide unique and reliable systems for detecting and analyzing the effect of chemicals and/or physical mutagens. As a group, plants offer systems for the analysis of almost all known genic and chromosomal aberrations which have been induced in eukaryotes by chemical and physical mutagens (Medina, 1987).

Fiskesjo (1985) suggested the Allium test as a standard in environmental monitoring. The Allium test is a short term chromosome conditions for the study of chormosome damage or disturbance of cell division, including the evaluation of risks of aneuploidy. Fiskesjo added that positive results (chromosomal aberration, disturbance in cell division, etc.) in the Allium should be considered as a warning and also as an indication that the tested chemicial may be a risk to human health and to our environment.

One of the oldest, simplest and least expensive methods for studying the induction of chromosome aberrations utilizes plant root tips as experimental material (Kihlman, 1975). Cytological procedures for the routine use of plant for environmental monitoring and as a test system for environmental insults: clastogenecity, carcinogenecity and teratogenecity, are discussed in a paper by Medina (1994).

This study was done to find out which *Allium sp.* is best to use as plant test system under the Cytogenetics Laboratory, P.N.R.I. conditions, and its response to potassium bromate, a flour additive which is now attracting attention due to its being a potential mutagen/carcinogen.

Materials and Methods

Three varieties of *Allium sp.* were chosen : multiplier variety ("sibuyas Tagalog", *A. fistulosum*), red creole and white onions (*A. cepa*). Two kilos of small (1.5 cm - 2.0 cm) bulbs of each variety were brought from a flea market on the understanding that they were from last year's harvest. Onions have a dormancy of one year and usually harvested onions of this year are kept in storage and last year's harvest are sold in the market this year.

The outer scales of the bulbs and the brownish bottom plate are removed, the ring of the root

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primordia being left intact. The peeled bulbs were put into fresh tap water during the cleansing procedure to protect the primordia from drying.

The bulbs were set overnight, using 1.5 cm diameter test tubes with a capacity of 15 ml, filled with tap water. The test chemical ($KBrO_3$) was started the following day in concentrations of 0 ppm, 25 ppm and 50 ppm. The experiment was terminated at day 5. Measurements and photographs of the roots were taken. Observation on the rooting were noted. See the experimental design below.

Experimental Design

Treatment ($KBrO_3$)	Multiplier	Red Creole	White
0 ppm	10	10	10
25 ppm	10	10	10
50 ppm	10	10	10

Results and Discussion

Of the tree varieties of *Allium sp.* used in the experiment, it appeared that *A. fistulosum* was the easiest to grow as its roots easily (Fig. 1) followed by red creole and white onion, in that order. Onions normally have a dormancy of one year (Kihlman, 1975) and since the information was obtained only from the vendor, the authors are not certain of the exact age of the onions. No data can be retrieved from the two other varieties (red creole and white onions). But, whether the varieties were newly harvested or not, the multiplier variety (*A. fistulosum)* rooted first and more profusely until the termination of the experiment. Thus, it was decided that the multiplier variety would be the source of the data used in this experiment.

The effect of $KBrO_3$ on the rooting is shown in Fig. 2 and Table I. The control set-up (0 ppm) had the average longest root lengtj of 38.6 + 2.98 mm and average shortest root length at 7.6 + 1.51 mm in contrast to the 25 ppm set-up with 15.8 + 1.19 mm and 5.6 + 0.99 mm as the average longest and shortest root lengths, respectively, and at the 50 ppm set-up with 13.1 + 1.16 mm and 3.7 + 0.52 as the average longest and shortest root lengths, respectively (Table II).

According to the Bureau of Food and Drugs director, Dr. Quintin L. Kintanar (Manila Bulletin, 1994), and the WHO (Manila Bulletin, 1994), potassium bromate ($KBrO_3$) has genotoxic and carcinogenic effects. This short-term study showed the $KBrO_3$ has growth retardation effects on onion roots.

In contrast to a study made by Grunfeld (1994) which showed that the 50 ppm, when added to flour, did not reveal any adverse effects, this study showed that onion grown in 50 ppm had shorter roots when compared to both the control and 25 ppm set-ups. Root length in the 25 ppm set-up was shorter than the roots grown in the 50 ppm set-up.

Intentionally no attempts were made to measure daily root growth from day 1 to day 5 to avoid damages on the roots and thereby affecting its growth.

Conclusion

The study was conducted using the *Allium* test, using three varieties of *Allium*. This was done to determine the best variety to use as a biological manitor for this specific chemical. Through the course of the experiment, the *Allium fistulosum* variety was observed to root faster and more profusely than the red creole and the white onion variety. Therefore, it was concluded that the most advisable variety of *Allium* for use as a biological monitor for this specific chemical was the *Allium fistulosum* variety.

Potassium bromate ($KBrO_3$), a flour additive which has long been used to enhance the quality of bread, is now attracting attention as a possible mutagen/carcinogen. Studies have been made to refute the WHO's claim that it is a carcinogen (Grunfeld, 1994). This study was made to observe the effects of $KBrO_3$, using the *Allium* test, on the macroscopic level. Disturbances on the macroscopic level may indicate disturbances in the microscopic level. Through the course of the experiment, it was determined that there were significant differences between the root growth of the three set-ups, with the control set-up having the longest average root growth, followed by the 25 ppm set-up and lastly the 50 ppm set-up. These deviations from the normal root growth may imply that the tested chemical ($KBrO_3$) may have caused disturbances in the microscopic level and that it is a possible mutagen. Further observance of the samples at the microscopic level is currently ongoing to confirm the possibility of the tested chemical as a mutagen.

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Table I. Measurement of Root Lengths (cm)

Sample (onion bulbs)	Control KBrO3		25 ppm KBrO3		50 ppm KBrO3	
	Long	Short	Long	Short	Long	Short
3	40	20	10	2	10	3
3	52	7	12	2	11	2
3	46	12	19	3	10	3
3	36	4	17	4	17	2
3	27	7	16	6	16	4
3	53	8	12	9	13	4
3	26	4	16	4	11	3
3	36	8	23	10	11	6
3	38	8	17	10	22	7
3	32	8	16	6	13	3
30	386	76	158	56	131	37
	38.6	7.6	15.6	5.6	13.1	3.7
	±2.98	±1.51	±1.19	±0.99	±1.16	±0.52

Table II. Table of Mean, Standard Deviation and Standard Error

Statistical Treatments	Control		25 ppm		50 ppm	
	Long	Short	Long	Short	Long	Short
No. of observations	10	10	10	10	10	10
Sum	386 mm	76 mm	156 mm	56 mm	131 mm	37 mm
Mean, x	38.6 mm	7.6 mm	15.6 mm	5.6 mm	13.1 mm	3.7 mm
Variance,	88.27	22.80	14.18	9.62	13.43	2.68
Standard Deviation,	±9.4	±4.78	±3.77	±3.13	±3.67	±1.64
Coefficient of variability, v	0.24%	0.65%	0.24%	0.56%	0.28%	0.44%
Standard error of mean, E	±2.98	±1.51	±1.19	±0.99	±1.16	±0.52

