Vol. 6 May 2011 ISSN 20123981
doi: http://dx.doi.org/10.7719/jpair.v6i1.145

Phytochemical and Pesticidal Properties of *Barsanga* (*Cyperus rotundus* Linn.)

SOLITA EVANGELINE S. BAÑEZ
solitabanez@yahoo.com
University of Northern Philippines

LIZA CASTOR

Abstract - The study was conducted to test the phytochemical screening and insecticidal testing of Barsanga (Cyperus rotundus Linn). This study made use of the experimental research design in actual laboratory set-up. Three phases were included in the pursuit of this study: the extraction process, the qualitative test (phytochemical screening) and pesticidal test. Results showed that the ethanol extracts of the leaves, stems and roots of barsanga contain therapeutic components such as alkaloids, tannins, flavonoids and sterols. This implies that the plant is a good source of treatment for hypertension, tumor, wounds, sores, boils, stomachache, diarrhea, sore throat, burns, ulcer, nasal congestion, cough, hemorrhage, malaria, other rectal disorders, viral and fungal infections, inflammatory and cytotoxic activities. The plant is not an excellent emulsifying agent because it does not contain saponins and therefore cannot be used as detergent to replace soap. The Libermann-Burchard test for triterpenes showed negative results which implies then that barsanga is not a good source of Vitamin A. The tuber of Barsanga (Cyperus rotundus Linn.) can be made into an effective

pesticide. It is more effective than Carbamate and has almost the same efficacy as that of Organophosphate. Based on the conclusions, the researchers present the following recommendations: a follow-up study should be conducted to quantify, isolate and identify the type of alkaloids, tannins, saponins, sterols and flavonoids present in barsanga (Cyperus rotundus Linn.,the plant is recommended for microbiological and other pharmacological screenings; further studies on the plant's therapeutic properties should be conducted by interested researchers and drug companies; and the plant should be included in the compilation and documentation of medicinal plants in the Philippines through REDTI,NRCP, DOST and UP and be indexed at the Plant Resources of Southeast Asia (PROSEA).The use of barsanga tubers as an ecology friendly pesticides can be integrated in the production technology package of local agricultural production.

INTRODUCTION

Plants are used by man in a variety of ways. Some are used for landscaping and ornamentation, others for medicine while some plants are also used in botanical pesticides.

Insect pests have been one of man's most serious problems. Insects are great nuisance because they increase in number, they cause diseases such as H-fever, malaria, dengue, filariasis, etc. and they destroy crops.

Most pesticides today are synthetic and petroleum-based chemicals. The increasing use of these pesticides poses dangers to every living organism in the food chain.

It has been estimated that to develop a pesticide costs 45 million dollars. Considering the cost and the environmental problems that synthetic pesticides bring, the agricultural sector is looking for alternatives order to switch to natural pesticides. In the countryside, for example, some people burn dried peelings of lanzones to drive away mosquitoes.

Another great social concern at present is expensive medicines that ordinary people cannot afford to buy. The Department of Science and

Technology is developing medicines from plants and is encouraging the use of herbal medicines. Besides being economical, medicinal plants are effective and safe if properly used.

With these aforementioned reasons, the researchers investigated the *"barsanga"* scientifically known as *Cyperus rotundus* Linn., a common weed prevalent at the Philippines particularly in open areas at low and medium altitudes. It is very common in lawns, along roads, and waste places. It is pantropic in distribution.

The tuberous rhizome is slightly fragrant, and according to Chopra it contains essential oils. Hooper adds that the fragrance resembles lemon and cardamom. Nadkarni states that the tubers contain fat, carbohydrates, albuminous matter, starch, fiber and alkaloids.

Quisumbing (1951) cited Tavera stating that in the Philippines, *"barsanga"* is used for the treatment of dysentery. Furthermore, he cited Chopra, Kirtikal, Basu, and Nadkarni stating that in India, the roots are used medicinally and are demulcent. In China, Hooper reports that the tubers are also used as tonic, stimulant and stomachic. Nadkarni adds that the fresh tubers are applied to the breast in the form of paste or warm plaster as a galactagogue; and when dried, they are applied to spreading ulcers.

