FEASIBILITY OF USING THE SEAGRASS, *Enhalus acoroides*, IN PAPERMAKING

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"The Feasibility of Using the Seagrass, *Enhalus acoroides*, in Papermaking"

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ABSTRACT

The main purpose of this study is to determine the feasibility of using the fibers obtained from the seagrass, *Enhalus acoroides,* in papermaking. The seagrass fibers were used to further add to the other possible uses of seagrass fibers.

The fibers from the seagrass, *Enhalus acoroides,* and waste paper were used in this study. Paper was produced under different waste paper and seagrass fiber ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

The study determined if there is a significant difference between the breaking length, water retention, and market appeal among the five different treatments.

There is no significant difference between the breaking lengths of the various ratios.

Results showed that there is a significant difference amongst the market appeal and the water retention of the paper. The seagrass fiber and waste paper ratio with the highest significant difference in terms of water retention is the 0 waste paper: 100 seagrass fiber. The lowest significant difference in terms of water retention is the 50 waste paper: 50 seagrass fiber. The paper which ranked highest in the market appeal is the paper with the 0 waste paper: 100 seagrass fiber ratio and the lowest being the paper with the 75 waste paper : 25 seagrass fiber ratio.

Since it is feasible to create paper with the use of *Enhalus acoroides,* it is recommended that follow-up studies be conducted on the feasibility of the seagrass *Enhalus acoroides* leaves as pulp additive using more refined parameters and to test the feasibility of other seagrass species (e.g. *Thalassia hemprichi*i, etc.) as pulp additive.

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CHAPTER I

INTRODUCTION

A. Background of the Study

Writing paper first appeared between 2500 to 2000 BC. It was made from a tall reed called papyrus which grew along the Nile River in Egypt. Strips from the reed were glued together with starch. This sheet was superior to calf and goatskin parchments, clay bricks, waxed boards and other writing materials available at that time. (Reinhold, 1994)

Since paper was first created, the art of papermaking spread to other parts of the world. Papermaking techniques were soon discovered and developed to increase production and improve quality of paper. One of the techniques was the addition of an additive to the main pulp to improve the quality of the paper. Paper was usually a product of bleached kraft pulp or BKP, produced by the chemical pulping of wood. Bleached kraft pulp consists mainly of cellulose and hemicellulose, two polymers that are composed of sugar molecules. The glucose units in each of these two chemicals are linked together in such a way (beta-1-4) that they are much more resistant to chemical hydrolysis than starch molecules. The cellulose chains have a great tendency to form crystalline domains that involve internal hydrogen bonding. These domains are responsible for the fact that the fibers do not dissolve in water. (http://www4.ncsu.edu/~hubbe/DSR.htm).

The addition of a dry-strength additive to BKP resulted in a paper of improved quality, because it increases the relative bonded area or strength per unit of bonded area between the fibers in a sheet of paper. (Nogra, 1998; http://www4.ncsu.edu/~hubbe/DSR.htm). Paper is a commodity of thin material produced by the amalgamation of fibers, typically vegetable fibers composed of cellulose, which are subsequently held together by hydrogen bonding. While the fibers used are usually natural in origin, a wide variety of synthetic fibers, such as polypropylene and polyethylene, may be incorporated into paper as a way of imparting desirable physical properties. The most common source of these kinds of fibers is wood pulp from pulpwood trees, largely softwoods and hardwoods, such as spruce and aspen respectively. Other vegetable fiber materials including those of cotton, hemp, linen, and rice may be used.
(http://wikipedia.org/wiki/Paper).

Vegetable fibers are predominantly cellulose, which, unlike the protein of animal fibers, resists alkalies. Vegetable fibers resist most organic acids but are destroyed by strong mineral acids. Improper use of most bleach can also weaken or destroy these fibers.

There are four major types of vegetable fibers: seed fibers, which are the soft hairs that surround the seeds of certain plants; bast fibers, the tough fibers that grow between the bark and stem of many dicotyledonous plants; vascular fibers, the tough fibers found in the leaves and stems of monocotyledons; and grass-stem fibers (Microsoft Encarta Reference Library, 2003). Seagrass fibers are classified under grass-stem fibers. Seagrass fibers have been used internationally as rugs, nets, and the like.

Seagrasses are creeping, marine plants (Kirkman, 1990) found along temperate and tropical coastlines. They are neither true grass nor are they algae. They are the only true marine flowering plants with roots, stems, and leaves. Seagrass communities make important contributions to marine productivity. They provide food and shelter, and serve as breeding and nursery grounds for marine invertebrates and fishes, many of which are commercially important.

Seagrass fibers have been used around the world as rugs, baskets and other various products. In the Philippines however, these options have not been explored as much, and the seagrass has not been considered as a possible source of income which is why the deterioration and destruction of the seagrass communities remain rampant. The use of the seagrass might help the public realize its commercial value therefore, ensue its cultivation, similar to the rice and mango. At present, no studies have been conducted on the feasibility of the seagrass fibers as pulp additives.

This study aimed to determine the feasibility of using the seagrass fibers in papermaking. Quality of paper was indicated by its breaking length, water retention, and market appeal.

B. Statement of the Problem

What is the feasibility of using the seagrass, *Enhalus acoroides*, in papermaking?

C. Objectives of the Study

This study aims:

a.) To determine the breaking length, water retention and market appeal of the papers produced from the seagrass, *Enhalus acoroides*, under different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

b.) To compare the breaking length, water retention and market appeal of the papers produced from different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

D. Hypothesis of the Study

There will be no significant difference on the breaking length, water retention and market appeal of the paper produced from the different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75

seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

E. Research Paradigm

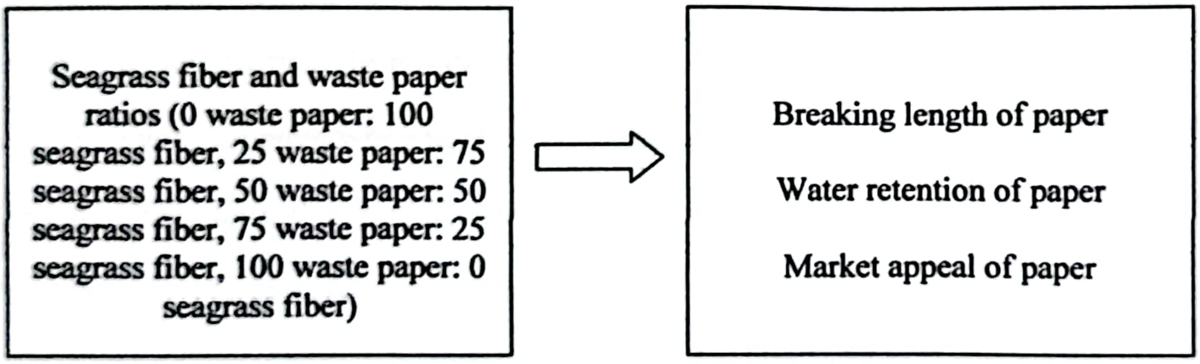

Figure 1. The Research Paradigm

F. Significance of the Study

This study aims to find out the effects of the seagrass, *Enhalus acoroides*, on the breaking length, water retention, and market appeal of paper when it is used in papermaking.

As of today, no studies have been conducted on the papermaking potential of the seagrass fibers. If the results of our study prove to be significant, this will help in improving areas with seagrass community since known uses of the seagrass fibers are rather limited, therefore, if our results prove significant, it would encourage the cultivation of the seagrass in various areas.

The paper industry would benefit from this as well since we would be testing the possibility of using a different type of fiber (seagrass) in the course of the study. If we yield significant results, the small businesses involved in the paper making industry would benefit as well.

Waste management will also improve since the papers used in this study will be waste paper. Despite the efforts of the government to control the waste management, the problem still poses a hassle to society. In the Philippines, waste generation is an average of 36,172.50 tons per year, i.e. 0.50 kg/capita/day (in urban areas) and 0.30 kg/capita/day (in rural areas) (http://www.unep.or.jp/Ietc/Publications/spc/State_of_waste_Management/2.asp).

This study will further encourage the recycling of waste paper

The study also encourages researchers to do further study on the other possible uses of seagrass. The public will be more informed of the potential economic importance of the seagrass and the culturing of the seagrass would be more prevalent, considering the fact that they would find it as another valuable source of income in their part.

G. Scope and Delimitations of the Study

This study aimed to find out the effects of the seagrass, *Enhalus acoroides*, on the breaking length, water retention, and market appeal of paper when it is used in papermaking.

The seagrass, *Enhalus acoroides*, was obtained from Villa Igang, Guimaras.

NaOH was used in chemical pulping.

There were five treatments, the treatments are as follows:

- 0 waste paper: 100 seagrass fiber
- 25 waste paper: 75 seagrass fiber
- 50 waste paper: 50 seagrass fiber
- 75 waste paper: 25 seagrass fiber
- 100 waste paper: 0 seagrass fiber

The making of the pulp, data gathering, and analysis was conducted in Philippine Science High School Western Visayas and in Barotac Nuevo.

The breaking length of the paper was measured by gradually adding weights (in Newton) connected to the paper samples.