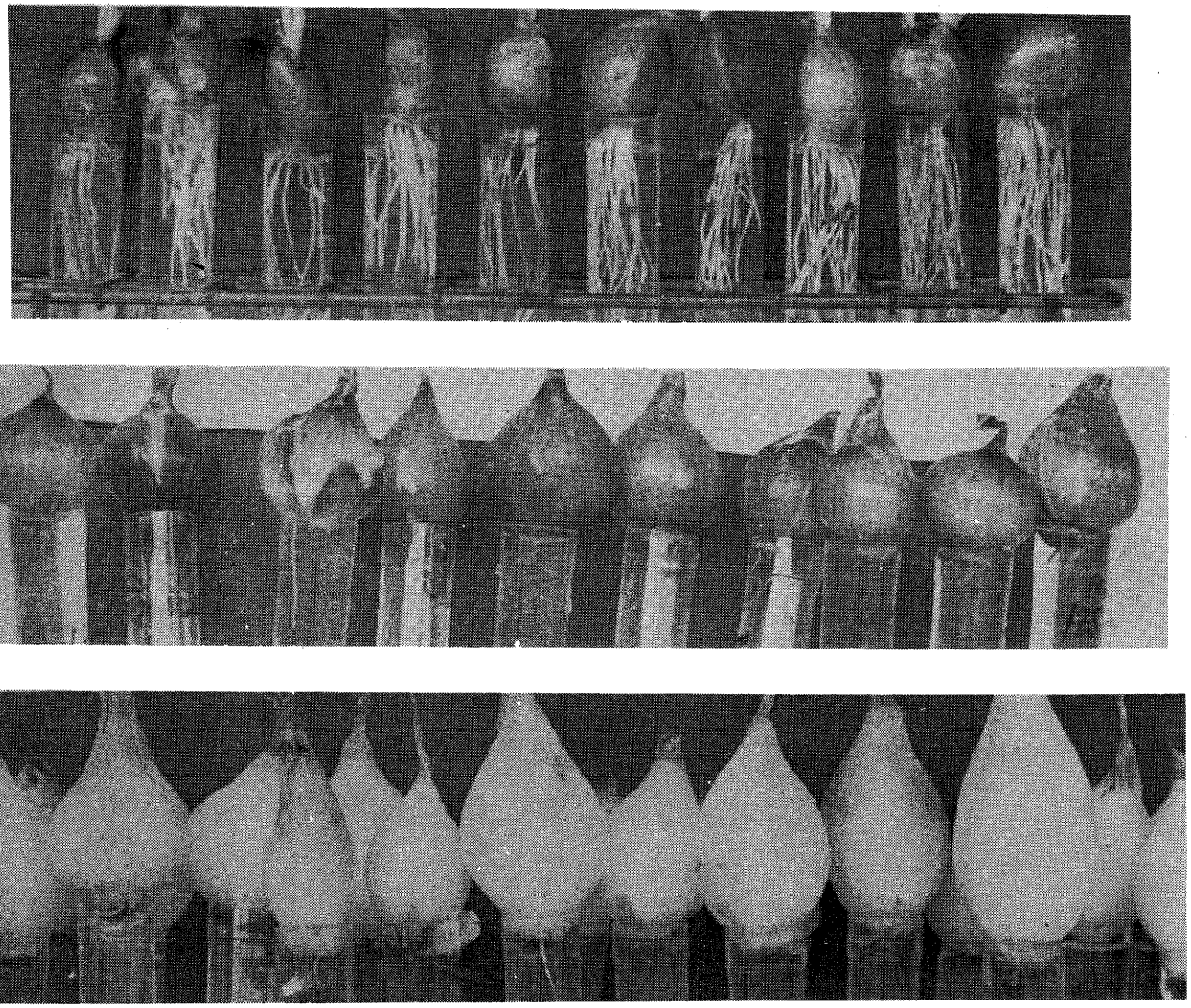

Figure 1a - 1c. Comparison of Growth Rate among controls using three varieties of Onions: (a) *A. fistulosum* (multiplier), (b) *A. cepa* (red creole), and (c) *A. cepa* (common white onion).

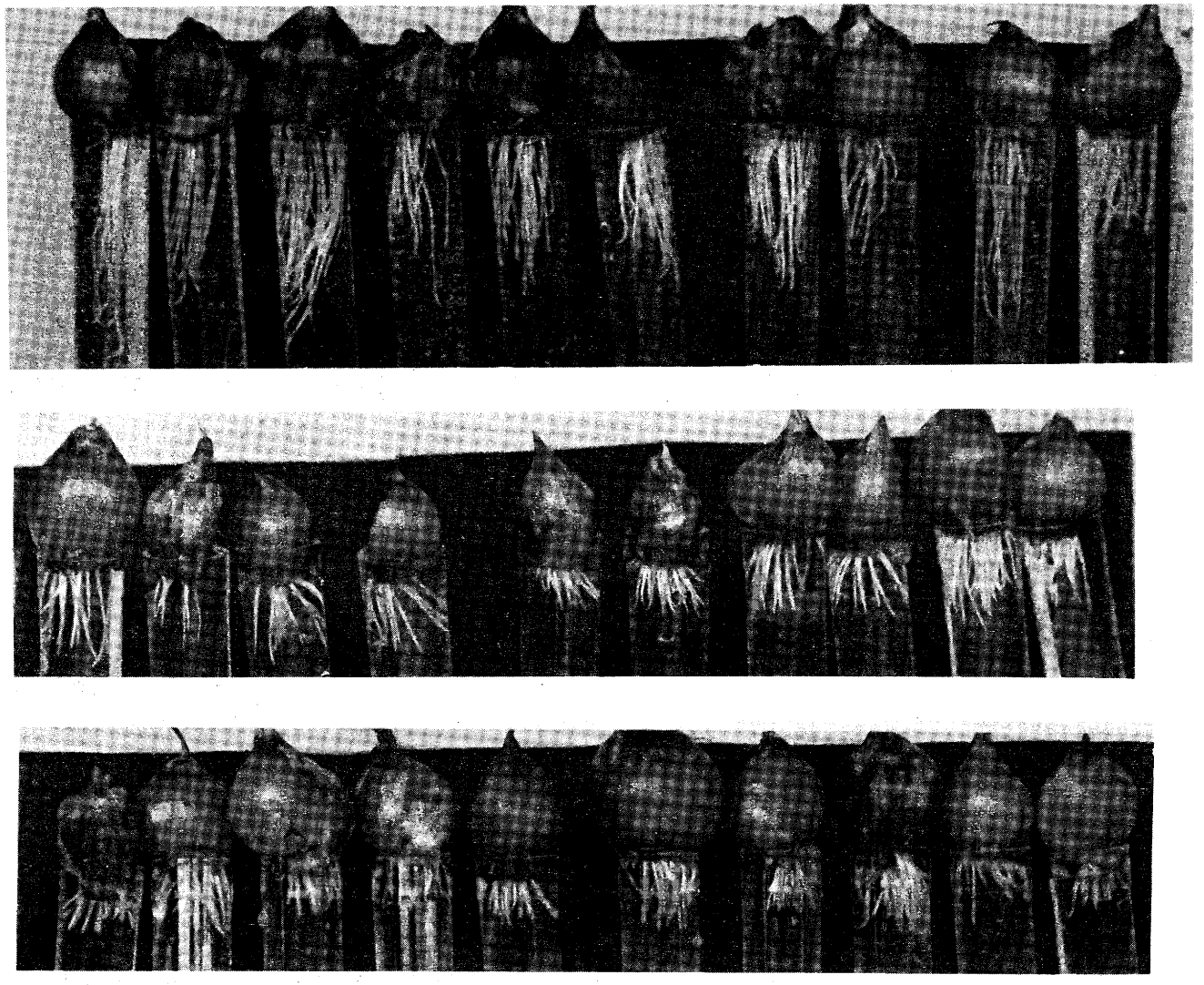

Figure 2a - 2c. Growth retardation effects of $KBrO_3$ after 5 days treatment in varying concentrations: (a) 0 ppm, (b) 25 ppm and (c) 50 ppm.