Commercial insecticides and drugs are very expensive that the common "tao" cannot afford to buy them. Most of all, these have many disadvantages because they cause air pollution and deplete the ozone layer.

The researchers studied the therapeutic and pesticidal properties of "*barsanga*" (*Cyperus rotundus* Linn.) because this plant is abundant in the locality. Pesticides and drugs that will be made out from this plant are environment-friendly and cheap.

OBJECTIVES OF THE STUDY

The study was conducted to perform phytochemical screening, and insecticidal testing of *"barsanga" (Cyperus rotundus* Linn.)

Specifically it tried to:

1. Determine the chemical constituents present in the leaves, stems and roots of *barsanga*.

2. Test the efficacy of *barsanga* insecticides on the following test insects:
    a) ants
    b) aphids
    c) flies and
    d) cockroaches

3.Determine the significant difference between and among the three pesticides: *barsanga* and two commercial pesticides (X and Y) using different test insects.

Scope and Delimitation

The focus of the study was to perform phytochemical screening, and insecticidal testing of "barsanga" *(Cyperus rotundus,* Linn.*)*

Furthermore, it was conducted to find out the effectiveness of *barsanga* as an insecticide against harmful insects. The product was compared to two commercial insecticides: X (non systemic, organophosphorous emulsifiable concentrate) and Y (with methomyl and inert ingredient).

In the determination of the therapeutic components, only qualitative tests were done. Quantitative test was beyond the scope of the study. Only the stems, leaves and roots were subjected for phytochemical analysis and only the tubers were used for pesticidal testing.

The air drying and extraction processes were conducted in the UNP Laboratory Room in July . The qualitative tests were done at DOST Bicutan Taguig, Metro Manila in August-September . The pesticidal test was done at Manangat Caoayan, Ilocos Sur and Salindeg, Vigan City in April-May .

FRAMEWORK

The experimental paradigm showing the variables and their interrelationships is presented in Figure 1.

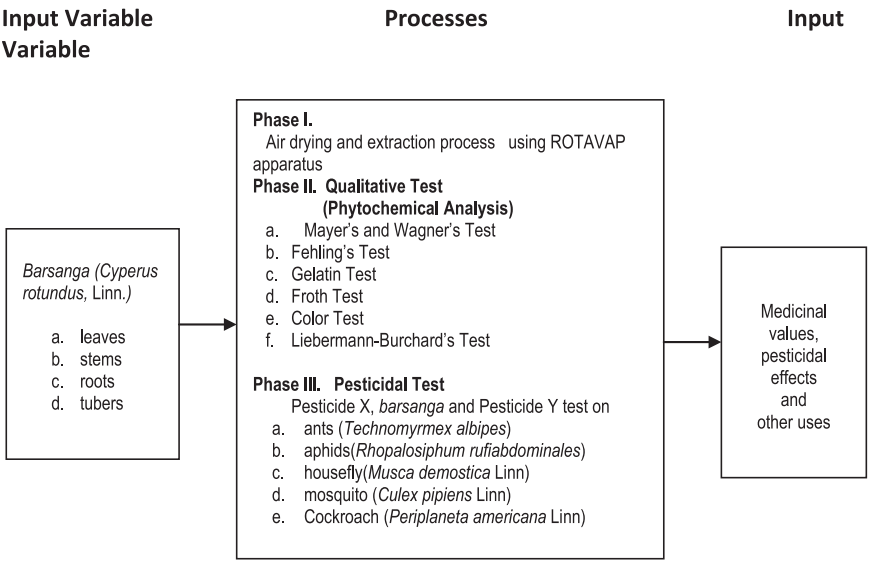

Figure 1. Diagram showing the variables and experimental processes.