The water retention capacity of the paper products was obtained by getting the % water uptake (or % mass increase) of the paper samples after soaking water.

The market appeal of the paper was tested by giving out paper samples to consumers for rating according to three categories: clarity and consistence, smoothness, and appeal.

H. Definition of Terms

Binder : Materials, which cause coating pigments to bond. The most frequently used binder is starch, but synthetic binders are also used to give improved performance.

Breaking length: A measurement of breaking length of paper corrected for its basis weight.

Cellulosic fiber: Four manufactured fibers, rayon, acetate, triacetate and lyocell, are cellulosic fibers. This means that one of the components used in their production is natural cellulose. Cellulose is wood pulp, generally obtained from trees. All of the remaining manufactured fibers are non-cellulosic, which means they are entirely chemically-based.

Concentration: The strength of a solution; number of molecules of a substance in a given volume (expressed as moles/cubic meter).

***Enhalus acoroides*:** Is the most common seagrass species found in the coastal areas of the Philippines. Its seeds can be eaten raw or used in making flour that could substitute flour commonly used in baking(Tacio,2005).

Fiber: Threadlike strand, usually pliable and capable of being spun into a yarn. Many different fibers are known to be usable; some 40 of these are of commercial importance, and others are of local or specialized use. Fibers may be classified as either natural or synthetic. The natural fibers may be further classed according to origin as animal, vegetable, or inorganic fibers.

Market appeal: Market appeal is operationally defined as the public's rating of the paper, how they find the quality according to their rational self-interest.

Paper: A material made of cellulose pulp, derived mainly from wood, rags, and certain grasses, processed into flexible sheets or rolls by deposit from an aqueous suspension, and used chiefly for writing, printing, drawing, wrapping, and covering walls.

Pulp: Crushed wood or other materials that are used to make paper. It is a chemically or mechanically produced raw material used in the production paper and paperboard.

Seagrass: An underwater marine grass with long thick blades that is harvested and processed into a material, similar to twine or jute, used for making baskets and matting.

Waste Paper: Waste paper is operationally defined as paper which has been used previously (e.g. scratch bond papers and the like).

Water Retention: The ability of the water samples to retain, absorb, or take up water, expressed in 5 mass increase or % water uptake of cut paper samples.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter discusses four topics, namely: (1) Paper, (2) Seagrass, (3) Paper Quality.

A. PAPER

Papers are thin sheets of compressed vegetable cellulose fibers. Paper is used for writing and printing, for wrapping and packaging, and for a variety of special purposes ranging from the filtration of precipitates from solutions to the manufacture of certain types of building materials. Its largest uses are for printing, writing, wrapping, and sanitary purposes, although it is employed for a wide variety of other uses.

A.1 Uses of Paper

Paper is one of the most important products ever invented by man. Widespread use of written communication would not have been possible without some cheap and practical materials to write on. Besides its role in communications, paper and paper products are important now for many other purposes (Baldivia et al., 1999). Common uses of paper include legal documents, including deeds, wills and certificates, where high permanence and proof against forgery are demanded, papers for fine book printing engraving and advertising, artists' paper for water color printing, drawing, sketching and lithography, all purpose cards stationeries, envelopes, invitations, and writing papers (Peralta, 2004).

A.2 Composition of Paper

All types of paper (Britannica, 1973) are made from pulp containing vegetable, mineral or manmade fibers that form a matted or melted sheet on a screen when moisture is removed. Nearly all paper is made up of cellulosic (vegetable) fibers.

All paper is basically made in the same way. Cellulose fibers are treated with chemicals and mixed with water. Paper can be made from cellulose fibers alone. However, such a paper will lack many properties and will be unsuitable for a large range of uses for which paper is needed. Many of these properties are supplied by adding chemicals, largely in the stock preparation process. While the selection of proper fibers for a given paper is important, non-fibrous materials added to the stock supply the required properties not inherent in paper made from fibers alone (Baldivia et al., 1999).

A.3 Sources of Paper

Paper is made up of bonded fibers of plant materials such as wood, straw, hemp, or cotton (Peralta, 2004). Results of past studies showed that corn husks and feathers were feasible materials for the production of packaging paper (Baldivia et al., 1999). Another study showed that coconut husk fibers were possible pulp additives to recycled papers. It was also recommended in the said study to use other sources of pulp additives in papermaking such as sugarcane leaves, waste dried leaves, and any other fibrous material (Pama et al., 1998). Corn, onion peelings, and "palagtiki" (*Eleusine indica*) (Cabato et al., 1997) are also acceptable raw materials that can be utilized in papermaking (Andrada et al., 2003). Other materials that can be used in papermaking include natural fibers such as abaca, salago, piña, maguey, ramie, and kenaf including cogon grass, water lily, talahib, latbang, suksuka, acbab, nipa, hablang, bamboo, mulberry barks, and other plants/trees which contain significant amount of fibers, agricultural waste such as banana stalks, rice straw, bagasse and corn husk, and semi-processed materials that include the following, pulp and recycled or de-inked waste paper (Peralta, 2004).

A.4 Waste Paper

Several local studies have used wastepapers to determine if they will be feasible if included in the pulp of some handmade paper products. Such usage of the said wastepapers will help reduce waste problems, which cause air, water, and land pollution. Metro Manila alone produces 13.28% of wastepaper out of 4000 tons of garbage daily and it would be useful to reutilize such an amount of trash. (Bato Balani, Vol. 15, No. 5). These wastepapers are comprised of the old used news papers, test papers, used writing papers, and even tissue papers. These materials are separately gathered from the different corners of any place (Pama et al, 1998).

B. SEAGRASS

Seagrasses are creeping, marine plants (Kirkman, 1990) commonly found in shallow littoral zones along temperate and tropical coastlines (Philips and Meñez, 1998). They are not true grasses nor are they algae (Lloyd, 1999). They are the only true marine flowering plants with stem, leaves and roots. Seagrasses are invaluable element of the coastal environment and their depth of growth is used as an indicator of water quality. They are not direct food source, at least when growing, due to high cellulose content, low nitrogen levels and the presence of phenolic acids. But seagrass beds shelter many marine forms, providing protection and breeding gounds (Davies et al). Seagrasses are the least studied among the habitats in most of coastal zones (Tacio, 2005).

Seagrass fibers may vary in color from light beige to darker brown with a green tinge, although the green tinge fades over time. One experiment conducted by Torbatinejad et al (2001) about the laboratory evaluations of some marine plants used a species of seagrass and compared it to twelve species of seaweed. The ground samples of the plants were analyzed for fiber content and other parameters. Results showed that the crude fiber in seagrass was considerably greater than in seaweed species (34.4 % vs 3.7 -10.1). Another study entitled "Structure and Properties of Fibers from Seagrass *Zostera marina*" conducted by Davies et al (2007) presented results that fibers extracted from *Zostera marina* commonly called eel-grass composed of 57% cellulose, slightly higher than 38% non-cellulosic polysaccharides and 5% residual matter so called Klason lignin.

B.1 *Enhalus acoroides*

Enhalus acoroides is rhizomatous, submerged, marine herb commonly found on intertidal areas on reef platforms, and tidal channels. Several uses of Enhalus acoroides have been documented. This species of seagrass is a very important source of food. Its seeds can be eaten raw. Dr. Marco Nemesio Montano has discovered that the seeds of Enhalus acoroides can be made into flour, a viable substitute for the ordinary flour used in baking (Tacio, 2005).

Values obtained from fifteen core samples in the coastal areas of Guimaras showed that the density of Enhalus acoroides is 32.66 shoots per square meter. The biomass expressed as gram dry weight per square meter of Enhalus acoroides is 44.04. seagrass biomass is the measure of the total weight of a given seagrass sample and the area it inhabits (Biyo, 2001).

B.2 Uses of Seagrass

Twine and thread are made from the fiber, and the cloth (often mixed with other fibers) is used in upholstery, tapestries, and other materials. Seagrass is harvested and processed into a material, similar to twine or jute, used for making baskets and matting. (Microsoft Encarta Reference Library, 2003).

According to a patent found in the US Patent Office, one invention by Herbert Abraham uses a certain variety of sea grass not treated with chemicals mixed with some waste papers and rags for the production of a fibrous felt which is a material used as a roof sealant. A result showed that a felted sheet has been formed and found to have a good breaking length, porosity and was much cheaper to manufacture than felt made from cotton and woolen rags (Abraham, 1917).

Dried seagrass material was commonly used as housing insulation, until well into this century. Its thermal and sound-proofing properties derived largely from the air spaces which occur in mats of seagrass material. One of the major beneficial properties of seagrass as insulation was that it was non-flammable, because of its high silicon content. A popular form of insulation in the United States was something called a Cabot's quilt, named after its inventor. This was a mat of dried seagrass material, inserted into the walls of houses. The material was also used to sound-proof radio studios in the USA and the UK (Cabot, 1986; Hurley, 1990; Thomas, 1961).

