DETERMINATION OF QUALITY AND UTILISATION OF ARAMINA FIBRES FROM THE PLANT URENA LOBATA AS A TEXTILE FIBRE IN KENYA

BY

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A Thesis submitted in partial fulfilment of the requirements for the Degree of Masters of Education in Home Economics at Kenyatta University 1998
DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

This thesis is dedicated to my loving Dad and Mum, Mr. & Mrs Joseph K. Gikunda, and my sisters Kagendo and Kinanu, and my brothers Jeremiah and Gatobu.

I am particularly grateful to the Kenya Bureau of Standards for allowing me to undertake this research while carrying out the fibre tests.

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ABSTRACT

Since Kenya imports most of the vegetable fibres apart from cotton and sisal, there is need for research in the development and utilisation of other vegetable fibre sources. This study however, was aimed at analysing the quality of aramina fibres from the plant Urena Lobata that grows widely and as a weed in Kenya.

Specifically the study was to determine the chemical and physical properties of aramina fibres, make sample yarns from fibres using hand spinning methods, construct sample articles using simple hand techniques and compare the aramina fibre qualities with the established properties of a textile fibre.

The methodology used was experimental and involved extraction of the fibre by retting process, situational observation of the experiments and note taking as well as making of sample articles. The analysis was done both qualitatively and quantitatively, and the results presented in terms of reports, tables and figures. The experiments were carried out at Kenya Bureau of Standards (Textile Quality Control Laboratory) where the necessary conditions for textile testing were maintained at temperature 20°C ± 2°C and Relative Humidity 65 ± 2%. The carding, spinning and dyeing processes were carried out at the Fine Art department (Kenyatta University).

The process of extraction of aramina fibres has not been documented. However, Joseph (1986), and Ghosh (1993) argue that the fibre can be extracted in a similar manner as jute. Therefore, the process of jute fibre extraction was adapted whereby the barks were stripped off from the wooden portion and subjected to partial rotting by immersion in water. The process took two (2) weeks and about 2.6 kg of fibres were obtained from 22 kg of unretted green bark. The unretted bark contained impurities and moisture hence were much heavier than the dry fibres.
The fibres were then subjected to various fibre tests. The fibre was found to have a staple length of 13.5 cm and burning characteristics like those of other natural cellulose fibres such as cotton and linen. The fibre has a moisture regain value of 9.7%, 42.9% stronger when wet than dry and percentage elongation was recorded to be 1.035 when dry and 1.3% when wet. The wetness of the fibre has significant effect on the elongation as well as on fibre strength (tenacity) which was found to be 2.0 g/d for the wet fibres while that of the dry fibres was found to be 1.4 %g/d. Chemically the fibre is affected by acids and this implies that the fibre cannot be dyed using dye stuffs that are acidic or stored in acidic solvents and this property is important in the formation of oxycellulose used in the manufacture of regenerated fibres. The fibre was found to be resilient and pliable. This quality made it possible to be spun into yarn which was later dyed and made into articles. Various methods used to make the articles include crocheting, plaiting, hand weaving, card weaving and macramé knots. The articles made include a shoulder bag, a table mat, a floor mat, a belt, a plant hanger and a toothpick holder cover.

In short, the fibre was found to qualify as a textile fibre and can be recommended for usage in the textile industry both at large and small scale. Since it’s locally available, cheap to obtain and of good spinning and dyeing quality it can be of a great use in the “jua Kali” sector.
CHAPTER ONE

1.1 BACKGROUND OF THE PROBLEM

The *Urena Lobata* is a perennial plant that grows as an erect shrub up to 2.4m high above the ground. The plant is self fertilised and the seeds are encased in a capillary coat which is difficult to remove. All the above-ground-parts are covered with stellate hairs. It has a short tap root with wide spreading lateral parts. Leaves are simple palmate with a length of up to 12 cm. They are green, hairy on the under surface, and the edges are deeply and irregularly toothed. The flowers are produced singly in the axis of the leaves on very short peduncles. They have fine, linear and pointed picalyx bracts united at the base. They alnate to calyx which consists of five short broad lobes. The plant produces tall stout woody stems branching little when cultivated. This is because they are thinly planted hence compete for the little sunlight that is available. At the top they bear alternate leaves on short petioles without stipules. During planting the seeds are soaked and treated with concentrated sulphuric acid. This treatment increases the percentage of germination (Cobley, 1965; Ghosh, 1983; Agnew, 1994).

About 70 to 90 kg of seed is required for planting one hectare of land. The fibre yield ranges from 11 to 27 quintals per hectare depending on soil fertility, rainfall and spacing. Harvesting is done when plants are flowering 4-6 months after sowing.

Naturally the plant does well in equatorial warm moist region and can be grown in the regions with $0^\circ$ to $26^\circ$C with well distributed rainfall. It is grown commercially as a textile fibre in Brazil where its known as aramina, in Congo (known as Congo Jute), Zaire,
Nigeria and Peru. In Kenya it is widespread at 1220 - 2740m above sea level (4,000-9000ft) (Blundell, 1987).

In general, textile fibres when classified according to their origin, fall under two main categories. These are man-made and natural fibres.

Man-made fibres fall under two main groups, depending on the origin of the fibre forming material. They can either be simple polymers, copolymers or heteropolymers. The fibres are further divided into two categories. These are the regenerated fibres that are obtained from materials of natural origin and synthetic fibres that are made purely from chemicals. The regenerated fibres are of two main types. These are regenerated cellulose fibres and regenerated protein fibres. Examples of regenerated cellulose fibres include rayons, viscose cotton and those of regenerated protein fibres include casein and groundnut fibres. Examples of synthetic fibres include nylon, polyester and acrylics (Thomason, 1969).

The natural fibres are divided into three main classes. These are vegetable fibres, animal fibres and mineral fibres. Mineral fibres are obtained from glass asbestos or aluminium. Animal fibres are copolymers obtained either from animal hairs such as wool or animal excretion such as silk. Vegetable fibres are obtained from seed hairs, and fruits such as cotton, coir and kapok; from the stem such as linen, jute and aramina; or from the main vascular system of monocotyledonous plants commonly referred to as leaf fibres. These include sisal, henequen, abaca (manila) and pineapple.

Arama fibres are obtained from Urena Lobata. They resemble jute more closely than other jute substitutes. They are also fine as jute and can be spun in the same machinery. The fibre is often used in admixture with jute. It's soft, lustrous and pale
yellow. It is used for making hessian, ropes, and carpets. In Malasya its widely used as a herb (Purseglove, 1968).

In Kenya, the plant grows naturally at the periferi of the Kenyan forests as a weed for example in Embu, Meru and Nyeri. In dense forests, it forms a canopy. The plant is traditionally used as a goat feed and the bark (which contains the fibres) is used to make ropes and baskets. In some parts of Africa its used for sacking, low-cost apparel and decorating fabrics (Joseph, 1986; Blundell, 1987; National Museums of Kenya).

1.2 STATEMENT OF THE PROBLEM

According to a paper presented at a National Symposium in 1981 by Industrial Research and Development, there is need for research in the development and utilization of other vegetable fibre sources. Currently, Kenya imports most of the vegetable fibres apart from cotton and sisal. Hence the increase on the production cost that has an influence on consumer prices. For example in 1995 the imports totaled to over ksh. 20 million (Central Bureau of Statistics, 1995). Though the aramina fibre has been used traditionally in Kenya to make ropes, it has not been tried on fabrics. The method of extraction used then, did not yield a clean fibre because of the pectin that embedded the fibres together. In addition, the quality of the fibre has also not been examined to verify its usage as a textile material. Hence the need for the present study.
1.3 PURPOSE OF THE STUDY

The study aimed at extracting the aramina fibre from the plant *Urena Lobata* that grows naturally in Kenyan forests as a weed. It also aimed at determining the chemical and physical properties of the fibre, making sample yarns, constructing sample articles and comparing the aramina fibre qualities with the established properties of a textile fibre.

1.4 RESEARCH OBJECTIVES

The study aimed at achieving the following objectives:

1. To determine the chemical and physical properties of aramina fibres.
2. To make sample yarns from fibres using hand spinning methods to verify its spinning quality.
3. To construct sample textile articles using simple hand techniques such as weaving, crotcheting, macramé knots and plaiting to test for flexibility.
4. To compare the aramina fibre qualities with the established properties of a textile fibre.

1.5 SIGNIFICANCE OF THE STUDY

The findings of this study will contribute to the body of knowledge in the textile area. They will also facilitate further research in the area thus make it possible to explore the possibility of making full use of the fibre as in other countries with the aim of boosting the economy. The fibre can also be used as a source of cellulose, substitute for linen and be blended with other fibres to increase their serviceability. This will then add to the
variety and quality of textile products available in the Kenyan market. If it is planted at large scale, it can provide for employment in farms and in the textile industry, thus contribute to industrialisation. At small scale the fibre can be used as a cash crop hence a source of family income.

1.5 LIMITATIONS OF THE STUDY

1. Fibre tests were limited to those that could be carried out using the available facilities and resources at the Kenya Bureau of Standards (KEBS).