The first frame shows the plant parts of *barsanga* which were used as input variable in the study.

The second frame shows the processing variables. They refer to the main processes involved in the study. These processes were: the air-drying and extraction process and qualitative test (phytochemical screening) and pesticidal test.

The third frame shows the output variables which refer to the findings of this study as *barsanga* having therapeutic and pesticidal properties.

Bañez, (2002) performed phytochemical screening of *linlina-aw (Peperomia pellucida* Linn.) and determined its analgesic, diuretic and antihypertensive properties. This is similar to the present study

because she also determined the chemical properties present in the plant. They differ in the pharmacological aspect, because vermifugal properties and toothache drop test were done. These were not included in the previous study. Other aspects are herbal *polvoron* making with *barsanga* included as an ingredient; and the pesticidal properties were tested on ants, aphids, mosquitoes, houseflies, and cockroaches which were not investigated in the previous study.

Morallo-Rejesus, et al. (1979) studied the insecticidal activity of two purified principles from the roots of both *tagestes* (marigold) and *makabuhai (Tinospora rumpi* Boer L.) by topical application. Two varieties of marigold, *tagestes erecta* and *tagestes patula* were compared. Results showed that the principles from *T. patula* L. was more than *T. erecta* L. against housefly and diamond blackmoth but the reverse was true against the rice green leaf hoppers. Principles from *T. patula* L. were five times less toxic than malathion against housefly while acephate and isoprocarb were equally as toxic as these principles against diamond blackmoth and rice green leafhopper, respectively. These two principles were identified as 5- (3-buten l-ynyl) -2-2-bithienyl (PA) and terthienyl (PB) by infrared and ultra violet spectral analysis.

The study of Morallo (1979) is similar to the present study because he determined the insecticidal property of the plant and made use of housefly test insects, however it differs from the present study because he didn't include phytochemical analysis and vermifugal and toothache drop tests. He made use of two plants and he used different insects such as diamond blackmoth and rice green leafhopper. The present study made use of *barsanga (Cyperus rotundus* Linn.) and aphids, mosquitoes, ants and cockroaches as test animals.

Alcantara (1981) conducted a study on the insecticidal activity of *Ageratum conyzoides* L. *(bulak manok).* The chloroform extract of the leaves of this plant was separated into crude fractions by layer chromatography and tested for insecticidal activity against four insect pests, namely: *Drosophila melanogaster, Musca domestica, Strophilus* zearmais and *Drysdercus cingulatrus*. Several fractions were highly toxic against *D. melanogaster* and *D. cingulatus*. These results were comparable with that obtained for the standard insecticide, malathion.

The study of Alcantara is similar to the present study because he

extracted the plant and studied its insecticidal property. It differs with the present study because he didn't perform phytochemical screening, vermifugal, toothache drop test and *polvoron* taste test which were included in the present study. He made use of different insect pests and he used chloroform to extract the plant instead of ethanol which was used in this study.

MATERIALS AND METHODS

This section presents the design of the study, the materials used, the experimental procedures and statistical treatment of the study.

Design of the study. This study made use of the experimental research design in actual laboratory set-up. Five phases were included:

Phase I. The gathering, air drying, the garbling and extraction processes were included in this phase.

Phase II. The qualitative tests for phytochemical screening to determine the presence of alkaloids, glycosides, tannins, saponins, flavonoids, triterpenes and sterols in the leaves, stems, and roots of *barsanga*.

A. Materials

Qualitative Tests

Barsanga leaves, stems, and roots
Weighing balance
Glass funnel
Ethyl alcohol
Petroleum ether
Test tubes
Testtube rack
Graduated cylinder
Test tube brush
Evaporating dish
Ethyl alcohol
Spatula
Distilled water
Waterbath apparatus
Filter paper
Erlenmeyer flasks
Beakers
Medicine dropper
Glass rod
Pipette
Test tube holder

This portion deals with the experimental procedures which were

strictly followed during the conduct of this study.