Several references document the use of seagrass as manure, although this is probably more for the algae and other marine organisms entangled within the seagrass mat, than the seagrass itself. *Posidonia oceanica*, when mixed with lime and phosphates, was used in Mediterranean countries as a meal for feeding poultry. This was also experimented in South Australia, although only on a limited basis. Washed up seagrass wrack is commercially used to make garden mulch, although there is speculatio n that this is largely for bulk.Various workers over the past few decades have studied the mineral composition of seagrasses, and concluded that, while considerable quantities of minerals such as Boron occur in seagrass material, it is not commercially viable to extract. There are suggestions that in Denmark seagrass material may have been burned as a source of salt, soda minerals or simply for warmth. Old reports also exist about seagrass as a relief for rheumatism (Waters, 1965; Stewart & Mills, 1975).

Japanese fishers used *Phyllospadix iwatensis* as a material for making wet weather gear up to the 1930s, when rubber became popular. There are unconfirmed reports of seagrass fiber being used for basket-weaving, although other aquatic (freshwater) vegetation may actually be used in this instance). Seagrass fiber is used to make "coir" mats and rugs. During the Second World War, seagrass fiber was used as a substitute for cotton in the manufacture of nitrocellulose (Mcroy and Helfferich, 1980).

C. PAPER QUALITY

C.1 Breaking Length

To calculate the breaking length, a certain procedure is being followed. The paper strip is taped using a strong duct tape on the edge of the table so that it hangs vertically. At the bottom of the paper strip, another tape is attached to hold a bucket which will carry the weights that will be gradually added until the paper snaps. The breaking length, expressed in centimeters (cm) is the total mass in grams needed (g) to break the strip of the paper over the product of the width at break (cm) and basis weight (g/cm^2) which is the mass of the sheet over the area of the sheet.

C.2 Water Retention

Water retention capacity is the ability of the water samples to retain, absorb, or take up water. The water retention is determined first by measuring the mass of the samples using a triple beam balance. These samples are soaked in water and the corresponding masses of the wet samples are measured. The difference of the mass of the wet sample and the mass of the paper when dry is computed, and the result is divided by the mass of the paper when dry. The final computations will be multiplied by 100%, expressed in % water uptake of cut paper samples (Nogra et al, 1998).

C.3 Market Appeal

Main criteria under market appeal include appearance, clarity/consistency, and smoothness. The finished paper products for each treatment are cut similarly and labeled. There are respondents from both public and private offices, and respondents from schools to rank the paper samples according to appearance, clarity/consistency, and smoothness (Cabato, 1997).

CHAPTER III

METHODOLOGY

I. Materials

- Five kilogram *Enhalus acoroides* leaves
- Ice Box
- Five hundred gram white scratch papers
- Basin
- Tap Water
- Mortar and Pestle
- Cheese Cloth
- Two hundred fifty Caustic soda (NaOH)
- Medium sized clay pots
- Hand Gloves
- Strainers
- Two hundred fifty grams Sodium Hypochlorite
- 9" x 11" Screen box
- Two hundred fifty grams Cassava Starch
- Stirring Rod
- "Pilon" (drying board)
- Peso coins

- Duct Tape
- Folders
- Knife
- Scissors

II. Equipments

- Triple Beam Balance
- Burner
- Analytical Balance
- Blender
- Weighing Scale
- Top loading balance

III. Procedure

A. Gathering of Seagrass

Five kilograms of the seagrass, *Enhalus acoroides*, leaves were collected from the coastal areas of Villa Igang, Guimaras. They were rinsed with seawater at the gathering site to remove adhering sediments. The gathered seagrasses were placed inside the ice box and then brought to the Philippine Science High School Western Visayas (PSHS-WV) research laboratory.

B. Procurement of Waste Papers

Five hundred grams of used long and short bond papers was collected from the PSHS-WV community. The crumples in the papers did not matter. These served as the waste papers.

C. Cleansing and Disintegration of Seagrass and Waste Papers

The seagrass leaves were scrubbed with a brush to remove epiphytes and other dirt. The scrubbed seagrass leaves were left to soak for 24 hours in a basin of tap water to further get rid of its dirt.

The waste paper were cut into small pieces of about 1cm and soaked in another basin to remove its dirt. This process helped soften the two materials in preparation for mechanical pulping using mortar and pestle.

D. Mechanical Pulping

After soaking the seagrass leaves, they were pounded using the mortar and pestle to reduce it into smaller and finer pieces. The soaked waste paper were also pounded in the same manner as the seagrass. The pounded seagrass and waste paper were washed separately using tap water. They were separately squeezed in a cheese cloth to remove the water.

E. Chemical Pulping of Seagrass Fibers and Waste Paper

The seagrass fibers and waste paper were placed in a separate clay pot instead of a metal pot because metal reacts with NaOH. The seagrass fibers and waste paper were separately measured. Water was added to the seagrass fibers and waste paper just to cover the plant material in the plant. Twenty five percent (25%) caustic soda by weight was added to the seagrass fibers and waste paper.

The two mixtures were boiled for 2 hours. By that time, they are already soft and slippery when rubbed between gloved fingers.

After boiling, the seagrass fibers and waste paper were separated from the mixture by collecting the pulps of seagrass fibers and waste paper with a fine strainer. The seagrass fibers and waste paper pulps were washed and squeezed in a cheese cloth to drain the mixture and remove any impurities.

F. Bleaching

The seagrass pulp and the waste paper pulp were separately bleached. Two hundred fifteen (215) grams of Sodium Hypochlorite, the bleaching agent used in the study, was dissolved in 20 liters of tap water in a basin. The 1 kilogram seagrass pulp was added to the mixture. The mixture was stirred thoroughly and was soaked for 1 hour with occasional stirring. The mixture was poured in the strainer thereby discarding the bleaching solution. The bleached pulp was washed with water thoroughly. Another 215 grams of Sodium Hypochlorite was dissolved in 20 liters of water in a basin. The 1 kilogram waste paper pulp was added to the mixture and was bleached in the same manner as the seagrass pulp.

G. **Weighing and Mixing**

The following proportions of seagrass pulp to waste paper pulp were made for each treatment by weighing the materials using a triple beam balance. There were five treatments, the treatments are as follows:

100 waste paper: 0 seagrass fiber	= 200g WP
75 waste paper: 25 seagrass fiber	= 150g WP; 50g SF
50 waste paper: 50 seagrass fiber	= 100gWP; 100g SF
25 waste paper: 75 seagrass fiber	= 150g SF; 50g WP
0 waste paper: 100 seagrass fiber	= 200g SF

Each treatment was combined using a blender.

H. **Adding of Binder**

A 25% cooked starch solution was prepared by mixing 250 grams of cassava starch to 750 ml of water. The mixture was cooked under low flame for around 15-20 minutes. This mixture was divided into five for the five treatments.

The five treatments were separately placed into 25% starch solution inside a basin and were properly mixed by stirring the mixture together.

I. **Paper making**

On a basin, prepared screen mold made from fine wire screen with a dimension of 9" x 11" was placed. The five treatments were separately poured into this mold. The mold was slowly shaken to distribute the pulp. A knife (cleaver) was used to smoothen the surfaces of the mixture.

The “pilon” was placed on top of the mold. The mold was quickly flipped, leaving the pulp mixture on top of the “pilon”. The formed sheets were transferred to the “pilon”. The mold was detached from the sheet. Another “pilon” was placed on top of the formed sheet. The ‘pilon’-sandwiched formed sheet was pressed using a rolling pin to achieve even distribution of pulp and was left to dry. This process was utilized for the rest of the treatments.

When the “pilon”-sandwiched formed sheets were already dry, the “pilons” were slowly and delicately peeled off from the formed sheets.

Two sheets of paper were produced for each treatment. Size of the paper produced is 8.5”x11”.

J. Data Gathering

Each sheet of paper was divided into 2 lengthwise. One lengthwise from every treatment was randomly picked and was used for testing the breaking length. Another lengthwise was randomly picked and was used for testing the water retention. The other two lengthwise left was further divided and used for the market appeal test.

J.1 Breaking Length

The lengthwise randomly picked for breaking length was divided into 4 strips, each measuring 2cm by 15 cm. A calculation sheet was used to record data in this test. Using a 10 cm length of duct tape, at least 3 cm length of the paper strip was taped to the table edge so that the strip hung vertically. Using about a 20 cm length of duct tape, the bucket was attached to the bottom of the paper strip. The tape looped around the bucket handle and then sandwiched the bottom part of the paper strip. At least 3 cm length of the paper strip was taped to the bucket's handle. The weighed peso coins were individually added to the bucket until the paper strip snaps. The number of coins was recorded in the said calculation sheet.

This process was utilized for the rest of the paper strips.

PAPER STRENGTH CALCULATION SHEET

Sample ID ____________________

Mass of Bucket ____________________ g
Mass of a penny ____________________ g

Sheet area = __________ m^2
Sheet mass = __________ g
Basis weight = Sheet mass/Sheet area = __________ g/m^2

# of pennies to break strip (result 1) = __________
# of pennies to break strip (result 2) = __________
# of pennies to break strip (result 3) = __________

# of pennies to break strip (Average) = __________

Mass of pennies to break strip (Average) = __________
Total mass to break strip (pennies + bucket), m_t = __________ g

Width at break (W) (result 1) = __________ mm
Width at break (W) (result 2) = __________ mm
Width at break (W) (result 3) = __________ mm

Width at break (Average) = __________ mm = __________ m

$$\text{Breaking length} = \frac{m_t}{W \times \text{Basis Weight}} = \frac{(\qquad g)}{(\qquad m)(\qquad g/m^2)}$$

Breaking length = ____________________ m

Note: In order to obtain the breaking length in meters, be careful to use the appropriate units specified in the formula.

