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The Fibres of the Hawaiian Islands.

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The cultivation of fibre-yielding plants has of late years been one of rapidly increasing importance. The subject has for some time received exhaustive research in the United States where the total annual importation of raw and manufactured fibrous materials approximates in value the sum of $100,000,000. The demand for many forms of fibre manufactures, particularly those used in binding, has, it is asserted, always been in excess of the supply, and at the present time is increasing at an extraordinary rate. This, coupled with the decline and deterioration of flax and hemp culture in European countries, has caused a great stimulus to investigation as to the value of new fibres and the possibility of supplying the demand with products of home origin.

It will be the endeavor of this paper to present briefly a review of various fibres, particularly those of native Hawaiian origin and those of possible introduction to these islands. Attention will also be directed to what success has already been achieved in fibre culture in Hawaii and the result given of experiments conducted at the Museum on the preparation and testing of various kinds.

It is worthy of note that the most important fibres of today were the staple ones of ancient times. Flax, cotton, hemp, and the host of palms, grasses and reeds of commerce all boast a remote antiquity. It has often been remarked that no new species of domestic animal has been added to our possessions since the dawn of history, and this statement with some limitations may be advanced with respect to fibres. Even the recently introduced Sisal hemp was in use by the Aztecs, and the till late little known China grass was utilized in the Orient so far ago that all record of its origin is forgotten. The earliest fibre which is known to have been cultvated is flax. Fragments of linen fabric have been found among the prehistoric remains of the Swiss Lake-dwellers, a people coeval with the mammoth. The cere cloth used by the ancient Egyptians in the preservation of their dead was linen, and the monuments of this historic people depict the full process of its manufacture. The

records of cotton are no less ancient, and Herodotus writes, "There are trees which grow wild in India, the fruit of which is a wool exceeding in beauty and quality that of sheep. The Indians make their clothes of this tree wool." (Herod. iii, 106.) The ancient Hebrew writings are full of references to spinning and weaving. White and violet hangings of cotton are described in Esther[1] as adorning the king's palace, and the failure of flax is recorded by Hosea (ii, 9) as among God's punishments. The Hindus have, from time immemorable, been conversant with the manufacture of the most exquisite muslin, which derives its name from Mosul, a city famous for its manufacture, on the Tigris. The ancient cities Calicut, Damascus and Nanking point to the early origin of the fabrics to which they have given their names. The use of papyrus was well known to the Egyptians, and Pliny mentions its use by these people for their matting and sails, and small boats are even said to have been made of it.

All fibres suited for weaving are characterized either by irregularities in their surface, which take the form of serrations or dentations to prevent the individual fibres from slipping one upon another, or they possess a more or less tendency to twist and curl. In addition to these structural peculiarities the commercial value of a fibre depends directly upon many other characteristics, chief of which are the length, strength, flexibility, texture and color of the filaments, together with their composition, facility of cultivation and capacity for bleaching and taking dyes.

Vegetable fibres consist as a rule of woody cylindrical cells, generally overlapping one another and traversing the structure of the plant to give it rigidity and strength. Wood cells occur most plentifully in the bast layer which underlies the true bark. As, however, Dicotyledonous plants are the only ones that possess a true bark it is only this class of plant which yields bast fibre. Among the chief bast or cortical fibres of commerce are flax, hemp and jute.

In Monocotyledons the fibrous cells are incorporated with the fibro-vascular bundles which occur throughout the body of the stems and leaves, forming, as it were, the supporting structure of the plant. These bundles deprived of their soft cellular matter

[1] Esther i, 6. The Hebrew *carpas*, Greek κάρπασος. Sanscrit *karpâsa*, was used to denote either cotton or flax, and recent authorities render this passage describing the palace of Ahasuerus (Xerxes) at Susa "white and violet hangings of cotton."

afford another class of fibres which may be called "structural" or "foliaceous." Among the chief of these are Manila hemp, coir, sisal and pita.

A third class of fibres is obtained from the down or hair surrounding the seed or seed capsule of certain plants. The most important of these is cotton, which is produced in bolls contained in the seed envelope of various species of *Gossypium*.