B. Method

Phase I. Preparation of Extracts

Fresh leaves, stems, roots of *barsanga* were gathered in Metro Vigan. They were washed thoroughly and air-dried for a week.

The leaves, stems and roots were finely cut into small pieces. Five hundred grams of the finely cut materials were placed in an Erlenmeyer flask and were weighed in a balance. The material was completely submerged in a sufficient amount of ethyl alcohol, stoppered and soaked for twenty-four hours. Then it was filtered through a glass funnel.

The plant material was rinsed with 95% ethyl alcohol. Garbling was done by removing all extraneous matters such as insects, dirt, dust, etc. Extraction was done in water bath and rotavap apparatus.

The filtrates were concentrated under vacuo to about fifty milliliters. The exact volume of the concentrated extracts was measured. The extracts were transferred in tightly stoppered containers were stored inside a refrigerator. The extracts were ready for chemical analysis.

Phase II. Qualitative Tests (Phytochemical Screening)

Phytochemical screening determined the presence of alkaloids, glycosides, tannins, saponins, flavonoids, triterpenes and sterols in the stems, leaves and roots of *barsanga*. Methods and procedures were adopted from the Chemistry Division, Department of Science and Technology, Bicutan, Taguig, Metro Manila that included the following:

Screening for Alkaloids *(Alkaloidal test for leaves, stems and roots)*. Ten milliliters of the ethanol extract was evaporated to syrup consistency on an evaporating dish over a water bath. Five milliliters of hydrochloric acid solution was added to the concentrated extract while heating. The solution was stirred for about five minutes, then, cooled to room temperature. To this was added about 0.5 gram of

sodium chloride powder. It was stirred and enough fresh hydrochloric acid solution was added that brought the filtrate to a final volume of 3 milliliters. The solution was divided in two test tubes.

In the first test tube, 1 milliliter aliquot and a few drops of Mayer's reagent were added. The formation of precipitate upon the addition of the Mayer's reagent was suggestive of the presence of alkaloids.

In the second test tube, a few drops of Wagner's reagent were added and a precipitate for Wagner's test indicated a positive result.

Test for Glycosides (Fehling's Test). Ten milliliters of ethanol extract was dissolved in a hot water and filtered. The filtrate was used for the test. Two (2) ml each sample was placed in two test tubes. To sample 1:1 ml diluted HCL was added. To sample 2, nothing was added. Then the two test tubes were heated in a boiling water bath for 5 minutes. Then the test tubes were cooled. Both were neutralized with anhydrous sodium carbonate until no more effervescence was produced. Fehling's solution was added, then, the two test tubes were heated over again in a water bath for two minutes. An increase in the amount of brick red precipitate in the hydrolyzed sample as compared to the other sample indicated the presence of glycosides.

Test for Tannins (Gelatin Test). Ten milliliters of the ethanol extract was dried over a water bath and then cooled. The residue was re-extracted with twenty milliliters of hot distilled water, cooled. Five drops of 10% sodium chloride solution was added to salt out undesirable constituents and then the residue was filtered.

The filtrate was divided into two test tubes A and B. Test tube A was kept as the control. To test tube B, 3 drops of 1% gelatin solution was added. The formation of precipitates suggested the presence of tannins.

Test for Saponins (Froth Test). Ten milliliters of the ethanol extract was dissolved in hot water. The aqueous extract was shaken vigorously for about thirty (30) seconds and was allowed to stand and was observed over a period of thirty (30) minutes. The formation of honeycomb froths at a height of three (3) cm indicated positive results.

Test for Flavonoids (Color test). Two milliliters of the leaf extract

was treated with two ml 10% hydrochloric acid and magnesium turnings. Red coloration was indicative of flavonoid presence.

Test for Triterpenes and Sterols (Libbermann-Burchard Test). Two milliliters of leaf extract was dissolved in acetic anhydride. The soluble portion was decanted and to this, 1-2 drops of concentrated sulfuric acid were added. A pink to red color was indicative of triterpenes, while a pink to blue was indicative of sterols.