ILLUSTRATION OF THE EXPERIMENT

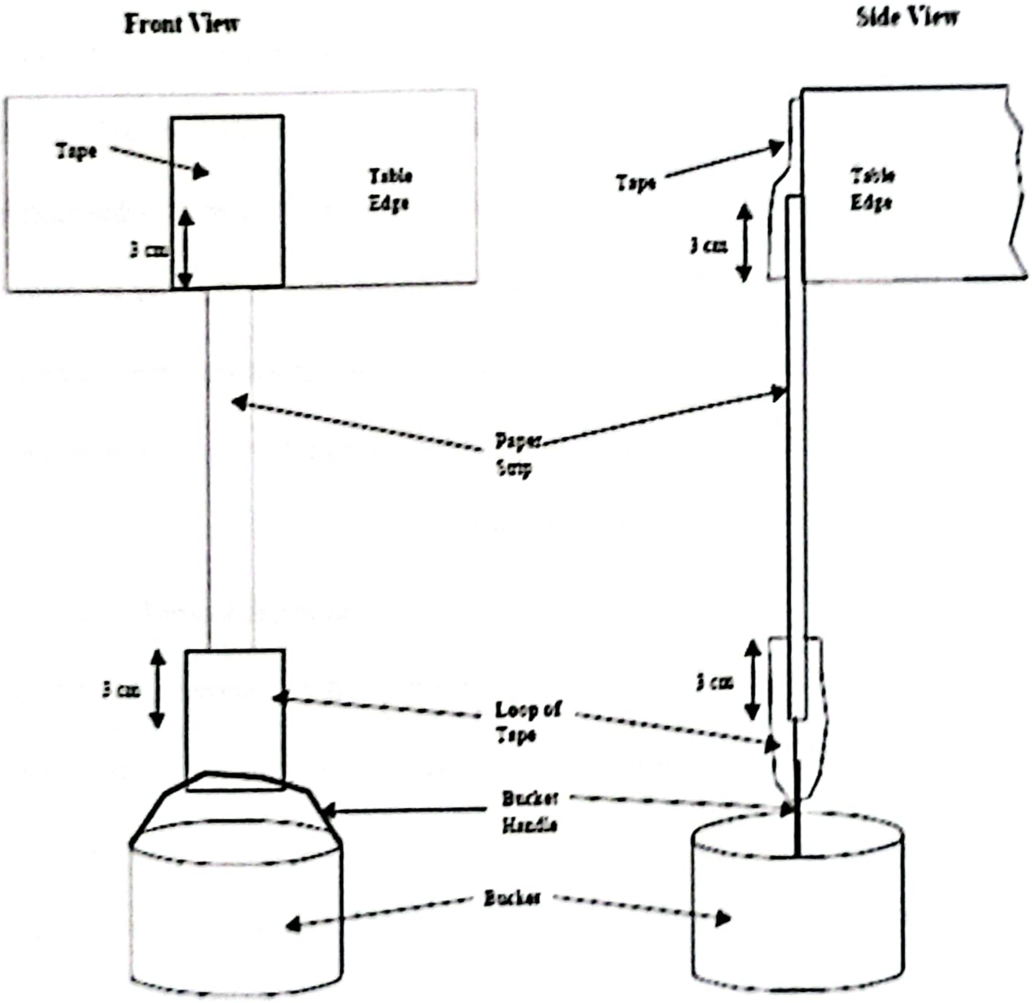

FIGURE 2. Breaking Length Illustration

J.2 Water Retention

The lengthwise randomly picked for water retention was divided into five, each measuring 4" x 4". Water retention was obtained by weighing the samples using the analytical balance. The dry paper samples were weighed. They were then submerged into water for three minutes. Water in the surface of the sample was allowed to run off for 20 seconds before they were weighed again. Water retention was computed using the formula:

$$\text{Water retention} = \frac{\text{Final weight - Initial weight x 100\%}}{\text{Initial weight}}$$

J. 3 Market Appeal

Every lengthwise left from every treatment was divided into eight pieces. Each piece from every treatment was placed in a folder along with the criteria written below. This folder was presented to randomly picked respondents from public and private institutions. The government offices who participated in the survey were Local Government Unit (LGU) and Department of Environment and Natural Resuorces (DENR) while the private organizations were Allied Bank of the Philippines, Banco de Oro, Family Diagnostics Center, Iloilo Electric Cooperative II (ILECO) and Barotac Nuevo- Dumangas- Anilao Planters Associaton, Inc. (BDAPAI). Forty eight students from the seniors of Philippine Science High School Western Visayas were choen at random to evaluate the paper samples. All 108 respondents were recognized to be using paper in their everyday lives.

Market appeal was assess through the paper sample's smoothness, clarity or consistency and appearance. The smoothness of the paper was evaluated by asking the respondents to have a feel of the paper's surface and judge how rough or smooth it is. The clarity and consistency is its quality of being clear and being able to maintain a particular color, no matter what it is. The appearance refers to its overall physical aspects to the viewers.

Criteria	10	8	6	4	2
Smoothness	Smoothness is very fine and completely smooth in all areas.	Smoothness is fine and smooth in most areas.	Smoothness is fine and smooth in some areas only.	Smoothness is barely fine and smooth in all areas.	Smoothness is not fine and smooth at all.
Clarity and Consistency	Color is very clear and very consistent all throughout.	Color is clear and consistent in most areas.	Color is clear and consistent in some areas.	Color is barely clear and consistent in all areas.	Color is not clear and consistent at all.
Appearance	Over-all appearance is excellent and very appealing, regardless of binder.	Over-all appearance is very good and quite appealing, regardless of binder.	Over-all appearance is good and appealing, regardless of binder.	Over-all appearance is bad and barely appealing, regardless of binder.	Over-all appearance is poor and not appealing at all, regardless of binder.

FIGURE 3. Market Appeal Criteria

K. Statistical Analysis

The ANOVA test was used for the water retention and the breaking length ad th Kruskal-Wallis, however, was used for the ranking of the different categories in the market appeal. It was used since the respondents were determined from a purposive sampling.

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to determine the feasibility of using the seagrass fibers obtained from *Enhalus acoroides* in papermaking. Five different types of paper were made using different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber). The papers were tested using the three indicators of paper quality: breaking length, water retention and market appeal.

The results showed that using fibers obtained from seagrass, *Enhalus acoroides* , is reasonably feasible.

A. Results

This study aimed to determine the feasibility of using the seagrass, *Enhalus acoroides* in papermaking by measuring the water retention, breaking length, and market appeal to describe the quality of paper produced.

The testing for the breaking length was conducted on January 12 and January 15 of the year 2007. The results were obtained by gradual addition of weights (in grams) connected to the paper samples. The sheets of paper for each treatment were cut into lengthwise pieces. One lengthwise piece was randomly picked and cut into five, equal parts. The area was then measured and was converted to m^2 and was recorded on the calculation sheet along with the paper's weight. Using a 10 cm length of duct tape, 3 cm of the strip was taped to the edge of the table so that it hangs vertically. Using 20 cm of duct tape, the bucket was then attached to the bottom of the paper strip. The weight of a one peso coin was then determined. These coins were then individually added to the bucket until the paper snaps. The number of coins that broke the paper was counted and recorded on the calculation sheet. The calculation sheet served as a guideline in determining the breaking length of the paper. Then the means of the breaking length of each treatment were calculated and then analyzed using the ANOVA test.

The paper with the highest breaking length mean is the paper made from 25 waste paper: 75 seagrass fiber. This was followed by the paper composed of 75 waste paper: 25 seagrass fiber, then the 0 waste paper: 100 seagrass fiber, and then the 50 waste paper: 50 seagrass fiber. The paper with the lowest breaking length mean was the paper made of 100 waste paper: 0 seagrass fiber (Table 1).

Table 1. Mean breaking length of each seagrass fiber and waste paper ratio (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

	100 waste paper: 0 seagrass fiber	75 waste paper: 25 seagrass fiber	50 waste paper: 50 seagrass fiber	25 waste paper: 75 seagrass fiber	0 waste paper: 100 seagrass fiber
Mean breaking length	1492.026	4327.7	2889.27	4391.653333	3215.182

The statistical analysis showed no significant difference between the breaking lengths of the seagrass fiber and waste paper ratios (Table 2).

Table 2. ANOVA test for the breaking length of each seagrass fiber and waste paper ratio (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

	Sum of Squares	Df	Mean Square	F	Sig.	Interpretation
Between Groups	17057258.732	4	4264314.683	1.344	.320	Not significant
Within Groups	31730428.034	10	3173042.803			
Total	48787686.766	14				

The testing for the water retention was conducted on January 12, 2007. Paper samples were cut and their weight was measured. They were then submerged in water for three minutes. Water on the paper's surface was allowed to run off and then it was weighed again. The means of the water retention for each treatment were calculated and then analyzed using the ANOVA test.