2. The method of fibre extraction process was limited to the retting process only.

1.6 ASSUMPTIONS

1. The fibre extracted could be spun and used in making articles of textile use.

2. The experimental formula used for other fibres can be used with aramina fibres.

1.7 DEFINITION OF TERMS

1. Polymer Compound whose molecule is formed from a large number of repeated units of one or more compounds of low molecular weight.

2. Simple polymer A polymer that contains molecules of the same compound.

3. Copolymer These are two simple polymers that combine together.

4. Heteropolymer Polymers that are of two different kinds of units
5. Decorticate - To remove the fleshy part of leaves by a mechanical process to liberate fibres.

6. Elastic recovery - Percentage of return form elongation to the original length.

7. Elongation - Amount of stretch or extension a fibre will accept before it breaks.

8. Fibre - A hair like unit of raw material from which clothes are made.

9. Huckling - A process in yarn manufacture where the fibres are drawn between sets of pins to separate the short and the long fibres.

10. Moisture equilibrium - The condition reached in a controlled atmosphere by a sample or specimen when there is no further significant loss or gain in weight.

11. Pectin - A substance that binds cell walls in plant tissue.

12. Retting - A process of partial rotting of the woody substance by immersing in water to separate the fibres.

13. Scutching - Separating of the rotted woody parts from the fibres by passing them between fluted rollers.

14. Tenacity - Term applied to strength of individual fibres; its the tensile stress expressed as force per unit linear density of the unstrained specimen.
15. Situational observation: Observation made as the experimental treatments are being administered.

16. Quintal: Weight equivalent to 100 kg.

17. Jua Kali Sector: Informal sector whereby the artisans work in the open environment usually under the hot sun without shelter. "Jua Kali" is a Kiswahili phrase which denotes "hot sun".


20. Plaiting: Twisting of three or more yarns under and over one another to make one rope-like length.

21. Weaving: Art of intertwining of threads, yarns or fibres at right angles to create a length of textile or cloth.
CHAPTER TWO

2.0 LITERATURE REVIEW

Due to the fact that little has been done in the extraction and utilization of aramina fibres in Kenya, most of the literature reviewed is based on work that has been done in other countries. According to Ghosh, (1993) aramina fibres are obtained using similar method as jute fibres. Therefore the process of extraction of jute fibres is reviewed. Since the study was to investigate into the quality of aramina fibres, textile properties are necessary. In addition, all textile testing should be carried out under desirable conditions hence the subsection of textile testing conditions. In general, literature is reviewed under the following subsections:

a) Current Kenyan status in textiles
b) Fibre extraction processes
c) Extraction of aramina fibres
d) Properties of textile fibres
e) Fibre testing conditions
f) Usage of aramina fibres.

2.1 CURRENT KENYAN STATUS IN TEXTILES

The Kenyan textile industry has been faced with various problems and this forces the industry to import raw materials. For example since the exit of the cotton lint and seed marketing board in 1995, cotton intake by ginneries has decreased from 181 thousand tonnes in 1994 to 160 thousand tonnes in 1995. Sisal has also recorded a decline for the
last three years. In 1995 the decline was about 17.7% as compared to 1994 (from 33.9 tonnes in 1994 to 27.9 tonnes in 1995) (Central Bureau of Statistics, 1996).

According to a paper presented at a symposium in 1981 by Industrial Research and Development, problems and constraints that face the industry include unavailability of good quality raw materials in sufficient quantities, high production costs, lack of supportive research and development, pricing and marketing problems, and lack of properly trained personnel. However, research and development needs to be carried out in the textile industry. It was therefore recommended that research is needed for saving energy, development of ancillary industries for import substitution, improving the quality of both yarn and textiles, and the development and utilisation of other fibre sources.

Isaak (1983), states that Kenya does not produce enough cotton to meet the textile mill's demands hence, cotton lint has to be imported. This is evidenced in the 1993/1994 import statistics. In 1993 total cotton imports were 4,975,802kg while for jute and other textile bast fibres totaled to 969,763kg. In 1995 there were no exports for jute and other bast fibres. This indicates that these type of fibres are not produced in large quantities to meet the consumer demand and for export. In general the textile sector recorded a decline of 27% of exports in 1995 (Central Bureau of Statistics, 1996).

As Arunga (1981), argues, there is therefore, need to explore the possibilities of substituting imported raw materials with or without modification of the manufacturing process.
2.2 FIBRE EXTRACTION PROCESSES

Various methods are used to extract fibres depending on their origin. However, some fibres are extracted using similar methods. For example, in order to obtain the man-made fibres, the viscose solution is forced through a spinneret. The size of the filament depends very much on the size of the openings in the spinneret, the stretching and other processings that follow. The viscose solution is made from reacting natural cellulose or protein with chemicals. However, the solution can also be obtained purely from chemicals. In general, there are three basic spinning methods:

a) The fibre solution can be forced through a spinneret into a liquid that causes coagulation and filament formation.

b) The solution can be forced into a warm air chamber. The warm air causes the solvent to evaporate so that the fibre can form and harden.

c) The fibre chemical can be melted and the molten solution is forced through a spinneret into an environment that causes the solution to harden (Thomason, 1969; Joseph, 1981; Makokha, 1990).

Animal fibres mainly include wool and silk. To obtain wool, the sheep are shorn by machine clippers to obtain fleece or clip wool. The fleece are then skirted and pressed into bales. On the other hand silk is produced by the silk worms that feed on mulberry leaves. The silk worm produce fluids from special glands situated at the head. As it comes in contact with the air, the fluid hardens forming two long filaments that are held together with silk gum produced from another gland. It makes a figure eight movement with the head and as the filaments harden they form a protective cocoon. To obtain the
silk fibres, the cocoons are immersed in boiling water to soften the gum and kill the moth. The filaments are then wound into skeins and packed in bales. The moths reserved for breeding purposes are allowed to emerge breaking the filaments into staple lengths.

Leaf fibres such as sisal, cantala, henequen and pine (from pineapple leaves) are extracted by machine decorticating, retting, chemical action or enzymatic action. For example, the pine fibres are extracted by decorticating and then treated for 10 minutes at controlled pressure (1-5atm) at 80-100°C with a solution containing 0.1-10% nonionic detergent and 0.2-2.2% sulphuric acid. Cantala fibres are extracted by retting process while the sisal and henequen fibres are extracted by machine or hand decorticating (Kariuki, 1993).

Cotton is obtained from the plant of the malivaceae family. When the plant matures, it produces pods which burst open. The pods are picked by hand or machine. The picker (type of a machine) pulls the fibre from the open bolls while the stripper pulls the entire boll from the plant. The cotton lint is then transported to the ginnery where the seeds, foreign matter such as dirt, twigs, leaves, parts of the bolls and stones are removed. The fibres are then packed into large bales, graded and sent to the factories (Joseph, 1981; Makokha, 1990).

Bast fibres which include flax, jute, hemp and aramina are extracted through the retting process. According to Ghosh (1983) aramina fibres are obtained the same way as jute and linen fibres. In general there are five major methods of retting. These are:

a) Stream retting - The plants are stacked along the banks of slow-moving streams for a long time.
b) Chemical retting - the plants are stacked into tanks filled with water and chemicals such as sodium hydroxide, sodium carbonate or dilute sulphuric acid. This method is the quickest method but care must be taken not to damage the fibres.

c) Pool retting - the plants are packed in sheaves and immersed in pools of stagnant water.

d) Tank retting - this is similar to pool retting but the stalks are stored in big tanks.

e) Dew retting - this method involves spreading the flax on the ground where it is exposed to action of dew and sunlight. It requires a long period of time with an average exposure of 4 to 6 weeks.

2.3 EXTRACTION OF ARAMINA FIBRES

The process of extraction of aramina fibres has not been documented. However, Joseph (1986) and Ghosh (1993) argue that the fibres are extracted in a similar manner as jute fibres.

Once the plant start flowering (4-6 months after sowing), they are harvested by cutting them off the ground. The leaves are ripped off, the bark is split loose from the wood and are subjected to partial rotting by immersion in water (retting). The fibre bundles lie loosely embedded into the inner side of the bark. The retting process commonly used is pool or tank retting. The retting process takes place in two main phases. These are:
(a) The physical phase - This begins when the bundles of bark are steeped in water. The tissues absorb the water and swell releasing soluble components into the retting water. The released substances are carbohydrates, nitrogenous compound and salts of different kinds which facilitate the growth and multiplication of microbes in the retting water.

(b) The biochemical phase - This starts as soon as the bacteria enter the barks. The bacteria disintegrate the cortex in order to break down the soft tissues that surround the fibres. The dissolution of the cementing materials, pectins and hemicelluloses, is brought about by anaerobic, aerobic and facultative bacteria. The by-products are acetic, lactic, butyric and ketoglutaric acids. The muck that accumulates at the bottom of a retting tank is rich in organic matter content and plant nutrients. It can be returned to the crop fields to enrich the soils. Solvents such as acetone, ethyl alcohol, butyl alcohol and mannitol are also produced.