Phase III. Pesticidal Test

Materials/Equipment

Barsanga Tuberous Rhizomes	Organophosphate
Carbamate	3 spray bottles
2 beakers	2 Erlenmeyer flasks
1 stirring rod	mortar and pestle
iron stand	wire gauge
alcohol lamp	denatured alcohol
water	basin
ants	aphids
mosquitoes	houseflies
cockroaches	thin clean cloth

Procedure

1. Gather 2 kgs. of *barsanga* tuberous rhizomes.
2. Wash the *barsanga* tubers thoroughly with water in a basin. Let the tubers dry for 20 min.
3. Pound the *barsanga* tubers using mortar and pestle.
4. Add 100 ml of ethyl alcohol to the pounded *barsanga* and soak overnight.
5. Boil the *barsanga* with alcohol in a beaker for 25 minutes.
6. After boiling, allow it to cool, then take the *barsanga* tuberous rhizomes from the container and extract the juice using a clean thin cloth.
7. For every 75 ml of *barsanga* insecticide, add 25 ml of water.

8. Place the *barsanga* insecticide in a spray bottle.

Ants, aphids, houseflies and cockroaches were collected, and placed in wooden box and covered with fine nets and sprayed with *barsanga* insecticides. Places where the sample insects are found to be abundant were also sprayed.

The sample insects were sprayed several times. The *barsanga* insecticide was then compared to commercial ones like Organophosphate and Carbamate to determine its effectiveness. The insects were keenly observed.

Statistical Treatment

To test the data that were gathered in this study, the following statistical tools were employed.

1. Rank was used to indicate the effectiveness of the insecticides used, *barsanga*, Organophosphate and Carbamate.
2. One-way analysis of variance (ANOVA) was used to determine the significant differences in the efficacy of insecticides used. The Scheffe Test was used to determine which insecticides were significantly different.

RESULTS

Qualitative Test (Phytochemical Test)

The therapeutic components in the *barsanga* leaves, stems, and roots are presented in Table 1.

Alkaloids. As shown in Table 1, a yellowish precipitate for Mayer's test and reddish precipitate for Wagner's test indicated a positive result. Alkaloids are used as analgesic and sedative. They reduce pain (The Columbia Electronic Encyclopedia Copyright, 2003). They are particularly useful to relieve cough and they lower the reflex irritability of the respiratory center.

They are also antihypertensive antineoplastic agents and

demonstrate encolytic property (anti-tumor activity). They are used to relieve nasal congestion, stop hemorrhage, stimulate muscles, combat malaria and dilate the pupil of the eye (US Educator Encyclopedia, 1987 p.61). The leaves, stems and roots of *barsanga* could be a potential cure for the above-mentioned illnesses.

Glycosides. There was no increase of brick red precipitate in the hydrolyzed sample in Fehling's test which indicated negative result on the leaves, stems and roots of the plant. This indicated that *barsanga* cannot heal heart failure.

Table 1. Qualitative test of *barsanga* leaves, stems and roots.

THERAPEUTIC COMPONENTS	ALCOHOLIC EXTRACT	INDICATORS
Alkaloids	Traces (+)	Formation of yellowish and reddish precipitates
Glycosides	Negative (-)	No increase of brick red precipitates
Tannins	Traces (+)	Heavy precipitates in the mixture
Saponins	Negative (-)	No formation of honeycomb froths
Flavonoids	Traces (+)	Formation of red color
Sterols	Moderate (++)	Production of blue color
Triterpenes	Negative (-)	Pink color did not change to red

Tannins. A heavy precipitation in the mixture upon the addition of gelatin solution was observed which indicated a positive result.

Recent reports show that tannins have potential medicinal value. They could be used as a treatment for diarrhea and extensive burns and maybe used for relief of various rectal disorders and excretion. They can also be used in the treatment of bedsore and weeping ulcers. These tannins were also formerly used for sore throat and stomatitis (Anderson, 1985, p. 490). Therefore, the plant could be potential source of treatment of the above-mentioned diseases.