The means showed that the paper with the highest water retention mean was the paper composed of 0 waste paper: 100 seagrass fiber ratio, followed by the 100 waste paper: 0 seagrass fiber, and 25 waste paper: 75 seagrass fiber. This was succeeded by the paper composed of 75 waste paper: 25 seagrass fiber. The paper with the lowest water retention mean was the paper made of 50 waste paper: 50 seagrass fiber (Table 3).

Table 3. Mean water retention of each seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

	100 waste paper: 0 seagrass fiber	75 waste paper: 25 seagrass fiber	50 waste paper: 50 seagrass fiber	25 waste paper: 75 seagrass fiber	0 waste paper: 100 seagrass fiber
ean water etention	255.42%	135.71%	97.09%	235.08%	299.05%

There is a significant difference between the water retention of the different seagrass fiber and waste paper ratios. The highest water retention belonging to the paper composed of 0 waste paper: 100 seagrass fiber (Table 4).

Table 4. ANOVA test for the water retention of each seagrass fiber and waste paper ratio (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

	Sum of Squares	Df	Mean Square	F	Sig.	Interpretation
Between Groups	168564.166	4	42141.041	100.218	.000	Significant
Within Groups	8409.877	20	420.494			
Total	176974.042	24				

The seagrass fiber and waste paper ratio with the highest significant difference in terms of water retention is the 0 waste paper: 100 seagrass fiber. The seagrass fiber level with the lowest significant difference in terms of water retention is the 50 waste paper: 50 seagrass fiber (Table 5). The significant differences of the papers were ranked as follows paper composed of 0 waste paper: 100 seagrass fiber > 25 waste paper: 75 seagrass fiber = 100 waste paper: 0 seagrass fiber >75 waste paper: 25 seagrass fiber > 50 waste paper: 50 seagrass fiber (Table 5).

Table 5. LSD Post-Hoc for the significant difference among the five seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

(I) REP	(J) REP	Mean Difference (I-J)	Std. Error	Sig.	Interpretation
100 waste paper: 0 seagrass fiber	75 waste paper: 25 seagrass fiber	119.7080	12.9691	.000	Significant
	50 waste paper: 50 seagrass fiber	158.3680	12.9691	.000	Significant
	25 waste paper: 75 seagrass fiber	-28.9960	12.9691	.037	Significant
	0 waste paper: 100 seagrass fiber	-43.6300	12.9691	.003	Significant
75 waste paper: 25 seagrass fiber	100 waste paper: 0 seagrass fiber	-119.7080	12.9691	.000	Significant
	50 waste paper: 50 seagrass fiber	38.6600	12.9691	.007	Significant
	25 waste paper: 75 seagrass fiber	-148.7040	12.9691	.000	Significant
	0 waste paper: 100 seagrass fiber	-163.3380	12.9691	.000	Significant
50 waste paper: 50 seagrass fiber	100 waste paper: 0 seagrass fiber	-158.3680	12.9691	.000	Significant
	75 waste paper: 25 seagrass fiber	-38.6600	12.9691	.007	Significant
	25 waste paper: 75 seagrass fiber	-187.3640	12.9691	.000	Significant
	0 waste paper: 100 seagrass fiber	-201.9980	12.9691	.000	Significant
25 waste paper: 75 seagrass	100 waste paper: 0 seagrass fiber	28.9960	12.9691	.037	Significant

fiber					
	75 waste paper: 25 seagrass fiber	148.7040	12.9691	.000	Significant
	50 waste paper: 50 seagrass fiber	187.3640	12.9691	.000	Significant
	0 waste paper: 100 seagrass fiber	-14.6340	12.9691	.273	Not Significant
0 waste paper: 100 seagrass fiber	100 waste paper: 0 seagrass fiber	43.6300	12.9691	.003	Significant
	75 waste paper: 25 seagrass fiber	163.3380	12.9691	.000	Significant
	50 waste paper: 50 seagrass fiber	201.9980	12.9691	.000	Significant
	25 waste paper: 75 seagrass fiber	14.6340	12.9691	.273	Not Significant

* The mean difference is significant at the .05 level.

The testing for the market appeal was conducted on December 28, 2007 and January 14, 2007. The paper samples were shown to various individuals who work for government and private offices and students as well. They were asked to judge the paper on its appearance, smoothness, and clarity. A grade of ten served as the highest score and two served as the lowest for criterion. The means for this test were then calculated and analyzed using the Kruskal Wallis Test.

Appearance was rated by the appeal of the over-all aspect of the paper regardless of its binder. The paper with the highest rating according to appearance is the paper made of 0 waste paper: 100 seagrass fibers. This was followed by paper composed of 100 waste paper: 0 seagrass fiber, 25 waste paper: 75 seagrass fiber, and 50 waste paper: 50 seagrass fiber. The paper with the lowest rating was the paper made using 75 waste paper: 25 seagrass fiber (Table 6).

Table 6. Ranking of the paper with different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber) according to appearance.

Seagrass fiber and waste paper ratios	N	Mean	Rank
100 waste paper: 0 seagrass fiber	99	266.02	2
75 waste paper: 25 seagrass fiber	100	212.82	5
50 waste paper: 50 seagrass fiber	100	229.83	4
25 waste paper: 75 seagrass fiber	100	261.79	3
0 waste paper: 100 seagrass fiber	100	279.71	1
Total	499		

There is a significant difference in the appearance, clarity and smoothness ratings among the different seagrass fiber and waste paper ratios (Table 7) with the 0 waste paper:100 seagrass fiber ratio as the most appealing among the five concentrations.

Table 7. Kruskal Wallis test

	Clarity	Appearance	Texture
Chi-Square	28.652	16.045	82.625
Df	4	4	4
Asymp. Sig.	.000	.003	.000

a. Kruskal Wallis Test
b. Grouping Variable:VAR00001

The clarity and consistence of the paper was based on the clarity and consistence of its color all throughout. The paper with the highest rating for its clarity is the paper made from 100 waste paper: 0 seagrass fiber. This was followed by the paper composed of 0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, and 50 waste paper: 50 seagrass fiber. The paper with the lowest ranking for clarity is the paper composed of 50 waste paper: 25 seagrass fiber (Table 8).

Table 8. Ranking of the paper with different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber) according to clarity.

Seagrass fiber and waste paper ratios	N	Mean	Rank
100 waste paper: 0 seagrass fiber	100	294.96	1
75 waste paper: 25 seagrass fiber	100	205.74	5
50 waste paper: 50 seagrass fiber	99	220.58	4
25 waste paper: 75 seagrass fiber	100	254.09	3
0 waste paper: 100 seagrass fiber	100	274.33	2
Total	499		

The rating for the smoothness was based on the fineness and smoothness of the paper in all areas. The paper with the highest rating in this regard is the paper composed of 0 waste paper: 100 seagrass fiber. This was followed by the paper with 25 waste paper: 75 seagrass fiber, and the 100 waste paper: 0 seagrass fiber. The paper composed of 50 waste paper: 50 seagrass fiber came next. The paper with the lowest rating for the texture is the one made from 75 waste paper: 25 seagrass fiber (Table 9).

Table 9. Ranking of the paper with different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber) according to smoothness.

Seagrass fiber and waste paper ratios	N	Mean	Rank
100 waste paper: 0 seagrass fiber	98	214.22	3
75 waste paper: 25 seagrass fiber	100	186.99	5
50 waste paper: 50 seagrass fiber	100	212.74	4
25 waste paper: 75 seagrass fiber	100	300.16	2
0 waste paper: 100 seagrass fiber	100	332.69	1
Total	498		

B. Discussion

The results of this study showed that the fibers from *Enhalus acoroides*, may be used in papermaking. The parameters under which the papers were tested were the breaking length, the water retention and the market appeal, these being the main indicators of paper quality. Five different types of paper were made and tested, each had a different seagrass fiber and waste paper ratio (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber).

The breaking length of the paper composed of 25 waste paper: 75 seagrass fiber proved to have the highest length. This implies that this type of paper was the most durable among the rest, though with no significant difference. The paper with the lowest breaking length was the paper composed of 100 waste paper: 0 seagrass fiber. This means that this type of paper was the least durable (David et al, 1996).

It was found that the papers which were supplemented with seagrass were less brittle as compared to the one composed of 100 waste paper: 0 seagrass fiber. This however, does not in any way imply that the greater the amount of seagrass fiber, the more durable the paper is. This is due to the fact that the breaking length of the paper made from 0 waste paper: 100 seagrass fiber was lower as compared to that of the 75 waste paper: 25 seagrass fiber. The levels that were more durable, were the ones with the 75:25 ratio (e.g. 25 waste paper: 75 seagrass fiber, and 75 waste paper: 25 seagrass fiber). The highest however, being the paper containing25 waste paper: 75 seagrass fiber. This is because the seagrass fibers provide the paper with enough support to make it sturdier as compared to the rest (http://aic.stanford.edu/sg/bpg/annual/v12/bp12-14.html).