Ghosh (1983) records that the retting process is best done in clear, slowly flowing water. The water should be non-saline and of enough volume to allow the bundles to float. The extraction of the fibres is done entirely by hand. It involves two main processes:

(a) Single bark method — The extractor squats at the edge of the retting tank, takes out each bundle and unties it. Four or five barks are taken out and extraction is started at the bottom. The barks are passed between two
sticks held together to remove the rotten matter. The fibres are then rolled into coils and kept ready for washing.

(b) Beat-break-Jerk method — The extractor lifts only the bottom end of a bundle above water and beats it with a wooden mallet to loosen the fibres. He then shakes the bundle vigorously to and fro in the water. The loose matter is washed away and the fibres are coiled ready for a second washing (Ghosh, 1983).

The fibres are uncoiled, thoroughly washed and dried under shade or mild sun because strong sun makes the fibres rough.

The aramina fibre has an attractive appearance. It is near white when carefully retted and is soft to the touch. Strands of commercial aramina are 48 cm long. The individual cells are less than 1/10th of an inch and the lumen is irregular. The fibre compares favourably with jute (Cobley, 1965; Cook, 1968).

2.4 PROPERTIES OF TEXTILE FIBRES

A polymer must possess certain essential properties or characteristics in order to qualify as a textile material. These characteristics can be categorized as primary and secondary. The primary characteristics are essential in the manufacturing industry while the secondary characteristics mainly improve consumer satisfaction.
(a) Primary Characteristics of Textile Fibres

(i) **High length-to-width ratio**: Fibrous materials must possess adequate staple or fibre length and the length must be considerably greater than the diameter. This property is important to permit processing into yarns and fabrics. The length also helps to determine its abrasion resistance. El Mogahzy (1992), states that there is a minimum fibre length below which fibres will not spin. Therefore, the longer the fibres the fewer the fibres per cross section required for a given strength. Longer fibres tend to increase yarn tenacity consequently reducing yarn diameter. Length is associated with not only spinning performance but also yarn properties and characteristics such as yarn appearance, evenness and strength. Short fibres create dull appearances and the yarn obtained is rough, fluffy and soft to the feel while longer fibres create a shiny appearances and the yarn is smooth and free from fluff. According to Joseph (1981), the minimum ratio of length-to-width is of 100:1. For example, cotton has a ratio of 1400:1, flax-1200:1, ramie-3000:1, wool-3000:1, and silk is the thinnest with the ratio of 33×10^6:1.

(ii) **Flexibility**: This is the ability of the fibre to bend easily without breaking. The fibres must be bendable, pliable or flexible in order to form yarns and fabrics that can be creased, have good drapability and have ability to move
with the body and permit general freedom of movement (Welford, 1960; Joseph, 1981; Makokha 1990). This property is also important because it determines the ease with which the fibres, yarns and fabrics will bend and it contributes a lot towards fabric durability.

(iii) Tenacity: Strength varies considerably among different fibres. However, fibres must have enough strength in order to provide durability and withstand mechanical friction especially during spinning processes. It is important to note that fibre strength does not always indicate comparable yarn or fabric strength. However, although measuring tenacity of a fibre will provide some guide, the strength of the fabric will also depend on many other factors. The strength of the fabric is more compatible to the strength of the yarns rather than that of the fibres. Fibres with high strength are useful in sheer and light weight fabrics and in products end-use that requires a high degree of strength such as industrial work clothes (Tortora, 1982, 1992). El Mogahzy (1992), also argues that fibre strength is a major contributing factor to yarn quality and spinning performance. The strength will also affect the hand, drape and similar characteristics of a fabric. With other properties remaining fairly constant, the stronger the fibre, the stronger will be the yarn or fabric. The high strength of a fibre is associated with a high degree crystallinity and for this reason the high strength fibres are stiffer than low strength fibres. The tenacity is expressed as gram per denier (g/d).
(iv) **Uniformity:** In order to obtain good quality yarns it's important that the fibres be similar in length and width, spinning quality and flexibility. Kroschwitz (1990) states that machine settings in textile spinning operations are based on fibre strength, and the processing efficiency is related to length uniformity. In general, staple fibres should not contain an excessive proportion of fibres significantly shorter or wider than the average.

(v) **Spinning quality or cohesiveness:** The fibres must possess the ability to stick together in yarn manufacturing processes.

(b) **Secondary Characteristics**

(i) **Physical Shape:** This includes the surface contour, shape of the cross-section, width and length of the fibre. The surface contour affects cohesiveness, resiliency and thickness of the fibre. It also contributes to the resistance to abrasion and piling, as well as comfort of the fabrics, including warmth (Joseph, 1981). The property of fineness or coarseness of textile fibres has been recognised as one of the most important of all fibre characteristics affecting processing behaviour and yarn properties (Goswami, "et al" (1977)).
(ii) **Moisture Content and Moisture regain:** In their natural state textiles are hygroscopic and the moisture content of the fibre increases as the humidity increases. Moisture regain varies from 15 per cent for wool to zero for glass. Fibres with good moisture regain accept dyes and finishes more readily than fibres with low regain. On the other hand fibres with low moisture regain will wash and dry quickly (Joseph 1981; Makokha 1990). A fibre that permits some moisture absorption is comfortable to wear, especially during the hot weather. However, they readily dry slowly and may be stained by water-borne soil. Tortora (1992), argues that the strength of some fibres is affected by the moisture they contain. For example, cotton is stronger when wet than dry whereas rayon and wool are weaker when wet than dry.

(iii) **Resiliency:** Most fabrics in everyday wear are subject to stretching or distortion. It is therefore expected that a fabric should return to its original size and shape after relaxing when stretched. It is essential that a fibre must have a certain amount of extensibility so as to withstand sudden strains placed upon it. This quality also determines the crease recovery of a fibre (Robakowsk, 1970).

(iv) **Density:** This indicates the mass per unit volume expressed as gm/cm. All textile fibres are heavier than water except Olefin which floats on water.
For example, Cotton has a density of 1.54-1.56 gm/cm. Glass fibres have a greater density because they are compact. Heavy fabrics result from fibres of high density and light weight fabrics result from fibres of low density (Peters, 1972).

(v) **Lustre:** This refers to the gloss, sheen or shine that a fibre possesses. Its the result of the amount of light reflected from the surface of the fibre and its measured by its degree of brightness or dullness. Fibre lustre depends on the longitudinal cross section and it determines the characteristics of the fibre (Tortora, 1992). Among the natural fibres, silk and mohair have a high lustre while cotton and wool have low lustre. Availability of fibres with different levels of lustre presents a base for appearance and aesthetic factors that consumers would look for.

(vi) **Flammability and other thermal reactions:** This property indicates the behaviour of fibres at various temperatures. These characteristics are important because they determine the care and use of the fabrics or articles that are made from such a fibre.

 Burning of small quantities may be used as a means of differentiating one fibre group from another. Although precise identification of individual fibres cannot be made by burning alone, burning can be used to identify the general fibre group the particular fibre belongs. For example, cellulosic fibres exhibit flammability characteristics much like that of paper, protein
fibres burn in a manner similar to hair, and synthetics melt when they burn. The odour produced when a fibre burns and the ash that remains after burning may also aid in the identification of the fibre.

(vii) Elastic recovery and elongation: These qualities are important for comfort, fabric strength and seam strength. Wool, silk and rayon are said to have the highest elongation while jute and linen have very little. Kroschwitz (1990), records that in general bast fibres are typically low in elongation and recovery from stretch. A fibre which will stretch or elongate more before breaking will show greater “toughness”, or durability than a stiffer fibre that breaks at the same load but at lower elongation.

Other characteristics that a good fibre should possess include affinity to dyes, molecular structure, fibre morphology, effect of chemicals, effect of environmental conditions such as sunlight and climatic variations, reaction to micro-organisms and insects, abundance in quantity for economic viability and softness (Hall, 1965; Joseph, 1981).

2.5 FIBRE TESTING CONDITIONS

Fibre testing involves a close scrutiny of the characteristics, properties or attributes that certain textiles possess. Tests that may be carried out range from performance to operating tests. Fibre tests involve both optical and reactive investigations of fibres.
Testing is an important activity inorder to assert that the quality is good enough for the fibre to be put into textile use (Moore, 1969; Luniak, 1973).

In textile testing, Tembwa (1993), denotes that the principle followed is to allow the textile material to remain in the conditioning room during its absorption cycle for a sufficient period of time to reach moisture equilibrium. This is said to be reached when the sample or specimen, during free exposure to moving air controlled at specified conditions, change in weight of the sample weighed successively at an internal of 2 hours is less than 0.25%.

According to Kenya Bureau of Standards (KEBS), (1977), all textile testing should be conducted under controlled conditions. Since almost all textile fibres are hygroscopic in nature, the relative humidity and atmospheric temperature affects both their mechanical and physical properties. Therefore, it is important to allow the textile material to remain in the conditioning room for a sufficient time to allow reach moisture equilibrium.