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The Macroscopic Effects of Potassium Bromate ($KBrO_3$) on Multiplier Onions, Allium fistulosum

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Introduction

Potassium bromate ($KBrO_3$) is used in bread and other bakery products since 1960's as a flour enhancer. It is being used by ninety percent of more than seven thousand bakery owners in the country. At present, $KBrO_3$ is still used as flour additive to come up with bigger volume of bread (*Manila Bulletin,* 1994a). In other Asian countries, there is already a trend towards bromate-free bread and bread products. Taiwan and Japan are the leading countries which promoted the bromate-free making of bread in Asia. Germany banned it in 1957, knowing that it is carcinogenic. Recently the Department of Health (DOH) batted for the banning of potassium bromate in the making of bread due to its carcinogenic effect, based on the recommendation of World Health Organization (WHO) on the carcinogenic potential of potassium bromate and the detection of its residue in bakery products. The Bureau of Food and Drug (BFAD) said that potassium bromate contain substances which have genotoxic and carcinogenic effects (*Manila Bulletin,* 1994). In contrast, Dr. Y. Grunfeld, an American toxicologist, has declared that bread additive, potassium bromate, is safe (*Manila Bulletin,* 1994b). According to Grunfeld, potassium is safe even at levels of up to 50 parts per million (ppm). The study was conducted in response to WHO reported stipulated that the observation is tentative and that comments are invited.

Root tips from several plant species have been used for the study of induced chromosomal aberrations, one of the most common, being the root tips from the various species of *Allium* (e.g., the common onion, *Allium cepa*, the tree onion, *Allium proliferum,* and the Welsh leek or multiplier onion or "sibuyas tagalog", *Allium fistulosum*) (Medina, III, 1987, and Kihlman, 1971, 1975).

Plant root tips as experimental material is one of the oldest, simplest and least expensive methods for studying the induction of chromosomal abberations.

Fiskesjo (1988, 1985a, 1985b, and 1981) suggested and utilized the *Allium* test as a standard in environmental monitoring as a part of test battery. The method included suggested parameters, used in this study. Medina (1988) developed a routine procedure for studying mitotic metaphase chromosome aberrations induced by ionizing radiation used in this study on mitotic parameter (Medina, III, 1994).

This study was conducted to shed light on the potential carcinogenecity/mutagenecity of potassium bromate and to provide data which maybe of benefit to the DOH and BFAD, in particular, and perhaps, WHO, in general.

There is no Philipipne data as yet on the carcinogenicity and mutagenicity, or toxicity of this popular baker's additive. This study hopes to contribute

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towards the understanding of the effects of $KBrO_3$ which will benefit principally the consumers and the Filipinos in general who are fond of eating "pad-de-sal" or the more sophisticated consumers of "pan-de-Americano" (or "tasty-bread").

iments. The test system used were year-old bulbs of multiplier onion variety, purchased from a flea market. Eighty (80) bulbs were used in the study. The pottasium bromate crystals weer dissolved in day-old tap water (to liberate chlorine) and placed in the refrigerator. The solution was brought out of the frigo to equilibrate to room temperature before use. The control (0 ppm) used refrigerated tap water only (Table II). The original experiment (Bascos et al., 1994) was conducted using up to 50 ppm potassium bromate only but after the second replication it was decided to include the next higher dose, which is 75 ppm. The original dose was based on the suggested maximum safe level, 50 ppm, for bread and other bakery products (Manila Bulletin, 1994c).

Table I. KBrO3 Assay (min. 99.8%)

ph of 5% solution at 25°C	5.0 - 9.0
Insoluble matter	
Bromide (Br)	max. 0.005%
Sulfate (SO)	max. 0.005%
Iron (Fe)	max. 0.005%
Sodium (Na)	max. 0.001%
Trace impurities (in ppm)	max. 0.01 %
Nitrogen compounds (as N)	max. 5.0 %
Meavy metals (as Pb)	max. 5.0 %

Materials and Methods

Potassium bromate ($KBrO_3$, J.T. Baker Chemicals B.V. - Holland, Reagent Grade) bought from Belman Compania Incorporada, Quezon City, with the following assay (Table I), was used in the exper-

The bulbs were washed on tap water and the outer scales of the bulbs and the brownish bottom plates were removed, the ring of primordia being left intact.

The peeled bulbs were put into day-old tap water during the cleaning procedure to protect the primordia from dessicating. The bulbs were set overnight, using 1.5 cm diameter test tubes with the capacity of 15 ml filled with tap water. The test chemical (potassium bromate) dissolved in tap water was started the following day (day 1) in concentration levels of 0 ppm, 25 ppm, 50 ppm, and 75 ppm. The experiment was terminated at day 5. Observation were done at the macroscopic level

(Fiskejo, 1985). The macroscopic parameters included : turgescence, root form, colour, number of roots produced and root length. Each trial consisted of ten bulbs per dose.

Results and Discussion

The measurements made on root grotwh, number of roots produced and root forms are presented in Tables III and IV. Fig. 1 shows the growth restriction effect of varying concenctration of $KBrO_3$ on multiplier onion roots.

At the end of the 5 days of cultivation the longest root from the control, 0 ppm; 25 ppm, 50 ppm and 75 ppm showed an average length of 55.7 + 2.83 mm, 24.9 + 0.30 mm, 18.4 _ 2.91 MM and 11.0 + 0.20 mm, respectively. The shortest roots showed the same trend of decreasing root length proportional to the level of KBrO from 6.35 + 0.85 mm in the control to 3.55 + 0.45 mm, 2.9 + 0.10 mm and 2.3 + 0.30 mm in the 25 ppm, 50 ppm and 75 ppm levels, respectively. The total root growth of long roots (Table III) at 25 ppm treated onion bulbs showed only 45% increase in comparison to the control. The 50 and 75 ppm showed a much shorter growth at 34% and 20% of the control while the short roots showed 49% at 25 ppm; 46% at 50 ppm and 36% at 75 ppm in contrast to the control shortest roots.

Restriction or inhibition of root growth (Fiskejo, 1985) is an indication of toxicity and it is also the sum total of all damaging effects.

Table IV shows the results of observations on the other macroscopical parameters, i.e., number of roots produced and the aberrant root form (bending or curving).