Another test to which the paper samples were subjected to was the water retention. This test measures the ability of the samples to retain, absorb, or take up water. The higher its percentage, the more water it can be able to absorb (Nogra et al, 1998). The study revealed that the paper composed of 0 waste paper: 100 seagrass fiber was the one with the highest water retention. The higher the water retention, the more susceptible it is to water damage. This means that the paper composed of 0 waste paper: 100 seagrass fiber is the one most likely to suffer from water damage. The paper with the lowest water retention was the one composed of 50 waste paper: 50 seagrass fiber. This implies that this composition makes the paper the least inclined to suffer from water damage since it absorbs more moisture from the environment (http://www.coastal-style.com/seagrassweave.html).

It was also found out that the papers whose composition were not diverse (e.g. 0 waste paper: 0 waste paper: 100 seagrass fiber and 100 waste paper: 0 seagrass fiber) were prone to water damage as their water retention capacity were higher than that of the rest. The paper that contained 25 waste paper: 75 seagrass fiber and 75 waste paper: 25 seagrass fiber respectively, were found to have the succeeding high water retention. This shows that these ratios of waste paper and seagrass fibers are less predisposed to water damage as compared to the former (0 waste paper: 100 seagrass fiber and 100 waste paper: 0 seagrass fiber). The paper with the lowest water retention was found to be the paper composed of 50 waste paper: 50 seagrass fiber. This indicates that paper with this level of seagrass fibers would endure less water damage as compared to the four other treatments.

This may be due to the fact that equal amounts of seagrass fiber and waste paper makes the paper less absorbent of water, thus, making it the least vulnerable to water damage (http://www.fpl.fs.fed.us/documnts/pdf2000/klung00b.pdf).

The last parameter to which the samples were subjected to was the market appeal. This has three categories beneath it: clarity, appearance and smoothness. The market appeal was obtained by a panel of randomly chosen consumers, ranging from students and employees from private and public sectors. They were made to rate the paper based on a criteria given to them. They scored it as to what they saw fit in terms of meeting the criteria. The paper samples presented to them weren't labeled as to prevent bias.

The first criterion under the market appeal was the appearance. The appearance was based on how appealing over-all they found the paper samples given to them, regardless of the binder. The sample that was ranked as the highest in this aspect was the paper composing of 0 waste paper: 100 seagrass fiber and the lowest being the one made up of 75 waste paper: 25 seagrass fiber.

This suggests that consumers find the appearance of the paper composed of 0 waste paper: 100 seagrass fiber as the most appealing over-all among all the other samples. This may be credited to the interesting façade exhibited by the seagrass fibers.

The next criterion under the market appeal was the paper's clarity and consistency. The clarity and consistency was judged by the lucidity and uniformity of the paper's color all throughout. The paper that was ranked as the highest in this feature was the paper composed of 100 waste paper: 0 seagrass fiber. The lowest was the paper consisting of 75 waste paper: 25 seagrass fiber.

This may be attributed to the fact that the paper composed of 100 waste paper: 0 seagrass fiber did not have traces of seagrass fiber on its surface. The paper that ranked second was the paper made up of 0 waste paper: 100 seagrass fiber. This may have occurred on the grounds that the 0 waste paper: 100 seagrass fiber paper did not have waste paper combined with it, therefore giving it the uniformity that was specified by the criteria. The paper with the 75 waste paper: 25 seagrass fiber component may have deemed inconsistent since the fibers were more visible since 75% of it was made up of waste paper, which served as a backdrop for the fibers.

This means that the consumers find the paper composed of 100 waste paper: 0 seagrass fiber as the most alluring in terms of clarity and consistency.

The final criterion was the texture of the paper. This was evaluated according to the paper's fineness and smoothness of the paper in all areas. The sample that was ranked as the highest by the panel of consumers was the paper with the 0 waste paper: 100 seagrass fiber ratio. The lowest ranked was the paper composed of 75 waste paper: 25 seagrass fiber.

The reason behind this is that the texture of the paper from 0 waste paper: 100 seagrass fiber was proven to be smoother as compared to the rest. The paper composed of 75 waste paper: 25 seagrass fiber was rough and grainy to the consumers.

This suggests that the consumers find that the texture of the 0 waste paper: 100 seagrass fiber more appealing as compared to the rest.

The results of this study shows that usage of fibers from the seagrass, *Enhalus acoroides*, as a pulp additive in papermaking, based on the indicators of paper quality (breaking length, water retention and market appeal) is indeed feasible.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Seagrass fibers have been used as raw materials for making rugs, baskets, and other various products. Twine and thread are made from this fiber and used in upholstery, tapestries and the like as well (Microsoft Encarta Reference Library, 2003).

Enhalus acoroides is a rhizomatous, submerged, marine herb. This species of seagrass is an important source of food whose seeds can be eaten raw or turned into flour that may serve as a viable substitute for ordinary baking flour (Tacio,2005).

Papers are thin sheets of compressed vegetable cellulose fibers. It is employed for a wide variety of other uses, yet its largest uses are for printing, writing, wrapping and sanitary purposes. All types are made from pulp containing vegetable, mineral, or manmade fibers that form a matted or melted sheet. Most paper is made up of cellulosic fibers.

The quality of paper can be measured using the following: breaking length, water retention, and market appeal. The breaking length is used as basis to measure the strength of the paper. Water retention is the capacity of the paper samples to retain, absorb, or take up water, while market appeal on the other hand is a test to determine the marketability of the paper samples and its appeal to consumers.

The objectives of the study are:

1.) To determine the breaking length, water retention and market appeal of the papers produced from the seagrass, *Enhalus acoroides*, under different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber.

2.) To compare the breaking length, water retention and market appeal of the papers produced from different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber.

It was hypothesized that there will be no significant difference on the breaking length, water retention, and market appeal of the paper produced from the different seagrass fiber and waste paper ratios (0 waste paper: 100 seagrass fiber, 25 waste paper: 75 seagrass fiber, 50 waste paper: 50 seagrass fiber, 75 waste paper: 25 seagrass fiber, 100 waste paper: 0 seagrass fiber.

A. Summary

1.) The means between the breaking lengths of the five treatments showed no significant difference among them. The paper with the highest breaking length was the paper composed of 25 waste paper: 75 seagrass fiber and the lowest being the one made up of 100 waste paper: 0 seagrass fiber.

2.) The means of the water retention showed a significant difference between the five seagrass fiber levels. The paper sample with the highest water retention was the paper composed of 0 waste paper: 100 seagrass fiber. The lowest water retention belonged to the paper with the 50 waste paper: 50 seagrass fiber composition.

3.) The means of the three market appeal criteria all showed significant differences among all treatments.

4.) The first category under the market appeal is the appearance. The highest ranked according to appearance was the paper made up of 0 waste paper: 100 seagrass fiber, the lowest ranked was the paper composed of 75 waste paper: 25 seagrass fiber.

5.) The second measure of market appeal was the clarity and consistency. The highest ranked was the paper composed of 100 waste paper: 0 seagrass fiber, the lowest being the one composed of 75 waste paper: 25 seagrass fiber.

6.) The final decisive factor of market appeal was the texture. The results showed that the panel ranked the paper composed of 0 waste paper: 100 seagrass fiberas the highest and the paper composed of 75 waste paper: 25 seagrass fiber as the lowest.

B. Conclusion

The usage of fibers acquired from the seagrass, *Enhalus acoroides*, as a pulp additive in papermaking is feasible, based on the indicators of paper quality (breaking length, water retention and market appeal).

C. Recommendations

After analyzing the data obtained from the breaking length, water retention, and market appeal analysis, reviewing the conditions during the conduct of the study and the procedure followed; the recommendations for future studies are as follows:

1. Conduct follow-up studies on the feasibility of the seagrass *Enhalus acoroides* leaves as pulp additive using more refined parameters.
2. Test the feasibility of other seagrass species (e.g. *Thalassia hemprichii*, etc.) as pulp additive.
3. Compare feasibility of two or more seagrass species as pulp additive.
4. Use a certain cellulosic fiber extraction process.
5. Test the feasibility of the different parts of the seagrass *Enhalus acoroides* as pulp additive.
6. Test varied concentrations of caustic soda (NaOH) during chemical pulping on its effect on the paper produced.
7. Use a different bleaching agent in the papermaking process.

8. Conduct a study testing the effect of varying the binder or the binder concentration on the paper.

9. Finally, we recommend further studies similar to this to verify the results and data collected by this study.

LITERATURE CITED

Anonymous. Human Uses of Seagrass [internet]. Available from: http://www. science.murdoch.edu.au/centres/others/seagrass_forum/seagrass_uses.html Accessed 2007 May 3.

Anonymous. North Carolina State University [internet]. Available from: <http://rcso.edu./hubbe/DSR.htm>.

Anonymous. North Carolina State University [internet]. Available from: <http:// www4.ncsu.edu/~hubbe/DSR.htm>.

Anonymous. United Nations Environment Programme [internet]. Available from: www.unep.or.jp/letc/publicastions/spc/state_of_waste_management/2.asp

Anonymous. Wikipedia [internet]. Available from: <http://en.wikipedia.org/ wiki/papers>.