This is done by bringing the material to a relatively low moisture content (equilibrium in the atmosphere) between 10-25% RH with temperatures not exceeding 50°C. The standard atmosphere for textile testing should be Relative Humidity of 65% and temperature of 20° C. The atmosphere in which physical tests on textile materials are performed is RH 65 ± 2% and temperature of 20 ± 2° C (KEBS, 1977; KEBS, 1987; Garner, 1967).
2.6 USAGE OF ARAMINA FIBRES

The plant is traditionally used as a goat feed and the bark (which contains the fibres) is used to make ropes and baskets. The fibres resemble jute more closely than other jute substitutes and are used in admixture with it. It is used for making hessian, ropes, and carpets in countries such as Zaire, Congo, Nigeria and Peru. In some parts of Africa its used for sacking, low-cost apparel and decorating fabrics. In Brazil its grown commercially as a Textile fibre (Joseph, 1986; Purseglove, 1968; Blundell, 1987; National Museums of Kenya), while in Malaysia the plant is used as a herb.
The general methodology was experimental in nature. The experimental fibres were randomly picked from the heap of fibres obtained and conditioned to reach moisture equilibrium. The experimental samples were then randomly picked from a large batch of the conditioned fibres. The testing methods were adapted from the standard methods established by Kenya Bureau of Standards (KEBS) and American Society for Testing and Materials (ASTM) and were carried out under standard conditions. These tests specifically focused on some of the physical and chemical properties of the aramina fibre. Tortora (1992), argues that established testing methods have validity and are accepted in the field as reliable. Therefore, the results obtained are treated as reliable and valid because the methods used for testing are established. The data collection procedures included:

a) Extraction of fibres.

b) Situational observation of the experiments and note taking.

c) Spinning of yarn and making of some textile articles.
3.1 DATA COLLECTION PROCEDURES

3.11 FIBRE EXTRACTION PROCESS

According to Ghosh (1983), the aramina fibres are extracted the same way as jute or linen fibres. For the purpose of this study the following procedure was adapted and carried out in a room with ordinary room temperatures.

The *Urena lobata* plant was obtained from Meru district where it grows naturally in the Mt. Kenya forests and as a weed in plenty. The plants were cut just above the ground. They were obtained purposively in order to obtain plants that were almost of the same age (not too old or too young). This was judged by observing the colour and size of the plant stem. The leaves were ripped off and the barks were stripped off from the woody portion. The barks were tied into handful bundles with the bottoms together. The bundles were then subjected to the retting process for about 2 weeks to rot away the cellulose matter, remove the chlorophyll and loosen the pectin that holds them together.

After they had rotten, the fibres were beaten using a wooden mallet to loosen the fibres. They were then shaken off to remove any extraneous matter and washed in plenty of water. The fibres were then dried under a shade to avoid bleaching by direct sunlight.

3.12 FIBRE TESTING PROCEDURES

Booth (1979), records that the sampling method used to select a fibre for testing depends upon the form in which the fibre is available. In this case the fibre samples were picked randomly from the heap of the conditioned fibres obtained. The samples were then randomly assigned for the experimental treatments.
The tests were carried out at the Kenya Bureau of Standards Textile Quality Control Laboratory with the standard textile testing conditions of Relative Humidity $65 \pm 2$ per cent and temperatures at $20^9 \pm 2^9$ C. to assure accuracy and replicality of the results. Testing assistance was sought from the Laboratory technicians who work in this laboratory. Established methods for textile testing were used to increase validity and reliability of the findings.

The fibres were subjected to the following tests: Burning, drying twist, dry distillation and the reactions with organic acids and alkalis. The following fibre parameters were investigated: Microscopic appearance (Longitudinal, Cross-section and Fibre Ash), Moisture Content and Regain, Length of Fibres, and Breaking Tenacity and Elongation (wet and dry).

(a) Microscopic Examination

Both the longitudinal and cross-sectional views of the fibre were examined. This examination is important for comparison with other fibres. The fibre shape and surface contours are among the most important determinants of the character of fibre luster. The cross-section contributes to characteristics such as appearance, hand or feel, surface texture, body and covering power.

Procedure:

(i) For the longitudinal examination, a single strand of fibre was placed on a microscope slide and a drop of liquid paraffin (mountant) was added. A slide cover was placed over the fibre and pressed lightly to eliminate air...
bubbles. The slide was then placed on the microscope stage and the fibre
was observed and the features noted.

(ii) For the cross-section view, a single strand of the fibre was suspended
vertically by hand with the free end of the fibre touching the bottom of a
cylindrical rubber container. Melted paraffin wax was poured into the
rubber-container and the fibre was held in position until the wax solidified,
firmly embedding the fibre as shown in figure 1&2 below. The rubber
container was pressed on the sides gently to release the cylindrical shaped
wax with the fibre embedded in the middle.

A very sharp razor was used to slice the wax in cross-section to expose the cross-
sectional view of the fibre. The section was then mounted on the microscope and the fibre
section brought to focus (Textile Institute, 1970). The observations were noted and
recorded.
Figure 1: Aramina fibre embedded in wax.

Figure 2: Pressing of the rubber container to remove the fibre embedding wax.
(b) **Burning Tests**

The aim of these tests was to investigate the thermal reaction of the aramina fibres. These shows the behaviour of the fibre at various temperatures which determine the use and care of any article that is made of the fibre. The tests are also important for fibre identification.

**Procedure:**

(i) A tuft of fibres was held by a pair of tongs and slowly brought close to (but not into) a small non-luminous flame. The reaction of the fibres was noted.

(ii) Another tuft of fibres was held as in (i) above and brought right into a non-luminous flame. The burning characteristics were noted.

(iii) Another tuft of fibres was placed close to a crystal of potassium nitrate on a metal plate. The temperature of the plate was raised using an electric heating plate until the crystal melted, (between 337°C and 339°C). The burning behaviour was observed.

(c) **Length of Fibres**

The aim of this test was to determine the length distribution of the aramina fibres. This helps in determining the average fibre length (staple length). El Mogahzy (1992), argues that the fibre length is very important in spinning because the longer the fibre is the less the fibres per cross-section required for a given strength. The length of a fibre is also associated with other properties such as yarn and fabric appearance and eveness.
Procedure:

One hundred single fibres were drawn at random and each fibre was straightened out carefully over a meter ruler. The length was recorded in centimetres.

(d) Moisture Content and Regain

The aim of this test was to determine the percentage of moisture contained by a fibre sample at moisture equilibrium in a standard atmosphere for textile testing. It was also to determine the percentage moisture regained by a dry sample of aramina fibres when placed in a standard atmosphere until it reached moisture equilibrium. Since textiles are hydroscopic in their natural state and moisture content increases as humidity increases its important therefore to determine this quality. Joseph, (1981) and Makokha, (1996) argue that a fibre with good moisture regain will always accept dyes and finishes more readily than a fibre with low regain.

Procedure:

Ten(10) samples of different weights were placed in an oven set at 110°C and dried for at least four(4) hours after which they were cooled in a desiccator. The fibre samples were then quickly transferred into a weighing scale for oven dry weight records.

The following formula was used.

\[ c = \frac{a - b}{a} \times 100 \]
Where $c =$ the moisture content

$b =$ the oven dry mass of sample in gm

$a =$ the original mass of sample in gm.

\[(i) \quad r = \frac{a - b}{b} \times 100\]

Where $r =$ the moisture regain

$a$ and $b$ as in formula (i) above.

(e) **Drying Twist Test**

The aim of this test was to determine the direction of movement of the free end of a wet strand of fibre when allowed to dry. The results can be used for identification of the fibre and comparison with the behaviour of other cellulose fibres.

**Procedure**

A strand of aramina fibres was drawn and soaked in distilled water for 10 minutes, it was then removed and held over an electric hot-plate with a pair of tongs. The direction of twist was noted and recorded as the fibre dried.

(f) **Dentification of Fibre Ash.**

The aim of observation was to identify the shape(s) of crystals which can be used for identification of the fibre. When various fibres are burnt, the microscopic appearance of the uncrashed ash crystals differ. For example, sisal has rod like structures while those for hemp are cluster crystals.
Procedure:

A tuft of fibres was allowed to burn and the ash was collected on a piece of mica. The ash was transferred onto a microscope slide, a drop of distilled water was used as a mountant and a cover slide placed over the ash. The ash particles were then observed under a microscope.

(g) Breaking Tenacity and Elongation (Wet and Dry)

The aim of these tests was to determine the mean breaking load per denier and percentage elongation at break as well as to compare the breaking tenacity and elongation at break for dry and wet fibres. Tenacity (strength) contributes to durability and resistance to mechanical friction especially during spinning processes. The strength of the fibre will also affect the handle and drape and the stronger the fibre the stronger the yarn. Elongation of a fibre determines its durability and versatility in use. A fibre that can stretch during wear will be more durable than one that is not elastic at all.