The number of roots produced showed a decrease of 25, 22 and 32% in the 25, 50 and 75 ppm $KBrO_3$ treated bulbs respectively when compared with the control, 0 ppm.

Fig. 2 shows the various aberrant root forms observed in all roots includeing the control. Although these forms have been observed in the control it is apparent that there was an increase in frequency in the treated bulbs upt to 50 ppm dose level. At 7 ppm it was 24% below the control. The number of aberrant root forms in treated bulbs decreases as the level of $KBrO_3$ is increased which indicate that the development of aberrant roots is

Table II. Experimental Design

Dose (ppm)	Replication I	II
0	10	10
25	10	10
50	10	10
75	10	10

perhaps arrested hnece did not develop further from the primodia. It may be noted from Figs. 2b - 2h that the tips of the aberrant roots vis-avis that of the control, Fig. 2a, show abrupt tapering close to the root cap, implying that there is a reduction in the generative capacity of the meristematic cells. This will also probably explain the gradual reduction in the number of roots produced by treated bulbs and the frequency of aberrant roots (Table IV).

There were no perceptible changes in turgescence. Root tips harvested at the end of the 50-day cultivation showed a slight change in colour from milky white to very light brown at 50 and 75 ppm dose levels, so light not even capturable by coloured film.

Since this growth restriction is the sum total of all damaging effects this study concentrated on these macroscopic parameters. Ther result of the microscopic studies will be the subject of another paper being prepared as a sequel to this one.

Conclusion

The results of the study based on the macroscopic parameters, i.e., change of colour, root forms and root length, indicated that the $KBrO_3$ at levels reported to be safe (50 ppm) may be biologically hazardous even at 25 ppm and much more pronounced at 75 ppm.

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Table III. Root lengths (mm) of A. fistulosum after 5 days of cultivation in different levels of KBrO3

Trials	Treatment							
	0 ppm		25 ppm		50 ppm		75 ppm	
	long	short	long	short	long	short	long	short
I	52.9 ± 2.69	5.5 ± 0.06	24.6 ± 2.74	3.1 ± 0.41	21.6 ± 1.82	3.0 ± 0.48	10.8 ± 0.93	2.0 ± 0.15
II	58.5 ± 3.11	7.2 ± 1.29	25.2 ± 3.48	4.0 ± 0.49	15.8 ± 2.11	2.8 ± 0.32	11.2 ± 0.99	2.6 ± 0.31
Total	111.4	12.7	49.80	7.10	37.40	5.8	22.0	4.6
Ave. ± S.E.	55.7 ± 2.83	6.35 ± 0.85	24.9 ± 0.30	3.55 ± 0.45	18.4 ± 2.91	2.9 ± 0.10	11.0 ± 0.20	2.3 ± 0.30
In % of control			45%	49%	34%	46%	20%	38%

Table IV. Number and forms of roots produced after 5 days of cultivation in varying levels of KBrO3.

Trials	Treatments							
	Control		25 ppm		50 ppm		75 ppm	
	No. of Roots	Bent	No. of Roots	Bent	No. of Roots	Bent	No. of Roots	Bent
I	40.5 ± 6.5	2.7 ± 0.58	36.7 ± 3.90	10.2 ± 1.91	36.2 ± 2.61	3.5 ± 0.66	27.5 ± 3.16	1.4 ± 0.54
II	35.6 ± 5.52	2.3 ± 0.42	20.3 ± 2.60	8.8 ± 1.76	23.3 ± 1.93	5.8 ± 1.26	24.3 ± 2.87	2.4 ± 0.70
Total	76	5.0	57	19	59.5	9.3	51.8	3.8
Ave. ± S.E.	38.05 ± 2.46	2.5 ± 0.20	28.5 ± 8.2	9.5 ± 0.70	29.75 ± 6.47	4.85 ± 1.15	25.9 ± 1.61	1.9 ± 0.50
In % of control			75%	380%	78%	188%	68%	76%

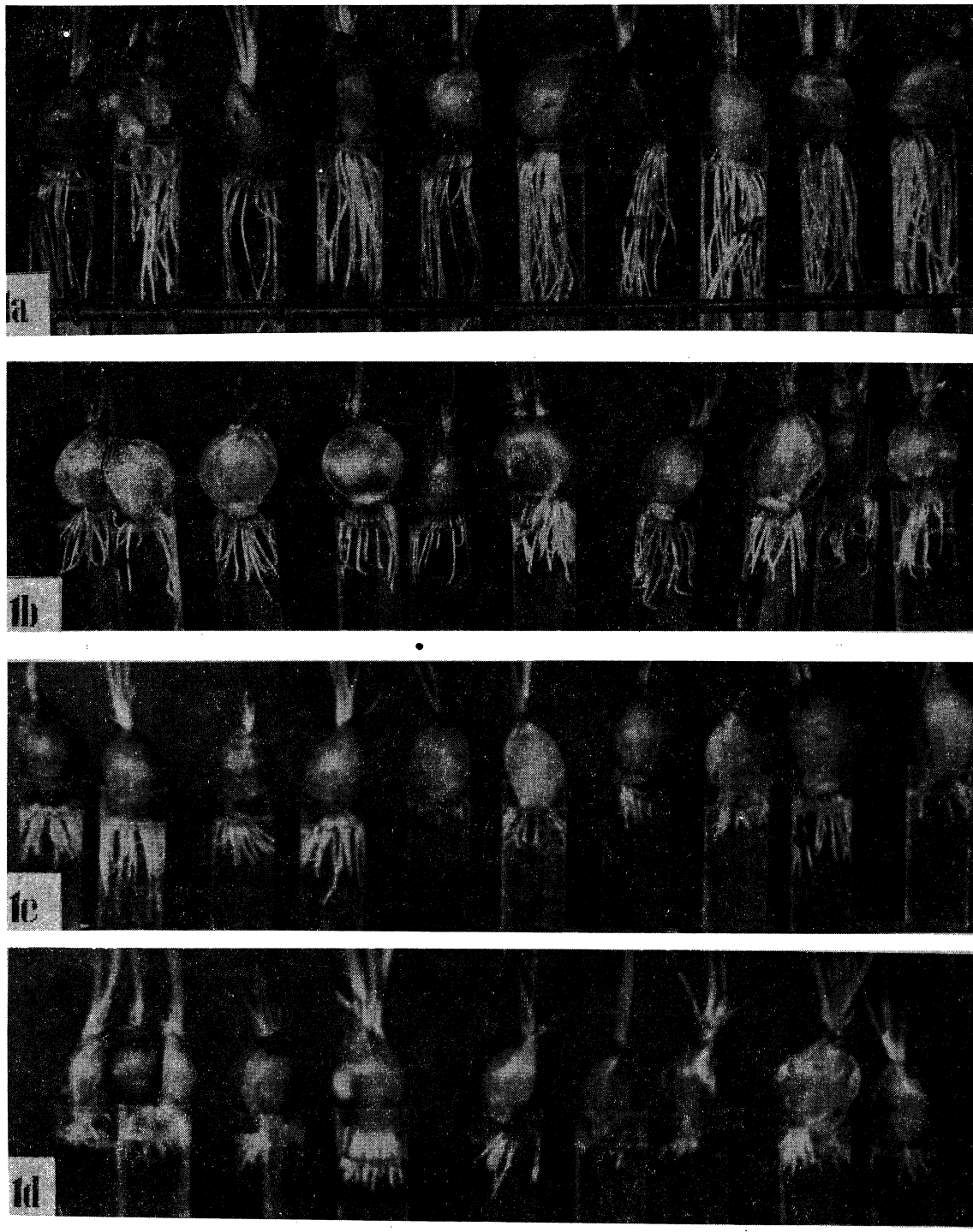

Figure 1. Growth restriction effects of KBrO after 3 days of treatment in different concentrations.