Saponins. No formation of honeycomb froths at 3.2 centimeters high in the froth test indicated a negative result. This means that the leaves, stems and roots of *barsanga* are not emulsifying agents. They

cannot be used as detergents to replace soap.

Flavonoids. The color test for flavonoids yielded a positive result. There was a formation of red color when the ethanol extract was treated with hydrochloric acid and magnesium turnings. This implies that *barsanga* has antifugal, anti-inflammatory and cytotoxic activities (Capal, 1992).

Sterols. A production of blue color in the Liebermann-Burchard test indicated the presence of sterols. This means that the plant could be a good source of medicine in the treatment of menstrual disorder and rickets and it could also be a good source of Vitamin D.

Triterpenes. The Liebermann-Burchard test for triterpenes yielded a negative result on the leaves, stems and roots of *barsanga*. The pink color did not change to red which indicated the absence of triterpenes. This means that the plant is not a good source of Vitamin A. (Cabatit, 1997).

Table 2 presents the effectiveness of the three pesticides used to test insects.

Table 2 Result of comparison among the three pesticides using different test insects

Species	Kinds Of Pesticides	No. Of Species Treated	Frequency Of Sprays	Morta-Lity	Time	Effect-Iveness Rank
1. Ants	Organophosphate	10	5	9	10 (sec)	2
	Barsanga	10	5	10	10 (sec)	1
	Carbamate	10	5	7	12 (sec)	3
2. Aphids	Organophosphate	10	3	9	9 (sec)	1
	Barsanga	10	3	8	10 (sec)	2
	Carbamate	10	3	7	11 (sec)	3
3. Houseflies	Organophosphate	10	7	9	19 (sec)	1
	Barsanga	10	7	8	20 (sec)	2

4. Mosquitoes	Carbamate	10	7	8	22 (sec)	3
	Organophosphate	10	6	9	14 (sec)	1
	Barsanga	10	6	9	15 (sec)	2
5. Cock-roaches	Carbamate	10	6	8	18 (sec)	3
	Organophosphate	10	8	8	3 (min)	1
	Barsanga	10	8	7	3 (min)	2
	Carbamate	10	8	6	4 (min)	3

As seen in Table 2 with the ants as test animals, *"barsanga"* ranked first because after 10 seconds, all the test animals died (10); Organophosphate ranked second with 9 ants dead after 10 seconds; and the last was Carbamate with seven dead after 12 seconds.

With the aphids, houseflies, mosquitoes and cockroaches as test animals, Organophosphate ranked first as far as efficacy is concerned followed by *barsanga* and last was Carbamate.

From the above data, it could be observed that the bigger the insect the harder it was to kill it.

Table 3 shows the ANOVA results on the mortality of insects using three pesticides.

Table 3. ANOVA Table on the differences of mortality of insects

Source of Variation	Sum of Squares	df	MSS	f-ratio	Critical Value	Interpretation
Between groups	6.9333	2	3.46665	4.75	3.88	Significant
Within groups	8.88	12	0.73			
Total	15.7333	14				

The f-ratio of 4.75 is significant at 0.05 probability level. This means that there is significant difference between and among the pesticides used in killing the insects.

Since the f-ratio is found significant, this is further subjected to t-test to determine which pairs of pesticides are significantly different.

Table 4 gives the result of the t-test on significant difference on the mortality between and among the pesticides used.

Table 4. Result of t-test on the significant difference between and among the pesticides

PESTICIDES	ORGANO-PHOSPHATE	BARSANGA	CARBAMATE
Organosphosphate	*Barsanga*	0.73	3.79*
Barsanga	Carbamate	------	1.9*
Carbamate	--------	--------	--------

*Significant at 0.05 level

Organophosphate when compared to Carbamate yielded a computed value of 3.79 which is higher than the t-value of 1.86. This is significant at .05 probability level. This implies that Organophosphate is more effective than Carbamate.