Procedure:

(i) Three strands of the aramina fibre were held together, straightened out and the length measured. A uniform length of 100mm (10cm) was used and the weight of each specimen was recorded. A constant rate of traverse (C.R.T.) tensile testing machine (model Zwick 1435) was set to obtain a nominal gauge of 100 mm and a traverse speed of 100mm/min. Each specimen was mounted between the jaws of the clamps in such a way as to remove slack without stretching the specimen. The machine was started and the
specimens pulled to a breaking point. Once the fibres broke the machine automatically stopped and recorded the breaking load (in gram/force) and the elongation at break (in percentage).

(ii) A similar test was used for testing the wet breaking tenacity and elongation of break. Each specimen was immersed in 0.1% Tinovetin J.U. wetting agent for 30 seconds and mounted between the jaws of the machine clamps. The above procedure was repeated and the results were recorded.

The denier of each strand (weight in grams of 9000 m of fibre) was calculated using the following formula:

\[
\text{Denier} = \frac{\text{Weight in gm} \times 9000}{\text{Length in metres}}
\]

The breaking tenacity in gram/denier (g/d) was obtained using the formula:

\[
\text{Breaking Tenacity} = \frac{\text{Breaking load in gram}}{\text{Denier of the strand}}
\]

(h) **Dry Distillation Test**

The aim of this test was to determine the acidity or alkalinity of the fumes of the burning fibre. This test can be of great value in fibre identification where fibres are identical in terms of physical/visual characteristics. Most natural cellulosic fibres are acidic in nature due to the presence of hydrogen and carbon ions.
Procedure:

A dry sample was heated in a dry test-tube which had moistened strips of blue and red litmus papers placed on its rim. The colour change of the litmus papers was then noted for the fumes.

(i) Chemical Reactions with Various Chemicals

The aim of the following tests was to note the reaction of the fibres. The reactions included swelling and dissolution, dissolution without swelling, disintegration, colour reactions and changes. The test is important because chemical reactions are utilised in the manufacture of fibres, cleaning, chemical finishing and in the textile dyeing. Tortora (1992) urges that, the application of finishes and dye stuffs on textiles must take into account the effect of acids, alkalis, organic solvents, and their effect on textile fibres. The chemicals used include:

i. Cold sulphuric acid 75%
ii. Cold concentrated hydrochloric acid
iii. Hot diluted nitric acid
iv. Boiling caustic soda or sodium hypochlorite.

3.13 SPINNING AND WEAVING

The aim of spinning and weaving was to investigate into the possible uses of the fibre. Yarns were spun using a hand spinning wheel. The spun yarn was dyed and sample articles were made using crocheting, hand weaving, card weaving, plaiting and macrame' knots techniques.
3.2 **DATA ANALYSIS**

The data analysis was done both quantitatively and qualitatively. It involved reporting of the observations during the fibre extraction (retting) process, the length of time taken for the shive to rot and the amount of fibre obtained.

It also involved observation of the fibre behaviour towards chemicals (organic acids and alkalis), heat and other reagents used in the various tests mentioned above. Observation of fibre ash characteristics, the PH of the fumes given off from the fibres during the dry distillation test and appearance of the fibres under the microscope was also carried out and recorded.

Both descriptive and inferential statistics were used for the parameters tested. These included; mean of the fibre length, moisture content and regain, elongation at break and breaking tenacity. The measures of variability were used to see how the values obtained spread around the mean. The standard deviation was computed for parameters such as the length of fibre, elongation at break and breaking tenacity.

In order to determine whether the aramina fibres could be used in Kenya as textile fibres the qualities were compared with the established properties of a textile fibre as outlined in chapter two above.

The data is presented in form of reports, tables and figures.
CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 INTRODUCTION

The study was to find out whether the aramina fibres found in Kenya qualify to be put into textile use. The study aimed at achieving the following objectives, which were to:

1. Determine the chemical and physical properties of aramina fibers.
2. Make sample yarns from the fibers using hand spinning methods.
3. Construct sample textile articles using simple hand weaving techniques.
4. Compare the determined qualities of aramina fibers with the established properties of a textile fibre.

In order to achieve objective (1) and (4) the following tests were carried out:

a. Microscopic examination (of fiber ash, longitudinal and cross-section appearance).
b. Burning tests.
c. Length of fibers.
d. Moisture content and regain.
e. Drying twist test.
f. Breaking tenacity and elongation at break (wet and dry).
g. Dry distillation test.
h. Reaction with organic acids and alkalis (cold sulphuric acid 75%, cold concentrated hydrochloric acid, hot diluted nitric acid and sodium hypochlorite).

To achieve objectives (2) and (3), yarn was spun and articles were made using simple hand techniques such as weaving, crotchetting, macramé knots and plaiting. This chapter presents statistical analysis of data and report of the findings under the following sub-topics:

1. Extraction of the fibers.
2. Fibre tests results.
3. Spinning and weaving.
4. Comparision with other textile properties.

4.1 EXTRACTION OF THE FIBRE:

The retting process took two(2) weeks. A total of 2.6 kg of fibres were obtained from 22 kg of green unretted bark. The retting process involve separation of the embedded fibres from the stem through partial rotting by immersion in water. In the process of beating the fibre using a wooden mallet to loosen them and the washing off of the extraneous matter, some of the fibres ended up as a waste. During the retting process a slimy fluid was produced. In the presence of air the fluid turned reddish in colour which is indicative of the presence of iron ions. The fibres produced were smooth in texture and soft to the handle. The colour of the fibres obtained ranged form dirty white to brown with a shiny appearance.
Plate 1: (i) Barks after retting and before washing.

(i) The green barks before retting.

(ii) Soaked barks for retting.
(iii) Barks after retting and before washing.

(iv) The fibers after washing.
4.2 **FIBRE TESTS:**

All the fiber tests in this section were carried out at the Kenya Bureau of Standards (Textile Quality Control Laboratory), where the atmospheric conditions necessary for textile testing were maintained. A few fibre bundles were picked at random from the batch of conditioned fibres and subjected to the tests as outlined in chapter three.

The following results were obtained. The carding spinning and dyeing of the fibres was carried out at the Fine Art Department (Kenyatta University).

(a) **Microscopic Examination.**

(i) **Longitudinal appearance:**

In the longitudinal view the fiber was observed to be hairy on the surface and tapering on both ends. Markings and striations were noticed to run along the fibre length. This examination can be further used in determination of the molecular orientation of the fibre. The molecular arrangement contributes to the difference in the physical properties of fibres. The striations are shadows that appear as dark lines caused by the valleys in between the lobes. The presence of these lobes is important because they increase the ability of the fibre to hide soil which is an important aspect for products such as carpets.
(ii) Cross-section view:

The edges were seen to be irregular (serated) and have a bean-shaped cuticle at the centre. Tortora (1992), notes that cross-section appearance vary from fibre to fibre ranging from circular to oval, triangular, dog-bone, U-shaped, tritobal to multilobal, and hollow. The observation made indicates that light rays reflected by the fibre are broken up due to the high number of fibre surfaces that face each other. This in turn contributes largely to the lustre of the fibre.

Figure 3: The longitudinal view of the Aramina fibre as viewed under a microscope (not drawn to scale).

Figure 4: The cross-section view of the Aramina fibre (Not drawn to scale)
(b) **Burning Test:**

When the specimen was brought near a flame, the fibers charred and hardened. When brought into the flame they flared up and smelt like burnt paper. This indicates that unless the fibre or articles made from this fibre are given flame-retardant finishes it would be risky to use it near open fires. This is a obvious hazard to high-risk groups such as the elderly, children, the handicapped, and cigarette smokers. The flame-retardant finish can be applied to the fibre, yarn, or fabric (Tortora, 1992). A very light grey ash was left behind. The ash could easily be crashed into powder. When put on a hot plate they charred and hardened while they turned black. However they did not melt. This indicates that aramina fibres are not thermoplastic, if exposed to dry heat at temperatures above 337°C, gradual decomposition and deterioration of the fibre occurs. This means that excessively high ironing temperatures can cause aramina to scorch.

(c) **Length of Fibres:**

The fibre length data is presented in a grouped frequency distribution table (Table 1) and graphically presented as in Figure 5 below. Length is an important attribute in fibre processing because as El Mongahzy (1992) states, there is a minimum length blow which the fibres will not spin. Length is also associated with characteristics such as yarn appearance, evenness and strength.
Table 1: Frequency table of grouped distribution of Aramina fibre length.

<table>
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<th>length in cm</th>
<th>frequency (fx)</th>
<th>cum freq (f(x))</th>
<th>mid-pt (x)</th>
<th>x²</th>
<th>fx</th>
<th>f(x)²</th>
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<td>25</td>
<td>60</td>
<td>300</td>
</tr>
<tr>
<td>1-3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
</tbody>
</table>

Σfx = 1,349  Σf(x)² = 24,463

Figure 5: Graphical representation of the grouped data.
From the grouped distribution, the modal length is 11 cm with a frequency of 1.9.