1a. 0 ppm KBrO; 1b. 25 ppm KBrO; 1c. 50 ppm KBr; and 1d. 75 ppm KBrO.

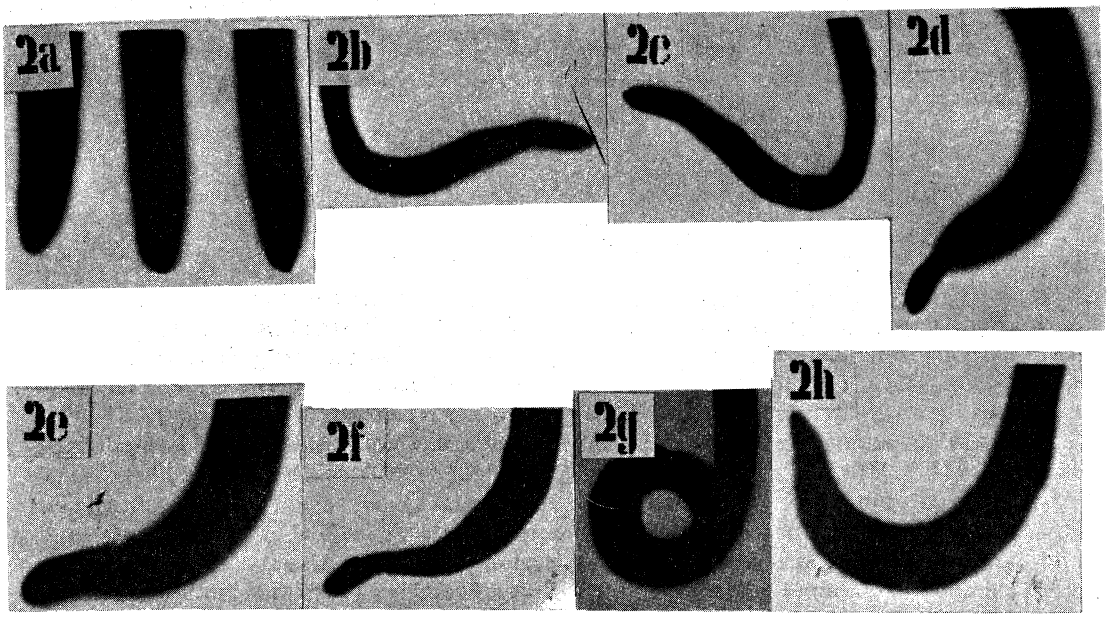

Figure 2. Aberrant root forms compared with root formation of control, 0 ppm.

2a. Control, 0 ppm; 2b - 2h. Roots from treated bulbs.

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Growth and Survival Studies of Transplanted Green Mussel, Perna viridis to Taklong Island, Guimaras.

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Abstract

This study dealt with the growth and survival of transplanted green mussel, *Perna viridis* from a stable community to Taklong Island, Guimaras. The culture rafts were situated at the UP Channel where green mussels were cultured at different stocking densities. There were four treatments at four replicates each in four culture rafts, thus, Treatment I (25 pc/bag); Treatment II (50 pc/bag); Treatment III (75 pc/bag); and, Treatment IV (100 pc/bag). Analysis of variance and Duncan's multiple range test conducted on the weight increments revealed that Treatment I and II had significantly higher weight gains than Treatment III and IV. There was no significant difference on length increments among treatments. Survival rates were 100% in Treatments I and II; 79.3% in Treatment III; and, 86.4% in Treatment IV. The final finding in this study was that, the culture of green mussel in Taklong island is highly feasible as exhibited by the growth and survival rates. Oceanographic parameters were found to be on their optimal levels.

Introduction

The green mussel, *(Perna viridis)* commonly called as "tahong or amahong" has become a popular food item among coastal people and the populace of Metro Manila. It is one of the most important marine products in the Philippines and abroad. Mussel culture is always done in natural water such as mangrove areas, coves and embayments. It provides very cheap animal protein, calcium, iron and iodine that could easily be available to common people.

In the Philippines, places along Manila Bay, Balayan Bay, Sapian Bay and Maqueda Bay to name a few are the areas where green mussels are mass produced. These areas have been supporting local farmers with the needed cheap animal protein. Incomes were used to pay for daily household expenses and to provide families with shelter and clothing. Many mussel farmers were able to send their children to school for college education.

Mussel could easily be grown by using the existing technology. Spats are collected and are either left to grow in the area or tranplanted to any suitable areas to grow out. Less time and energy is spent for culture. The culture media could be stationary and only occasional visit is required to see whether or not the mussels are still there.

It is hypothesized that, if mussels are transplanted into a suitable environment, they will establish a stable population and could be cultured for mass production to provide the local people the

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much needed animal protein for proper human nutrition.

In view of this hypothesis, this project was conducted to satisfy the following objectives :

1. To transplant green mussel, *Perna viridis* from a stable community to Taklong Island, Guimaras;

2. To determine the effects of different stocking densities on the growth and survival of green mussels; and,

3. To determine the possibility of mass culturing green mussel in Taklong Island, Guimaras.

It is also the objective of this study that, if found successful, the technology shall be transferred to the local people. The local people shall be invited to group discussions tackling the methods of culture of green mussel, meanwhile exposing them to the actual experimental set up. By this method, knowledge and technology could be handed down in a more gradual manner. By then, the local people would be able to imbibe the ultimate objective of the project, the culture of green mussel for mass production.

Review of Literature

Green mussel possesses a longitudinally compressed body and bivalve shells hinged dorsally that completely cover the body. The foot-like remainder of the body is also compressed dorsally. The most capaceous of this shellfish is the mantle cavity. The gills are usually very large, having assumed a food collecting function, in addition to that as gas exchange mechanism. The byssus of each individual act as an organ of attachment or holdfast on hard objects.

Mussels are usually either male or female, but a few are hermaphroditic (van der Schallie, 1969). The reproductive organs are found in the foot. They are paired bunches of tubes and open just in front of the renal aperture on each side. The spermatozoa are released through the dorsal siphon of the male and ventral siphon of the female. The eggs pass out of the genital aperture and come to lie in various parts of the gills. The spermatozoa enter the gills of the females with the water and fertilize the eggs inside the marsupium of the female.

The bivalve shell is composed of an outer peristracum covering from two to four calceneous layers. The valves of the shell are pulled together by two large mussels called adductors, acting antagonistically to the hinged ligaments. The outer layer is composed of aragonite or a mixture of aragonite and calcite and is deposited as prism or a minute lathes or tablets arranged in sheets or nacre.