Alego, CAV., Cruz, MKC., Lucela, DM., Miciano, KI., Policarpio, PMT. 2002. the Feasibility of Polysterene – coated Paper as a Substitute for Packaging. Bato Balani. 15-17.

Baldivia, G., Lazaro, G., Liad, JV., 1999. packagingt Materials From corn Husks and Feathers. Bato Balani. 16-18.

Bayona, ISG., Biyo, JAT., Lamzon, JSP. 2002 december 2. Community Structure of Seagrasses Along Selected Coastal Areas of the Philippines. Philippine Science High School Western Visayas. 70 p. Available from: Department of Science and Technology, Iloilo City.

Bentinganan, MJE., Cabato CGV., Dumancas, LZP., Paril, LS. 1997 December. The Effect of the Different Concentrations of Sodium Hydroxide (NaOH) on the Quality of Papers Made From Palagtiki (*Eleusine indica*). Bacolod City National High School. 33 p. Available from: Department of Science and Technology, Iloilo City.

David, XP., de la cruz, CA., Maramba, AN. 1995-1996. Wastepaper and Coir with Okra Mucilage. Bato Balani. 16-18.

Nogra, KJ., Pama, EA., 1998 December. The Effect of Different Levels of Coconut (*Cocos nucifera*) Husk Fibers as Pulp Additive to the Quality of

Recycled Papers. Bacolod City National High School. 59 p. Available from: Department of Science and Technology, Iloilo City.

Peralta, AG., Pedrosa, MAL., Ramos, AA.. nd. Production of Soft Nonwoven Material Using Abaca- Maguey Pulp Blend. Fiber Industry Development Authority. 11 p.

Peralta AG, et al. 2004. Handmade Paper Production. Fiber Industry Development Authority. BAI Compound, Visayas Avenue, Diliman, Quezon City, Philippines. 32 p.

Sabine, JR., Torbatinejad, N. 2001. Laboratory Evaluation of some Marine Plants on South Australian Beaches. Journal of Agricultural Science and Techno-logy. [internet]. 3(2). Available from:<http://jast .modares.ac.ir/browse. php?a_code=A-10-1-92&slc-lang=en&sid=>.Accessed 2007 May 3.