The median (md) is given as:

\[ L + \frac{\left(\frac{1}{2} n - C\right)i}{f} \]

where  
- \( L \): Lower class limit of class containing the median
- \( n \): Number of fibres
- \( C \): Cumulative frequency of the class below the median class
- \( i \): Class interval
- \( F \): Frequency of class containing the median

\[ Md = 9.5 + \frac{(50 - 33)3}{19} \]
\[ md = 9.5 + 2.68 \]
\[ = 12.18\text{cm} \]
\[ = 12.2\text{cm} \]

The mean length is given by total \( \sum fx/n \)

\[ \frac{1349}{100} = 13.49 \]
\[ = 13.5\text{cm} \]

The standard deviation is given as:

\[ \sqrt{\frac{\sum f(x^2) - (\sum fx)^2}{n}} \]
\[ \sqrt{\frac{24463 - 1819.01}{100}} \]

43
\[ \sqrt{62.6499} \approx 7.915 \approx 7.9 \]

The coefficient of variation is given as:

\[ v = \frac{Sdx \times 100\%}{\text{mean length}} \]

\[ = \frac{7.9 \times 100\%}{13.5} \]

\[ = 58.52\% \]

The length of the fibres ranged between 2.00cm and 46.00cm. The median length was 12.2cm and the mean length was 13.5cm with a standard deviation of 7.9. The coefficient of variation was 58.5%. The much difference in the fibre length could be due to fibre breakage while separating single strands of fibre because they are interwoven into each other as shown in figure 6 below.

Figure 6: Microscopic arrangement of fibres in a retted bark (not drawn to scale)
The difference could also have been caused by the breakage during the scrapping off stage. However, as the single fibres were being separated short fibres fell off. However, Goswami, “et al” (1977) argue that like all other physical properties of natural textile fibres, fibre length varies considerably within any sample. The variability in terms of the coefficient of variation may be as high as 40% or more. From the data above it shows that the fibre is of a length that can be spun. This quality was further confirmed when the fibres were spun into yarn that was later used to make the sample articles.

(d) Moisture Content and Regain.

The Kenya standard, KS 08 264 (1981) method of determining moisture content and regain was adapted. The results are shown on table 2 below. The moisture content (c) was obtained using the formula:

\[
C = \frac{(a - b)}{a} \times 100
\]

while the moisture regain (r) was obtained using the formula:

\[
r = \frac{(a - b)}{b} \times 100
\]

where

- \(a\) = the original weight in grams
- \(b\) = the oven dry weight in grams
Table 2: Moisture Content and Regain.

<table>
<thead>
<tr>
<th>sample no.</th>
<th>a) Original weight (gm)</th>
<th>b) oven dry weight (gm)</th>
<th>c) moisture content (%)</th>
<th>r) moisture regain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.1486</td>
<td>4.6773</td>
<td>9.154</td>
<td>10.076</td>
</tr>
<tr>
<td>2</td>
<td>3.1959</td>
<td>2.9032</td>
<td>9.159</td>
<td>10.081</td>
</tr>
<tr>
<td>3</td>
<td>1.64</td>
<td>1.4925</td>
<td>8.994</td>
<td>9.882</td>
</tr>
<tr>
<td>4</td>
<td>4.4973</td>
<td>4.1698</td>
<td>7.282</td>
<td>7.854</td>
</tr>
<tr>
<td>5</td>
<td>7.4459</td>
<td>6.7725</td>
<td>9.044</td>
<td>9.943</td>
</tr>
<tr>
<td>6</td>
<td>6.1309</td>
<td>5.5894</td>
<td>8.832</td>
<td>9.688</td>
</tr>
<tr>
<td>7</td>
<td>10.0372</td>
<td>9.1243</td>
<td>9.095</td>
<td>10.005</td>
</tr>
<tr>
<td>8</td>
<td>6.385</td>
<td>5.7729</td>
<td>9.587</td>
<td>10.603</td>
</tr>
<tr>
<td>9</td>
<td>3.413</td>
<td>3.1039</td>
<td>9.057</td>
<td>9.958</td>
</tr>
<tr>
<td>10</td>
<td>3.3679</td>
<td>3.0838</td>
<td>8.436</td>
<td>9.213</td>
</tr>
</tbody>
</table>

\[ \Sigma C = 88.596\% \quad \Sigma r = 97.303\% \]

Mean = 8.8596\% \quad \text{Mean} = 9.7303\%

\[ \approx 8.86\% \quad \approx 9.73\% \]

From the table the mean moisture content is 8.8596\% which is equivalent to 8.86\%. This is an indication that the fibre can accept water-borne dyes and special finishes readily and are easy to launder. However, the fibre will dry slowly and may be stained by water-borne soil. The mean moisture regain is 9.7303\% which is equivalent to 9.73\%. This shows that the fibre can absorb moisture up to 9.7\% of its own weight without feeling damp. Garner (1967), argues that fibres with high regain are much easier to twist in spinning than dry ones. This attribute was further confirmed when the fibres were spun.
(E) Drying Twist Test:

When the wet aramina fibres were brought near an electric hot plate they twisted in a clockwise direction. The behaviour was consistent with that of other bast fibres. This is an important observation that can be used for identification and comparison with the behaviour of other cellulose fibres.

(F) Breaking Tenacity and Elongation at Break (Wet and Dry).

The fibre strength parameters were found by breaking three strands of fibres on an Instron tensile tester. The thickness of a fibre will influence its ability to withstand a lengthwise pull (tenacity), so before tenacity can be measured, a unit for thickness (denier) is needed. This is the ratio of the mass a fibre can just support without breaking to the fibre fitness. For example, a 2 denier fibre with a tenacity of 2.5 g/d can just support a mass of 5g, with a load more than that the fibre just breaks (Fritz A. and Cat J. 1986).

The results are presented in tables 3, 4 and 5 below.

**Table 3**: Fibre Denier of Aramina fibre

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight in gm</th>
<th>Length in meters</th>
<th>Denier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00325</td>
<td>0.175</td>
<td>167.1</td>
</tr>
<tr>
<td>2</td>
<td>0.00265</td>
<td>0.15</td>
<td>159</td>
</tr>
<tr>
<td>3</td>
<td>0.00301</td>
<td>0.135</td>
<td>200.7</td>
</tr>
<tr>
<td>4</td>
<td>0.00345</td>
<td>0.175</td>
<td>177.4</td>
</tr>
<tr>
<td>5</td>
<td>0.0033</td>
<td>0.15</td>
<td>198</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0031</td>
<td>0.142</td>
<td>180.4</td>
</tr>
<tr>
<td>Stad deviation</td>
<td>0.0005</td>
<td>0.039</td>
<td>33.8</td>
</tr>
<tr>
<td>Co-efficient of variation</td>
<td>16.1</td>
<td>27.5</td>
<td>18.7</td>
</tr>
</tbody>
</table>

The denier of the fibre was calculated using the formula:

\[
\text{weight in gram} \times 9000 / \text{Length in meters}
\]
The denier of the fibre was found to be 180.4 denier with a standard deviation of 33.8 and a coefficient of variation of 18.7. The denier of the fibre is important in determining the breaking tenacity whether the fibre is wet or dry. This means 9000 metres of fibre or yarn will weigh 180.4 grams.

Table 4: Breaking Tenacity and Elongation at Break of Dry Aramina Fibres.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Breaking Load (gf)</th>
<th>Elongation (%)</th>
<th>Breaking tenacity g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>363</td>
<td>0.88</td>
<td>2.00</td>
</tr>
<tr>
<td>2</td>
<td>188</td>
<td>0.61</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>355</td>
<td>0.97</td>
<td>2.00</td>
</tr>
<tr>
<td>4</td>
<td>155</td>
<td>1.04</td>
<td>0.9</td>
</tr>
<tr>
<td>5</td>
<td>204</td>
<td>1.67</td>
<td>1.1</td>
</tr>
<tr>
<td>Mean</td>
<td>253</td>
<td>1.03</td>
<td>1.4</td>
</tr>
<tr>
<td>Std deviation</td>
<td>88</td>
<td>0.35</td>
<td>1.07</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>34.8</td>
<td>34.0</td>
<td>76.2</td>
</tr>
</tbody>
</table>

Table 5: Breaking tenacity and Elongation at break of wet aramina fibres.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Breaking Load (gf)</th>
<th>Elongation (%)</th>
<th>Breaking tenacity g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>404</td>
<td>1.58</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>396</td>
<td>1.65</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>306</td>
<td>0.78</td>
<td>1.7</td>
</tr>
<tr>
<td>4</td>
<td>322</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>5</td>
<td>355</td>
<td>0.97</td>
<td>2.0</td>
</tr>
<tr>
<td>Mean</td>
<td>357</td>
<td>1.26</td>
<td>2.0</td>
</tr>
<tr>
<td>Std deviation</td>
<td>38.9</td>
<td>0.34</td>
<td>0.4</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>10.9</td>
<td>27</td>
<td>20</td>
</tr>
</tbody>
</table>

Yeager (1988), urges that the fibre strength is an important variable in textile product performance. However, both fibre strength and elongation must be considered...
together in any judgement of potential serviceability. Elongation is especially crucial to abrasion resistance. Hollen, "et al" (1979) highlights that a minimum elongation of 10% is desirable for ease in textile processing.