Trueman (1966) reported the importance of body fluids and shell adduction in the hydraulic mechanism of the foot extension. The nature of the *Mytilus sp. byssus* and its formation remain to be less fully elucidated despite much investigations. The factors influencing the rate of byssus threat production and the mechanical properties of the threads have received attention for some years (Maheo, 1969; Glaus, 1968; Reish and Ayers, 1968; van Winkle, 1970; Martella, 1974; Allem et. al., 1976; Smeathers and Vincent, 1979; Price, 1981; 1982).

Of all the activities done regarding mussels, the economic values of these species play the most important role. Romashko (1984a; 1984b) reported that mussels are usually sought for their lustrous shells which are manufactured into various ornamental articles like buttons. Places like Spain, Holland, Italy and France in the north temperate regions use *Mytilus edulis* for food and is cultured intensively. In New England, this is used as fertilizer for its abundance in availability (Iversen, 1968). In the Philippines, its food value is the most important governing factor in the craze of culturing mussels, particularly the species, *Perna viridis.*

There are many species of commercially exploited mussel around the world. In the Philippines, the most exploited species are the green mussel, *Perna viridis,* and the brown mussels *(Modiolus metcalfei and M. philippinarum).* In the north temperate regions, *M. edulis* is cultured intensively. In New England, the dark-purple to black colored *M. edulis* is used as fertilizer.

The Philippines, due to its archipelagic nature comprising of 7,100 islands, could possibly be one of the best suited areas for the culture of mussels.

The methods of transplanting, thinning and culling which are practiced in other countries may be adapted under the Philippine condition. The tray method of culture of mussel is innovative and is advantageous for culling, ease of laying and harvesting of products, reduction of silt and infestation of pests. Furthermore, the author recommends the verification of the culture methods of green mussels using the different types of media as trays (e.g. bamboo slats/mattings).

Materials and Methods

The study was conducted from December 1989 to November 1990 at the U.P. channel in Taklong Island, Guimaras.

Experimental Units

The study used sixteen bamboo rafts (2m x 5m). There were four stations at four rafts/station installed at different designated locations along the U.P. channel at Taklong Island, Guimaras. Green mussel, *P. viridis* were stocked at four stocking densities such as: Treatment I - 25 pc/bag; Treatment II - 50 pc/bag; Treatment III - 75 pc/bag; and Treatment IV - 100 pc/bag. In each station, there were four treatment at four replicates, each assigned at random (Ostler and Mensing, 1975; Steel and Torrie, 1980). The bags were hanged from the rafts by the use of nylong string. Results were analyzed statistically using the Systat computer package program (Wilkinson, 1984).

Experimental Animals

Green mussels were secured from Sapian Bay, Capiz. The mussels were collected late in the afternoon, placed in jute sacks and transported very early morning. Upon arrival at Taklong Island, the green mussels were placed in a cool dry place for 6 hours and then immersed in seawater for acclimation. This was done in five days to ensure the survival of the test animals. Upon sorting, measuring and weighing, they were stocked in their designated rafts and were monitored every 15 days. The culches were lifter out of the water and visually counting the specimens. Weight, length and width wre measured for the determination of growth and survival. Occular inspection and checking of predators weer done by scuba/skin diving. Mortalities observed one month after stocking were charged against handling and were replaced with mussels of at least the same size and weight. After that, mortalities were recorded and charged against experimental treatments.

Other Factors

Oceanographic data were monitored every 15 days from February 1, 1990. The data collected were on water and air temperatures (clinical thermometer), soil and water pH (battery operated portable pH meter), dissolved oxygen (battery operated portable DO meter), and salinity (efractometer). Primary productivity were also determined using the light-and-dark bottle method (Swingle, 1969). Plankton tows were also done to determine plankton abundance using the 53-u plankton net and a compound teachin microscope. Soil samples were also collected to determine the dry and were soil pH and soil total organic matter content (FAO, 1975).

The high plankton counts revealed that the area was conducive to the culture of mussels. There was high value in February (861.20 x 100 cells/ml). A gradual decline towards a low value in July (200 x 1000 cells/ml) is suggestive of another turnover from the warm to cool weather conditions. The total plankton count was highest in August at a value of 3280 x 100 cells/ml indicating a most favorable plankton bloom due to high nutrient availability from the previous summer plant matter production in the mangrove areas. The lowest value was attained in November of 127.5 x 100 cells/ml due to the effects of typhoon Ruping.

The growth of the cultured mussels indicated a favorable response to the new environment. From the initial data on August 1, 1990, the growth in length showed a steady increase until November 30, 1990 (four months of culture period), as shown.

Figure 1 shows the general trend of the increase in length of the mussel cultured from August 1 to November 30, 1990. It could be seen that all treatments and replicates showed a positive increase indicating that the green shell could be acclimatized and cultured in U.P. channel of Taklong Island, Guimaras. It must be noted that despite the dramatic disturbance of typhoon Ruping last November 13, growth was not hampered in any replicate of any treatment. This implies that mussel is euryhaline and resistant to physical and chemical stress.

Growth rate in terms of weight was not as convincing as that of the length. Treatments I and II gave positive values at alomst the same level. The steady increase in weight indicated that the organisms were experiencing a kind of stress that resulted into the decrease in weight increments relative to Treatments I and II. Treatment I with the lowest stocking density had the greatest weight increment and Treatment IV had the lowest.

Aside from the crowding effects at higher stocking density, the typhoon caused the two rafts to be drifted to the shore. The specimens were recovered and the rafts were installed back to their places.

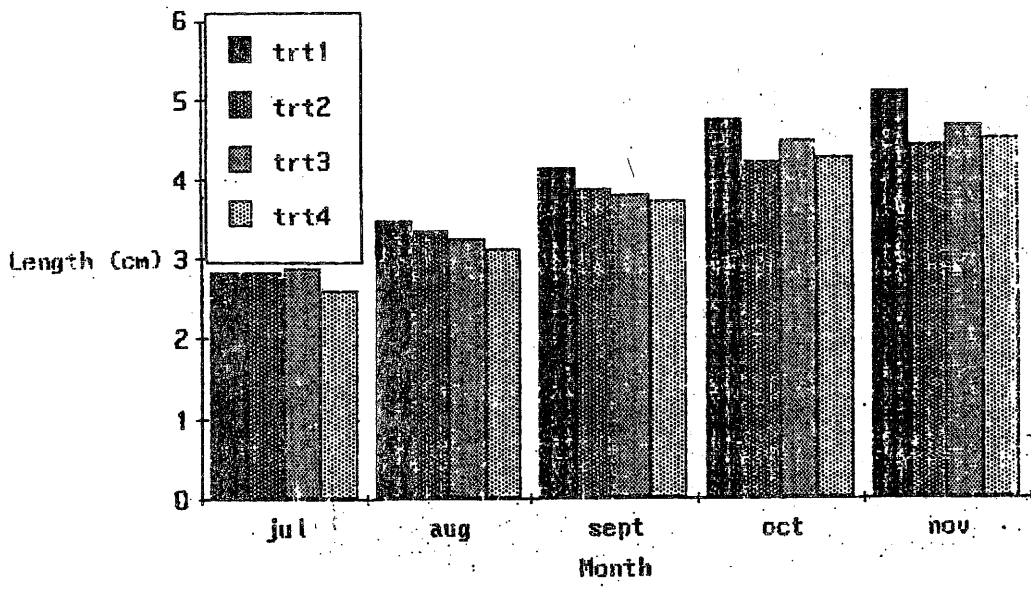

Figure 1. The trend of growth in length (cm) of P. viridis cultured from August 1 to November 30, 1990.