Barsanga pesticide when compared to Carbamate showed a computed value of 1.9 which is higher than the t-value of 1.86. This is significant at .05 probability level. This implies that *barsanga* is more effective than Carbamate.

Organophosphate and *barsanga* when compared did not show significant difference at .05 probability level, this implies that Organophosphate has almost the same effectiveness as that of *barsanga* pesticide.

CONCLUSION

The ethanol extracts of the leaves, stems and roots of *barsanga* contain therapeutic components such as alkaloids, tannins, flavonoids and sterols. This implies that the plant is a good source of treatment for hypertension, tumor, wounds, sores, boils, stomachache, diarrhea, sore throat, burns, ulcer, nasal congestion, cough, hemorrhage, malaria, other rectal disorders, viral and fungal infections, inflammatory and cytotoxic activities. The plant is not an excellent emulsifying agent because it does not contain saponins and therefore cannot be used as

detergent to replace soap. The Libermann-Burchard test for triterpenes showed negative results which implies then that *barsanga* is not a good source of Vitamin A.

The tuber of *Barsanga* (*Cyperus rotundus* Linn.) can be made into an effective pesticide. It is more effective than Carbamate and has almost the same efficacy as that of Organophosphate.

RECOMMENDATIONS

The following recommendations are presented, based on the results of the study.

1. The *barsanga* tuber can be a good substitute for commercial pesticides. It is environment-friendly because it does not contribute to air pollution. The farmers should patiently prepare *barsanga* tuber pesticide for their crops and to solve their problems regarding expensive commercial pesticides. This way, they, too, help save the earth from total destruction because *barsanga* pesticide does not contain hazardous chemicals that deplete the ozone layer.
2. The greater the weight of the insect, the longer should be its period of exposure to the *barsanga* pesticidal spray and dosage should also be higher.
3. A follow-up study should be conducted for pesticidal/ insecticidal testing on other species of insects using other kinds of plants.
4. The toxicity level of Barsanga(Cyperus rotundus) should be determined to pave a way to other pharmacological studies of the plant.
5. The result of this research is recommended to be listed in the compilation and documentation of Medicinal Plants in the Philippines through REDTI, NRCP, DOST and UP and be indexed at PROSEA, Plant Resources of Southeast Asia.

LITERATURE CITED

Alcantara, J.
1985 *Insecticidal Activity Screening and Identification of Two Major Crystalline Fractions in Ageratum Conyzoides L.* Unpublished Masters Thesis, U.P. Los Baños, 1981.

Anderson, B.
1985 *Remington's Pharmaceutical Sciences*. Pennsylvania: Mack Pub. Co., 1975.

Bañez, S. S.
1995 *Phytochemical Screening and Pharmacological Testing of Sanggumay Orchid (Dendrobium superbum Reichb)*. UNP Research Journal, 1995.

Bañez, S. S.
2001 T*oxicologic Analysis of Linlinna-aw (Peperomia pellucida Linn.)* UNP Research Journal.

Capal
1992 *A Manual on Extraction Procedures and Microbiological Assay of Medicinal Plants*. Manila: DOST.

Guevara and Recio.
1985 *Phytochemical, Microbiological and Pharmacological Screening of Medicinal Plants*. Manila: UST Printing Press.

Isleta, N. I.
1992 *Herdin Current Awareness*. Herdin: PCHRD.

Rejesus, M. B.
1975 *Insecticidal Activity of Selected Plants with Emphasis on Marigold and Makabuhai*. Manila: NRCP Annual Report.

Quisumbing, E.
1951 *Medicinal Plants of the Philippines*. Manila: Bureau of Printing.

Santos, A.
1985 *Phytochemical Screening of Medicinal Plants*. Manila: UST Research Center.

US Educator Encyclopedia, 1986.

INTERNET SOURCE

http:// www.people vcu .edu/urdesai/car.htm