The breaking tenacity of the dry fibres ranged between 0.9g/d and 2.0g/d with a mean of 1.4g/d. The standard deviation is 1.07 while the coefficient of variation is 76.2. The percentage elongation was between 0.61% and 1.67% with a mean of 1.03%. The standard deviation is 0.35 while the coefficient of variation was found to be 34. On the other hand the breaking tenacity of the wet fibres ranged between 1.7g/d and 2.2g/d with a mean of 2.0g/d. The standard deviation is 0.4 while the coefficient of variation is 20. The percentage elongation was between 0.78% and 1.65% with a mean of 1.26%. The standard deviation is 0.34 while the coefficient of variation is 27. The correlation coefficient of the breaking tenacity and the breaking load of both the wet and dry fibres was found to be 1. The above figures show that there is a positive correlation between the breaking load and the breaking tenacity. The more force is used the higher the breaking tenacity in terms of gram per denier.

The correlation coefficient of the breaking tenacity and the percentage elongation of the wet fibres was computed to be 0.8 while that of the dry fibres was found to be -0.2. This indicates that the correlation coefficient of the breaking tenacity and percentage elongation is significantly affected by the wetness of the fibres. The wetness significantly affects the breaking tenacity of the fibres.

According to Grover E.B. and Harmby D.S. (1960), a coefficient of correlation, of breaking tenacity and breaking load, whether plus or minus, between 0.8 and 1.0 is considered as excellent, between 0.6 and 0.8 as good, between 0.3 and 0.6 as fair and
from 0 to 0.3 as a doubtful value for industrial data. This means that fibres with a
coefficient of correlation value between 0.3 and 1 can be used in industries as input
materials while a value below 0.3 indicates poor performance and its not strong enough
for industrial use. From the above data it is very clear that aramina fibres qualify for
industrial use since the coefficient of correlation of both the dry and wet fibres is 1. From
tables 4 and 5 above there is an increase of 42.9% in breaking tenacity in the wet fibres
given by the formula: 100(b-a)/a.

\[ \text{where } a = \text{mean breaking tenacity of dry fibres} \]
\[ b = \text{mean breaking tenacity of wet fibres}. \]

There is also an increase of 22.3% in the elongation at break in the wet fibres given by the
formula 100(w-y)/y.

\[ \text{where } w = \text{mean of elongation of wet fibres} \]
\[ y = \text{mean elongation of dry fibres}. \]

From a practical point of view, the wetness of a fibre can influence the fibre
strength which consequently will affect the yarn strength. This confirms Tortorais (1992),
argument that the strength of some fibre is affected by the moisture they contain. From
the above table it’s clear that the wet fibres are stronger than the dry fibres and stretch
more. This indicates that any article made from these fibres can be comfortably washed
and they can withstand washing friction.

From tables 4 and 5 above it can be noted that there is a great variation in the
breaking load that is required to rupture the fibres. This can be attributed to the different
fibre location in the plant, plant maturity or wearing of the fibre during the washing up.
Since the experimental sample was randomly chosen from the heap of fibres obtained,
there is a possibility of picking fibres that were of different strengths. The strength difference can be attributed to whether the fibre was located toward the base (near the roots), or the tender portion (apex) of the plant. It could also be due to difference in the plant age since the age was judged by optical observation. However, the method used could have contributed in that friction was used to separate the muck from the fibres and this could have had some detrimental effects on the strength of the fibre. This indicates that some fibre strands were much stronger than others.

(G) Examination of Fibre Ash.

The ash crashed into powder and the microscopic structure appeared as small chains bonded to each other as shown in figure 7 below. This observation is however important in determining the polymer arrangement of the fibre.

![Figure 7: Fibre ash crystals as observed under a microscope. (Not drawn to scale)](image)

(H) Dry Distillation Test.

The fumes produced are acidic in nature. The red litmus paper had no colour change while the blue litmus paper turned red. This is an attribute that is of importance to the manufacturing industry especially the chemical industry. This implies that if acidic solvents are used, the fibre can easily be dissolved or weakened.
(K) Chemical Reactions

When reacted with 75% sodium sulphate (200 ml) there was no swelling noted. However, the fibres changed the colour gradually from light brown to a very dark colour and lastly to black. The fibres also disintegrated gradually forming a dark solution. This is an indication that acid hydrolysis took place. When reacted with 100 ml concentrated hydrochloric acid (98%) the fibres did not disintegrate but changed to a dark brown colour. With nitric acid 50% (200 ml) the fibres turned to a slightly dark brown colour. When reacted with 100 ml of concentrated sodium hypochlorite, the fibres bleached and later turned to a yellowish colour. This indicates that the fibres can be bleached with sodium hypochlorite. When left soaked for 3 hours there was deterioration causing the fibres to disintegrate which is an evidence of acidic oxycelluloses.

Tortora (1992), indicates that cellulosic fibres are damaged by strong mineral acids and are harmed by quite diluted concentrations of these substances. The bonds connecting the sub-units are unstable to acid and the result is a loss of tensile strength and the susceptible fibres dissolved with time. From the above data, aramina fibres can be used for the formation of oxycellulose used in the manufacture of regenerated fibres (by acid hydrolysis). This also implies that acid can be used to produce permanently stiffened sheer fabrics whereby the acid is applied to break the outermost layer of fabric. The outer layer softens, the reaction is stopped, and the fabric is given a hard press that forms the outer fabric layer into a smooth, clear permanently stiffened finish. Since the fibre is damaged by acid, acid-free facilities are required for storage of aramina articles. Aramina fibres are sensitive to action of acid and this implies that they cannot be dyed using dyestuffs that require the presence of strong acids. On the other hand, sodium hypochlorite (oxidizing...
agent) did not harm the fibre rather it improved the appearance. However, if left for a long time the fibres weaken. This means that if any articles made out of this fibre is left for a long time in sodium hypochlorite, the chlorine will oxidize the colour as well as the fibre itself. Therefore, chlorine bleaches need to be used for short periods of time and rinsed out thoroughly before the fibre is damaged.

4.3 SPINNING AND WEAVING.

About 2.6 kg of fibres was obtained. They were bleached using sodium hypochlorite for 15 minutes and carded using a hand carder to make rolags. The rolags were then spun into yarn using a hand spinning wheel. A total of 2.2 kg 2-ply yarn was obtained. The yarn was dyed using procion dyes for 45 minutes to give it an aesthetic look. The yarn was hairy and very fluffy. However 400 gm of fibre was lost during carding due to the breakage of fibres.

Sample articles made are shown in plates 2-7 below. These include a table mat, shoulder bag, belt, toothpick holder cover, floor mat and a plant hanger. The techniques used to make the above articles are plaiting, crocheting, weaving and macramé knots.
Plate 2: Table mat using crocheting technique.

Plate 3: Floor mat using card weaving technique.
Plate 4: Plant hanger using plaiting technique.

Plate 5: Toothpick holder cover using macrame' knots.
Plate 6: Shoulder bag using crocheting techniques.

Plate 7: Belt using hand weaving technique.
4.4: COMPARISON WITH TEXTILE PROPERTIES.

The aramina fibres are of a staple length of between 2.00cm and 46.00cm. This indicates that it’s length is consistent with that of other fibres as outlined in table 6. This property therefore enabled the fibres to be spun into yarn. However, due to the presence of short fibres the yarn produced was fluffy, rough and soft to the feel.

The fibre is very flexible, it can easily bend without breaking and this property made it possible for the fibre to be spun into yarn and made into various sample articles. The articles made did not have a very good drapability and due to the bulkiness of the yarn, articles made were also bulky. For the weight of the articles to be improved, the fibres may need to undergo special treatment and processes such as singing and mercerisation.

El Mogahzy (1992), denotes that strength of a fibre has a major role to play in yarn quality and spinning performance. Aramina fibres recorded a tenacity of 1.4g/d when dry and 2.0g/d when wet. From table 6 it is very clear that aramina fibre is fairly strong and stronger when wet. This property is consistent with that of cotton and other vegetable fibres hence ideal for textile articles such as towels. Such a fibre can also be fairly used for heavy industrial work and may be of great importance for medium and light duty work such as clothing, upholstery etc.

Vegetable fibres are hydrophilic in nature and will readily absorb moisture from the atmosphere. This is true with aramina fibres which can absorb moisture up to 9.7% of it’s own weight without feeling damp. This indicates that aramina fibres are good moisture
absorbers and can take dye and other finishes easily. However, the fibre will also take long
to dry.

The aramina fibres burn readily like paper and care needs to be taken when in use
near open fires. The fibre is also resilient since it can stretch to about 1.3% of unit length
when wet and 1.03% when dry before it ruptures. This quality makes it good for textile
articles and shows that the articles made from it can withstand friction (stress and strain).

Table 6: Comparison of aramina fibres and other natural vegetable fibres.