Figure 2 below shows the general trend of the growth of *P. viridis* in terms of weight. It is shown that Treatment I and II steadily increased to the right indicating a positive weight increments, while, Treatments III and IV tapered off.

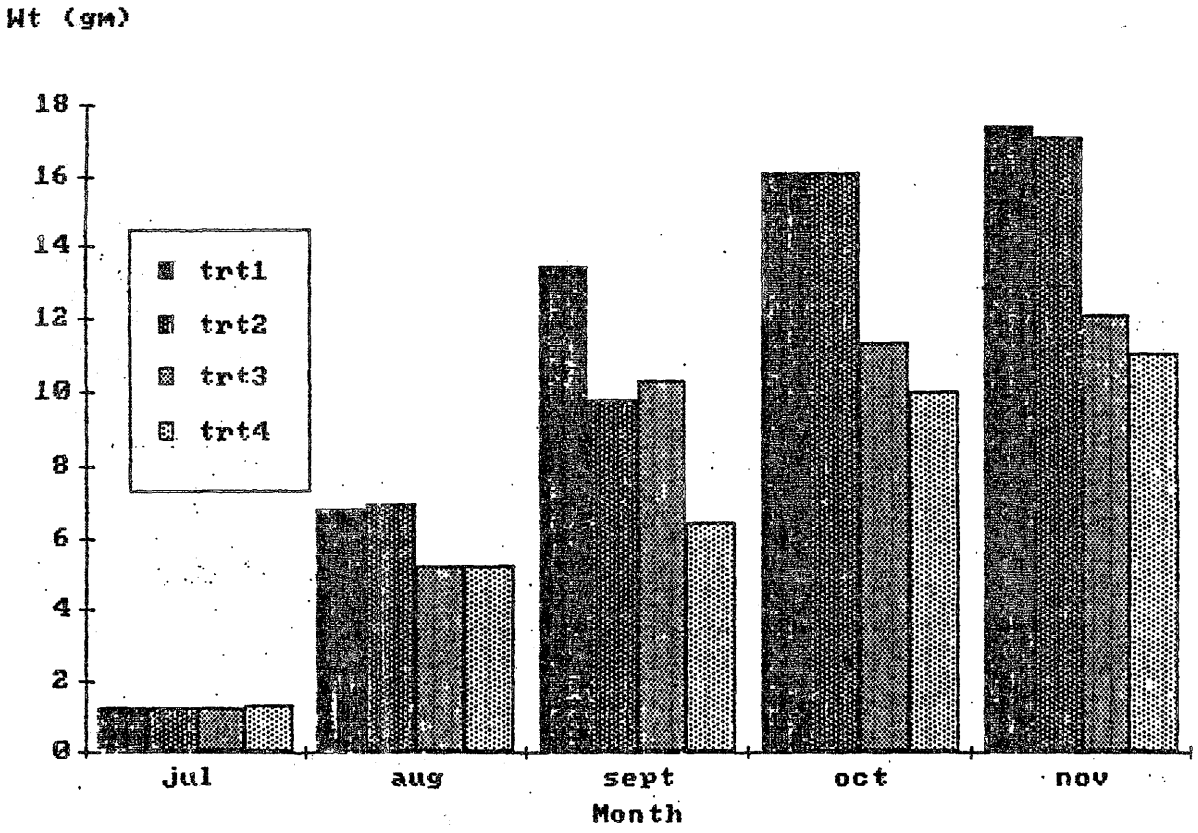

Figure 2. Growth trends on the weight of *P. viridis* cultured from August 1 to November 30, 1990.

Table 1. Oceanographic data collected from February 1 to November 26, 1990

Date	Temperature (°C)		D.O. (ppm)	Salinity (ppt)	pH	Water Depth (cm)	Primary Prodn (g °C/cu m)
	Air	Water					
02/01	28	30	6.60	34	7.00	122	-37.50
02/16	28	30	6.40	40	7.00	129	-37.50
03/03	28	30	6.40	43	7.10	155	75.00
03/17	24	28	5.90	46	7.10	147	-187.50
04/02	31	29	5.40	40	7.60	156	487.50
04/17	30	28	6.10	23	7.00	157	300.00
05/02	32	28	6.10	32	7.00	139	-150.00
05/17	30	20	7.00	30	7.00	136	262.50
06/01	30	22	6.20	33	7.60	100	375.00
06/16	27	28	6.20	32	7.60	146	112.50
07/01	27	30	7.00	38	7.70	90	525.00
07/15	29	30	7.20	40	7.30	110	450.00
07/30	30	29	7.80	41	7.70	65	112.00
08/14	24	20	7.60	22	7.60	45	487.50
08/30	31	28	7.20	40	7.60	25	487.50
09/14	30	28	7.20	40	7.60	10	487.50
09/28	31	28	7.20	40	7.60	40	487.50
10/13	22	26	10.00	44	7.30	45	750.00
10/28	30	29	7.40	40	7.10	5	187.50
11/12	30	29	7.40	40	7.10	6	150.00
11/26	29	30	7.40	40	7.10	7	562.00

Results and Discussion

Oceanographic data collected every 15 days from February 1, 1990 to November 26, 1990 revealed that they were all in the normal levels of fluctuations. Air temperatures ranged from a low of 24°C to a high of 31°C; while water temperature had a low value of 20°C to a high of 30°C. Water dissolved oxygen values were on the normal levels indicating that there was enough dissolved oxygen in the medium. Water pH values were slightly basic and normally buffered. Salinity was low on April 17 (23 ppt) and August 14 (22 ppt) due to heavy rains in the area.

Negative primary productivities were observed especially during the times of heavy rainfalls, otherwise the values were high up to 525 g C/cu m on July 1, 750 g C/cu m on October 22 and 562 g C/cu m on November 26, 1990.

Soil samples were composited and air-dried. Dry soil pH were found to be 7.04 to 7.99 at highly buffered soil system. Organic matter contents of the soil samples were found out to be basically low during June and July where there were turbulent mixing of the water in the shoreline; otherwise, values of 9.1 % in May to 5.3% in August indicated good soil conditions influenced by the mangrove swamp on its headland (Baldevarona, 1992a; 1992b).

There were several planktonic organisms identified from the samples collected. The most dominant species were *Chlorella* which was found basically throughout the experimental period, followed by the *Chaetoceros*, the nauplii stages of the shrimp species and zoea stages of the crustaceans. Ceratium and diatoms were also found in the collected samples.

Table 2. Soil samples analytical results.