PLATES

Plate 1. Cleaned *Enhalus acoroides*

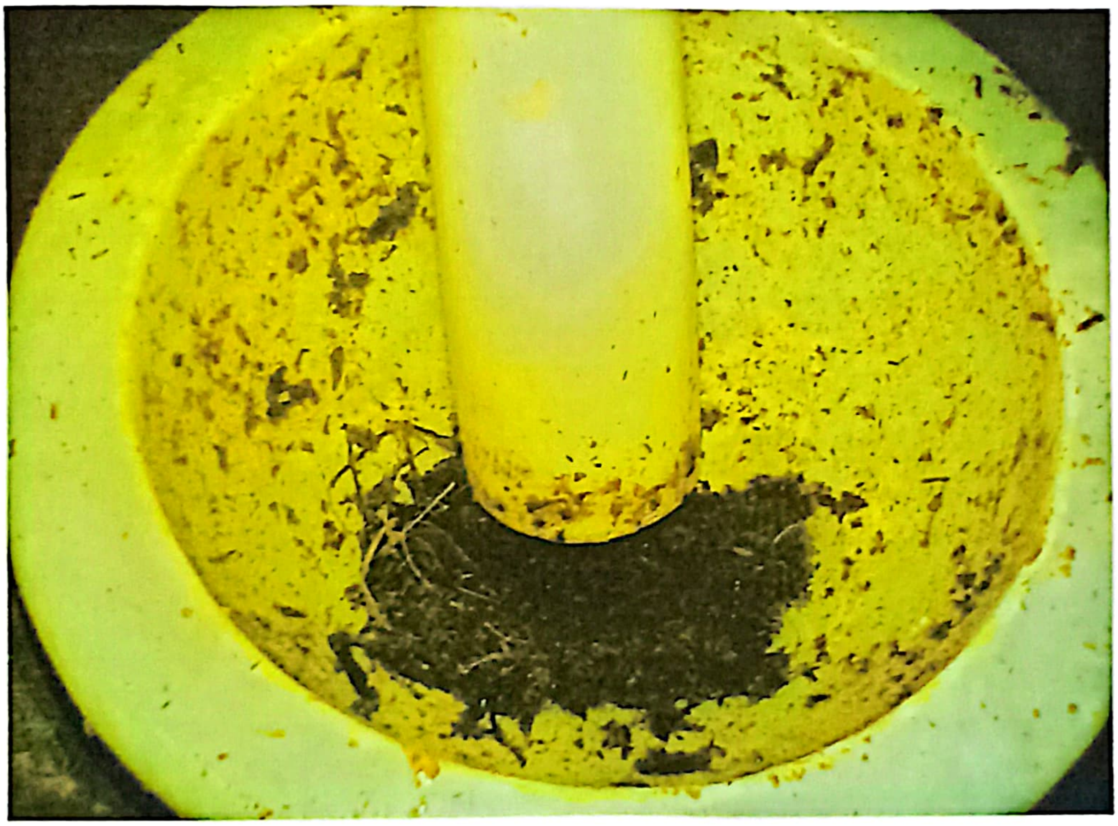

Plate 2. Mechanical pulping of *Enhalus acoroides*

Plate 3. Unwashed, mechanically pulped *Enhalus acoroides*

Plate 4. Washed, mechanically pulped, *Enhalus acoroides*

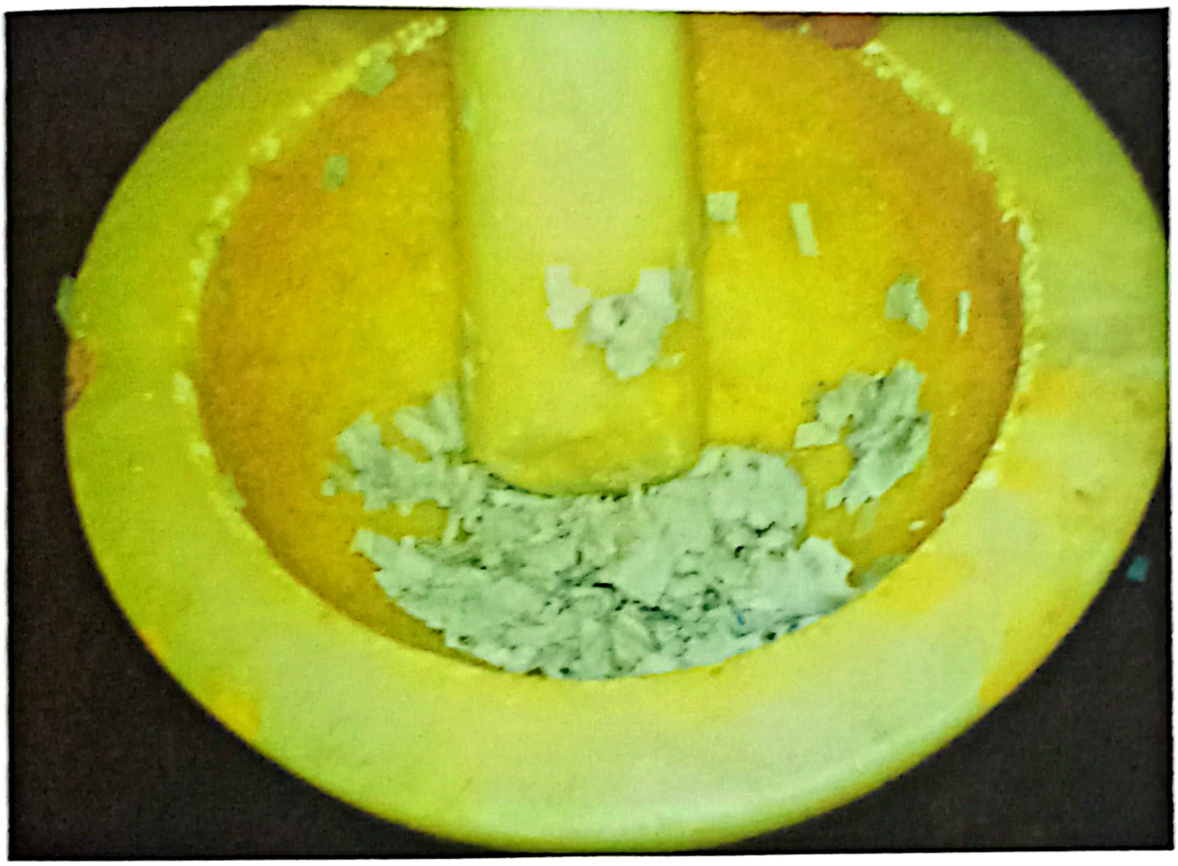

Plate 5. Mechanical pulping of the waste paper

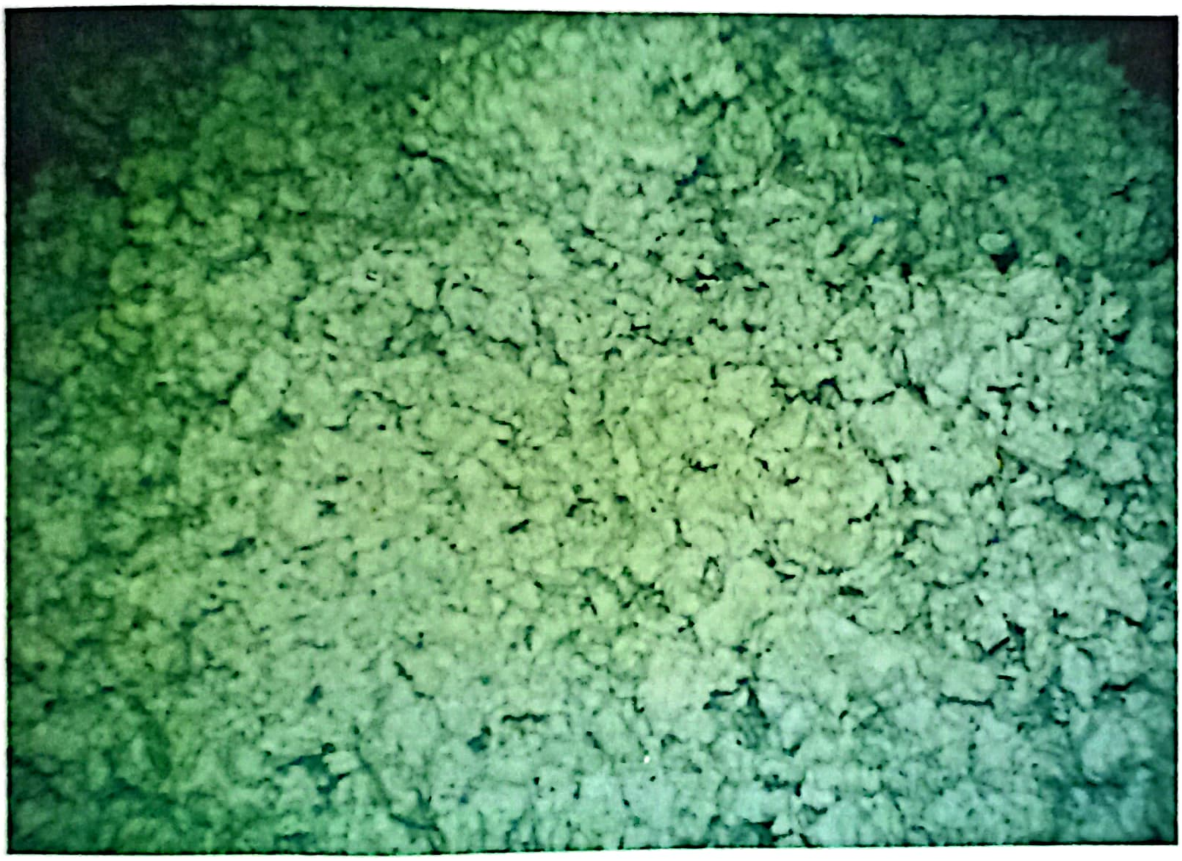

Plate 6. Pulped wastepaper

APPENDIX A

Raw Data

I. Breaking Length (in cm)

	100 waste paper: 0 seagrass fiber	75 waste paper: 25 seagrass fiber	50 waste paper: 50 seagrass fiber	25 waste paper: 75 seagrass fiber	0 waste paper: 100 seagrass fiber
1	1799.935	3635.88	1192.23	3308.9	3542.9
2	1008.584	2965.06	4630.18	7846.32	2987.79
3	1667.559	6382.16	2845.4	2019.74	3114.856

II. Water Retention

	100 waste paper: 0 seagrass fiber	75 waste paper: 25 seagrass fiber	50 waste paper: 50 seagrass fiber	25 waste paper: 75 seagrass fiber	0 waste paper: 100 seagrass fiber
1	273.59%	140.41%	113.30%	276.35%	284.42%
2	248.16%	153.32%	59.24%	314.83%	290.23%
3	262.08%	141.74%	102.25%	293.78%	324.59%
4	254.07%	96.97%	131.16%	265.47%	296.43%
5	239.21%	146.13%	79.52%	25.00%	299.59%

APPENDIX B

SPSS Print-outs

I. One way ANOVA Result for Breaking Length

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17057258.732	4	4264314.683	1.344	.320
Within Groups	31730428.034	10	3173042.803		
Total	48787686.766	14			

II. LSD for Breaking Length

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) var00001	(J) var00001	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
1.00	2.00	-2835.67167	1454.42836	.080	-6076.3400	404.9967
	3.00	-1397.24067	1454.42836	.359	-4637.9090	1843.4277
	4.00	-2899.62800	1454.42836	.074	-6140.2963	341.0403
	5.00	-1723.15600	1454.42836	.264	-4963.8243	1517.5123
2.00	1.00	2835.67167	1454.42836	.080	-404.9967	6076.3400
	3.00	1438.43100	1454.42836	.346	-1802.2373	4679.0993
	4.00	-63.95633	1454.42836	.966	-3304.6247	3176.7120
	5.00	1112.51567	1454.42836	.462	-2128.1527	4353.1840
3.00	1.00	1397.24067	1454.42836	.359	-1843.4277	4637.9090
	2.00	-1438.43100	1454.42836	.346	-4679.0993	1802.2373
	4.00	-1502.38733	1454.42836	.326	-4743.0557	1738.2810
	5.00	-325.91533	1454.42836	.827	-3566.5837	2914.7530
4.00	1.00	2899.62800	1454.42836	.074	-341.0403	6140.2963
	2.00	63.95633	1454.42836	.966	-3176.7120	3304.6247
	3.00	1502.38733	1454.42836	.326	-1738.2810	4743.0557
	5.00	1176.47200	1454.42836	.437	-2064.1963	4417.1403

5.00	1.00	1723.15600	1454.42836	.264	-1517.5123	4963.8243
	2.00	-1112.51567	1454.42836	.462	-4353.1840	2128.1527
	3.00	325.91533	1454.42836	.827	-2914.7530	3566.5837
	4.00	-1176.47200	1454.42836	.437	-4417.1403	2064.1963

III. One way ANOVA Result for Water Retention

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	168564.166	4	42141.041	100.218	.000
Within Groups	8409.877	20	420.494		
Total	176974.042	24			

IV. LSD for Water Retention

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) rep	(J) rep	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound
1.00	2.00	119.70800(*)	12.96910	.000	92.6549	146.7611
	3.00	158.36800(*)	12.96910	.000	131.3149	185.4211
	4.00	-28.99600(*)	12.96910	.037	-56.0491	-1.9429
	5.00	-43.63000(*)	12.96910	.003	-70.6831	-16.5769
2.00	1.00	-119.70800(*)	12.96910	.000	-146.7611	-92.6549
	3.00	38.66000(*)	12.96910	.007	11.6069	65.7131
	4.00	-148.70400(*)	12.96910	.000	-175.7571	-121.6509
	5.00	-163.33800(*)	12.96910	.000	-190.3911	-136.2849
3.00	1.00	-158.36800(*)	12.96910	.000	-185.4211	-131.3149
	2.00	-38.66000(*)	12.96910	.007	-65.7131	-11.6069
	4.00	-187.36400(*)	12.96910	.000	-214.4171	-160.3109
	5.00	-201.99800(*)	12.96910	.000	-229.0511	-174.9449
4.00	1.00	28.99600(*)	12.96910	.037	1.9429	56.0491
	2.00	148.70400(*)	12.96910	.000	121.6509	175.7571

	3.00	187.36400(*)	12.96910	.000	160.3109	214.4171
	5.00	-14.63400	12.96910	.273	-41.6871	12.4191
5.00	1.00	43.63000(*)	12.96910	.003	16.5769	70.6831
	2.00	163.33800(*)	12.96910	.000	136.2849	190.3911
	3.00	201.99800(*)	12.96910	.000	174.9449	229.0511
	4.00	14.63400	12.96910	.273	-12.4191	41.6871

* The mean difference is significant at the .05 level.

V. Kruskal-Wallis Test for Appearance

Ranks

	var00001	N	Mean Rank
var00002	1.00	99	266.02
	2.00	100	212.82
	3.00	100	229.83
	4.00	100	261.79
	5.00	100	279.71
	Total	499	

Test Statistics(a,b)

	var00002
Chi-Square	16.045
df	4
Asymp. Sig.	.003

VI. Kruskal-Wallis Test for Clarity/ Consistency

Ranks

	var00001	N	Mean Rank
var00002	1.00	100	294.96
	2.00	100	205.75
	3.00	99	220.58
	4.00	100	254.09
	5.00	100	274.33
	Total	499	

Test Statistics(a,b)

	var00002
Chi-Square	28.652
df	4
Asymp. Sig.	.000

VII. Kruskal-Wallis Test for Smoothness

Ranks

	var00001	N	Mean Rank
var00002	1.00	98	214.22
	2.00	100	186.99
	3.00	100	212.74
	4.00	100	300.16
	5.00	100	332.69
	Total	498	

Test Statistics(a,b)

	var00002
Chi-Square	82.625
df	4
Asymp. Sig.	.000