<table>
<thead>
<tr>
<th></th>
<th>Cotton</th>
<th>Linen</th>
<th>Sisal</th>
<th>Pineapple</th>
<th>Jute</th>
<th>Aramina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Length(cm)</td>
<td>6.25</td>
<td>56</td>
<td>130</td>
<td>70</td>
<td></td>
<td>46</td>
</tr>
<tr>
<td>Colour</td>
<td>White</td>
<td>Cream</td>
<td>White</td>
<td>White</td>
<td>Light to dark brown</td>
<td>Light brown</td>
</tr>
<tr>
<td>Tenacity dry(g/d)</td>
<td>3.0 - 5.0</td>
<td>3.0 - 5.8</td>
<td></td>
<td>2.4</td>
<td>3.8 - 5.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Tenacity wet(g/d)</td>
<td>3.0 - 6.0</td>
<td>6.5</td>
<td></td>
<td>1.8</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Elongation dry (%)</td>
<td>3 - 10</td>
<td>2.7 - 3.3</td>
<td></td>
<td>1.82</td>
<td>1.2 - 1.9</td>
<td>1.03</td>
</tr>
<tr>
<td>Elongation wet (%)</td>
<td>5 - 13</td>
<td>2.2</td>
<td></td>
<td>1.97</td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td>Moisture regain(%)</td>
<td>8.5</td>
<td>12.0</td>
<td>12 - 13</td>
<td>10.4</td>
<td>13.7</td>
<td>9.7</td>
</tr>
<tr>
<td>Stronger when wet than dry</td>
<td>10 - 20</td>
<td>20 - 22.4</td>
<td></td>
<td></td>
<td></td>
<td>42.9</td>
</tr>
</tbody>
</table>

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 SUMMARY:

The study was carried out to analyse the properties of Aramina fibres from the plant *Urena lobata* that grows locally as a weed in Kenya. The general aim was to investigate into the properties of the fibre and find out whether it can be put into any textile use given that Kenya imports most of the vegetable fibres apart from cotton and sisal.

To identify the physical properties of the fibre, and to compare these properties with already established textile properties with other cellulose fibres, a number of parameters were tested. In order to obtain the fibre, the barks were stripped off from the woody portion and subjected to a retting process for two weeks. The retting process involved partial rotting by immersion in water. A total of 2.6 kg fibre was obtained from 22 kg of green unretted bark. The fibre obtained was smooth in texture, soft to the touch and had a shiny lustre. However, the method used was tedious and many fibres were washed off with the muck that led to wastage.

The fibres were then subjected to various tests to determine the physical and chemical properties. This was carried out at Kenya Bureau of Standards (Textile Quality Control Laboratory) where the necessary conditions of textile testing were maintained. The following tests were carried out:
a. Microscopic examination (of fibre ash, longitudinal and cross-section appearance)

b. Burning tests

c. Length of fibres

d. Moisture content and Regain

e. Dry twist test

f. Breaking tenacity and elongation at break (wet and dry)

g. Dry distillation test

h. Reaction with organic acids and alkalis (cold sulphuric acid 75%, cold concentrated hydrochloric acid, hot diluted nitric acid and sodium hypochlorite).

When observed under a microscope, the aramina fibre was found to have striations running along the fibre length and the fibre had irregular serrated edges with a bean-shaped cuticle at the centre. Burning properties were characteristic of other natural cellulose fibres. The fibre flared up and smelt like burnt paper when brought into flame, and charred and hardened when near a flame or when put on an electric hot-plate. The length of the fibre ranged between 2 cm and 46 cm with a staple length of 13.5 cm.

The moisture content was found to be 8.86% and the regain to be 9.73%. The fibre strength which was found to increase with wet fibres was about 1.4g/d for the dry fibres and 2.0g/d for the wet fibres. The wet fibres recorded a strength increase of 42.9%. The fibre denier which is important for computing fibre strength (tenacity) was found to be 180.4. The elongation at break was also found to increase with wetness of the fibre. This was about 1.03% for the dry fibres and 1.26% for the wet fibres. The aramina fibre
is easily oxidized by sodium hypochlorite which leads to deterioration. However, it is acidic in nature and can easily be dissolved or weakened by the presence of acidic solvents. When reacted with 75% sodium sulphate (200 ml) it gradually changed colour from light brown to black and disintegrated resulting to a dark solution. This is evidence of acid hydrolysis. When reacted with 100 ml concentrated (98%) hydrochloric acid, the fibre did not disintegrate but turned into a dark brown colour. With 200 ml nitric acid (50%) the fibre turned to slightly dark brown colour. However, with 100 ml concentrated sodium hypochlorite, the fibre was bleached to white and when left for a 3 hours they turned to a bright yellow colour. This is evidence of oxidation by the chlorine and subsequent fibre deterioration.

On comparison with other natural cellulosic fibres, the aramina fibres were found to have characteristics that were similar to those of the cellulose fibres. The maximum fibre length was more than that of cotton (6.25 cm) and less than that of linen (56 cm). This made it possible for the fibre to be spun into yarn.

The moisture regain value which was found to be 9.7% which is slightly above that of cotton (8.5%). The findings on the strength of the fibre showned that aramina fibres are 42.9% stronger when wet than dry. This property stands out uniquely because cotton is only 20% stronger while linen is 22.4%. Like all other cellulosic fibres, aramina fibres smell like burnt paper and flare up in flame when brought near an open fire.

Yarn was also made from the fibres using hand-spinning wheel. The fibres carded into rolags and a 2-ply yarn was spun and dyed using procion dyes. The yarns obtained were soft, strong and pliable. A few sample articles were then made using hand techniques and card weaving. Crocheting technique was used to make a table mat and a
shoulder bag, card weaving technique was used to make a floor mat and hand weaving technique was used to make a belt. Macramé knots were used to make a tooth pick holder cover while plaiting technique was used to make a plant hanger. This clearly shows that the fibre can be used in various ways to make textile articles though the articles made were bulky and fluffy.

In summary the aramina fibres were found to possess the following properties:

(a) Physical properties

i. Staple length of about 13.5 cm

ii. Stronger than cotton and linen when wet.

iii. Good moisture absorber (can absorb upto 9-7% of its own weight without feeling damp) hence comfortable to wear in hot weather.

iv. Burns readily when near open fires and smells like burnt paper.

v. Low elongation as compared to other natural cellulose fibre.

vi. Good spinning quality

vii. Flexible and pliable.

(b) Chemical properties

(i) Takes dye well

(ii) Affected by strong acids (dissolved)

(iii) Acidic in nature

(iv) Can be bleached using household chlorine breaches but prolonged exposure weakens the fibre.
2. Women groups such as the Anyany self-help group, Yatta women group
and other self-help groups that make articles such as traditional baskets,
floor rugs and mats for sale can benefit greatly from the fibre since it's
cheap to obtain and locally available.

3. At a family level, the production, utilisation and sale of aramina fibres can
be a source of family income if grown as a cash crop.

4. Kenya aims at being industrialised by the year 2020, through utilising local
raw materials available in order to put up industries. Aramina fibres can be
maximally utilised towards the realisation of this goal. This would
substitute imported natural vegetable fibres and aid in rural
industrialisation.

5. The method of fibre extraction was slow and may not be appropriate for
large scale production. Therefore, there is need to explore other methods
for use in large scale production.

6. Since the study has established that the fibre can be used for textile
purposes, further research is needed to find out the economic viability if the
project is undertaken.

7. The spun yarn was very fluffy and bulky. Research is needed to find out
which treatment can be given to make the yarn less fluffy and bulky. For
example the effect of mercerisation and singeing.

8. Other fibre qualities that have a significance effect on the yarn and fabric
quality such as fibre diameter, fibre maturity, trash content, specific gravity,
fibre dimensions (cell composition, molecular structure, molecular weight),
uniformity and effects of various dyes and dyeing techniques need to be investigated into.

9. Other methods of measuring fibre parameters such as micronaire and gravimetric methods can be tried out for comparison purposes.

10. Since only the quality of the fibre has been investigated, there is need to investigate further on the quality of yarns and articles made from the fibre.

11. A study is also needed to analyse the products of decomposition and the matter content of the muck that accumulates at the bottom of the retting tank.

12. Other possible ways of utilising the fibre need to be tried out. For example paper making, production of regenerated fibres, use with other fibres etc.

13. There is need for investigating into the maturity stage where the fibre yield (quality and quantity) is optimal putting in consideration the agronomie variables.
APPENDIX

6.0 REFERENCES


Polytechnic.


Your Ref. No. : BS76/4/46

Miss Lydia Nkatha Gikunda
E55/7652/95
Kenyatta University
Home Economics Dept.
P.O. Box 43844
NAIROBI

Dear Madam,

QUALITY TESTING OF ARAMINA FIBRES

Please refer to your letter dated 21/11/96. Your request to make use of our facilities during the month of Feb/March 1997 to carry out tests has been accepted. Consequently, you should call upon the Head of the Biochemical Laboratories to discuss the requirements before commencement of the analysis.

Yours faithfully,

B.W. Muchui(Mrs)
For: HEAD, CORPORATE PLANNING AND DEVELOPMENT

Kenya Bureau of Standards
(A STATUTORY ORGANIZATION OF GOVERNMENT)