Date	pH	Total Organic Matter (% C)
02/01	7.23	6.50
02/16	7.68	8.20
03/03	7.29	6.70
03/17	7.25	5.80
04/02	7.04	6.30
04/17	7.30	9.20
05/02	7.08	9.10
05/17	7.05	4.00
06/01	7.99	1.20
06/16	7.99	2.30
07/01	7.99	3.40
07/15	7.99	3.40
07/30	7.06	2.70
08/14	7.99	2.80
08/30	7.05	5.30
09/14	7.06	6.00
09/28	7.08	6.50
10/13	7.09	6.60
10/28	7.09	6.90
11/12	7.07	6.90
11/26	7.10	7.20

Table 3. Average growth in length (cm) mussel of P. viridis cultured from August 1 to November 30, 1990.

Treatment	Replicate	D A T E S					Final Increment
		07/31	08/30	09/30	10/30	11/30	
I (25/bag)	A	2.78	3.70	4.65	4.81	5.02	2.24
	B	3.12	3.50	4.05	4.63	4.91	1.79
	C	3.03	3.37	4.13	4.71	5.07	2.04
	D	2.30	3.40	3.78	4.83	5.03	2.73
	Average	2.81	3.49	4.15	4.75	5.01	2.20
II (50/bag)	A	2.91	3.20	4.03	4.32	4.53	1.62
	B	3.06	3.40	4.00	4.29	4.42	1.36
	C	2.82	3.26	3.91	4.00	4.21	1.39
	D	2.55	3.50	3.56	4.32	4.53	1.98
	Average	2.84	3.34	3.88	4.23	4.42	1.59
III (75/bag)	A	2.59	3.40	4.01	4.51	4.71	2.12
	B	3.08	3.13	3.71	4.49	4.60	1.52
	C	3.18	3.30	3.85	4.47	4.62	1.44
	D	2.63	3.10	3.62	4.51	4.72	2.09
	Average	2.87	3.23	3.80	4.50	4.66	1.79
IV (100/bag)	A	2.67	3.03	3.64	4.27	4.42	1.75
	B	2.57	3.14	3.77	4.30	4.53	1.96
	C	2.56	3.11	3.78	4.25	4.58	2.02
	D	2.48	3.20	3.65	4.30	4.49	2.01
	Average	2.57	3.12	3.71	4.28	4.51	1.94

Table 4. Average growth in weight (g) of green mussel P. viridis cultured from August 1 to November 30, 1990.

Treatment	Replicate	DATES					
		07/31	08/30	09/27	10/30	11/30	Final Increment
I (25/bag)	A	1.30	6.42	14.91	15.54	17.73	16.43
	B	1.28	2.38	12.25	16.55	18.00	16.72
	C	1.31	9.19	16.53	17.48	17.53	16.22
	D	1.30	9.12	10.18	14.68	15.94	14.64
	Average	1.30	6.78	13.47	16.06	17.30	16.00
II (50/bag)	A	1.35	5.63	7.11	15.58	16.90	15.55
	B	1.26	5.78	11.09	16.63	17.20	15.94
	C	1.32	6.85	10.80	17.46	18.30	16.98
	D	1.28	9.56	10.14	14.68	15.90	14.62
	Average	1.30	6.96	9.79	16.09	17.08	15.77
III (75/bag)	A	1.26	6.38	8.07	10.38	11.42	10.16
	B	1.24	2.67	11.47	11.58	11.96	10.72
	C	1.35	4.58	10.73	11.09	12.01	10.66
	D	1.24	7.27	10.92	12.41	12.94	11.70
	Average	1.27	5.23	10.30	11.37	12.08	10.81
IV (100/bag)	A	1.29	7.35	9.15	11.46	12.50	11.21
	B	1.29	3.69	3.89	9.12	10.13	8.84
	C	1.35	5.05	5.95	10.33	11.00	9.65
	D	1.32	4.84	6.71	9.12	10.42	9.10
	Average	1.31	5.23	6.43	10.01	11.01	9.70

Table 5. Mean growth increments in length (cm) and weight (gm) and survival rates of P. viridis cultured from August 1 to November 30, 1990.

Treatment	Replicate	Length (cm)	Weight (g)	Survival Rate (%)
I	A	2.24	16.43	100.00
(25/bag)	B	1.79	16.72	100.00
	C	2.04	16.22	100.00
	D	2.73	14.64	100.00
	Mean	2.20	16.00	100.00
II	A	1.62	15.55	100.00
(50/bag)	B	1.36	15.94	100.00
	C	1.39	16.98	100.00
	D	1.98	14.62	100.00
	Mean	1.59	15.77	100.00
III	A	2.12	10.16	83.30
(75/bag)	B	1.52	10.72	80.00
	C	1.44	10.66	77.30
	D	2.09	11.70	76.60
	Mean	1.79	10.81	79.30
IV	A	1.75	11.21	75.10
(100/bag)	B	1.96	8.84	90.00
	C	2.02	9.65	85.50
	D	2.01	9.10	95.20
	Mean	1.94	9.70	86.45

The table apparently shows no significant difference among the treatments, however, there is a gradual decline of mean increments by treatment. Treatment I had a mean gain of 16,00 g while Treatment IV had only 9.70 g. If only Treatments I and II are considered, apparently there was no significant difference, as with Treatments III and IV only. Difference is shown if Treatments I and II are compared with Treatment III and IV.

Based on the ANOVA result above, it is clear that there was no significant difference on growth in length among the Treatments. The mussels grew on considerably the same rate in terms of length increments implying that stocking densities did not affect the length increments.

Table 6. Analysis of variance on the mean growth in length (cm) of P. viridis cultured from August 1 to November 30, 1989 at different stocking densities.

Source	SS	dF	MS	F-ratio	P > 0.05
Treatment	0.795	3	0.265	2.73	0.09 NS
Error	1.164	12	0.097		
Total	1.959	15	0.362		

NS - not significant

Table 7. Analysis of variance on the mean growth in weight (g) of P. viridis cultured from August 1 to November 30, 1989 at different stocking densities.

Source	SS	dF	MS	F-ratio	P > 0.05
Treatment	129.47	3	43.157	51.313	0.000**
Error	10.093	12	0.841		
Total	139.563	15	43.998		

** = Highly significant

Analysis of variance results reveal that there was a significant difference among the weight increments of the *P. viridis* culture for three months. It is clear to note that the Treatments I and II have significantly higher weight increments than those of Treatments III and IV, based on Duncan's Multiple Range Test (Walpole, 1982). Treatments I and II were found to be not significantly different from each other, so much so, with Treatment III and IV.

The results of this study showed that , even though the mussels grew uniformly in terms of length in all, treatments, lower stocking densities brought about significant differences in favor of the lower stocking densities. The differences could be attributed to the differences in survival rates brought about by typhoon Ruping. The drifting away of two rafts might have caused the mortalities and the loss of weight at higher stocking densities.

Conclusion

The results of the study revealed that the culture of green mussel, *P. viridis* in Taklong Island is highly commendable. The constant interaction among the local people and their intermittent visitations on the culture area, triggered interest on the activities being done. Of those who have the knowledge of the activities in the study, most have expressed interest in the actual participation, if allowed to do so. In view of this, further investigation on the culturability of green shell shall be conducted with particular attention on reproduction studies.

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