The method of separating fibres from the plant depends materially upon their structure. As a general rule the process involves steeping or macerating in water (termed "retting"), beating and scraping (known as "heckling"), washing, drying and bleaching. With certain fibres some of these processes may be unnecessary, but in broad terms the manufacture of fibre may be said to embrace them all. Modern machinery is making important changes and introducing new methods and economy of time and expense. Before the introduction of mechanical aid the preparation of fibre was necessarily slow and laborious. In former times retting appears to have played a more important part than now, nearly all fibres being first subjected to this treatment; that of the coco palm, known as coir, was allowed in some instances to macerate for two years. The process of retting is now not so often resorted to, as it is found that it injures the quality of the fibre both as to strength and color: it must, however, always form a necessary part in the preparation of some fibres.

In extracting fibres by hand, bast varieties are best obtained by gently beating the bark with a wooden mallet to loosen and separate the filaments. These should then be thoroughly washed and freed from extraneous matter and then immersed for a greater or less time in water until the fibre can be cleaned from impurities. The preparation is completed by such drying and bleaching as is required.

The process of hand preparation of structural fibre follows much the same lines as are required for bast ones. With pulpy plants, such as the agaves and plantains, retting may be dispensed with altogether, and fibre obtained in this way usually commands a better price on the market. As a rule the more quickly the sap and pulp be removed after cutting, the cleaner and stronger the fibre. Clearness and texture often form a good criterion as to strength.

From an economical standpoint fibres may be classified according to their use. Cotton, flax, pineapple and ramie are finer fabric fibres, while jute and coir are used for matting and sacking. Threads, twines, ropes and cordage are supplied by flax, hemp, plantain and sisal, and the various manufactures of brooms, paper, nets, mats and baskets are made from a host of sedges, reeds, bambus, palms, seaweeds and other plants.

Of the many hundreds of useful fibre-producing plants probably less than forty supply the markets of the world. It is believed that these Islands may be made abundantly productive of fibres adapted to every description of manufacture, from the coarsest sacking to the most delicate muslin or lawn.

Although the usual arrangement of the fibres noticed in this paper would be a division founded on their structure and botanical classification it has seemed better in this case to adopt a different method. A brief description is first given of the standard commercial fibres, flax, hemp and jute, as it is by these a comparison is drawn to the quality of other and less known varieties. The fibrous plants native to the Hawaiian Islands and the introduced ones then follow in alphabetical order. The importance of botanical origin has not been entirely overlooked and attention is in each case directed to this. The following fibres have been described:

BAST OR CORTICAL FIBRES: Cotton, Flax, Hemp, Hibiscus (hau), Jute, Mulberry, Okra, Olonâ, Pandanus (hala), Ramie, Rosella and Sunflower.

STRUCTURAL OR FOLIACEOUS FIBRES: Bambu (ohe), Coir (niu), Manila Hemp, New Zealand Flax, Pineapple, Pita, Sansevieria and Sisal.

SURFACE FIBRES: Cotton and Pulu.

FLAX.

EXOGEN. BAST FIBRE. *Linaceæ. Linum usitatissimum.*

Flax is believed to be the earliest vegetable fibre used by man for clothing, and its cultivation and manfacture are known to have been followed for at least five thousand years, *Linum angustifolium* being the reputed source of the prehistoric fabric of the Stone Age. More than one hundred species are recognized, of which *Linum usitatissimum* affords the flax of commerce. The *Linaceæ* are dis-

tributed throughout the world, being found principally in temperate zones. The commercial variety is grown extensively in Great Britain, Sweden and most other European countries, the finest flax being produced in Belgium. Considerable success has awarded the growth of this plant in the United States, but its culture is on the whole technical and beset with many possibilities of failure. Specimens of flax grown by Mr. A. F. Cooke at Palolo have been examined and a fair sample of fibre was obtained. Mr. Cook is experimenting in this direction and looks to obtain three harvests a year.

HEMP.

EXOGEN. BAST FIBRE. *Urticaceæ. Cannabis sativa.*

The term "hemp" is used commercially as indefinitely and generally as the word "fibre." It has almost acquired the position of a generic name, and seldom appears without such a descriptive prefix as Manila, Sisal, Indian, Russian, Sunn, and a host of others which refer to fibres of utterly distinct origin. Correctly speaking the term "hemp" should only be applied to *Cannabis sativa*, an annual herbaceous shrub of the *Urticaceæ*, a well known fibre-producing order which also furnishes two other invaluable materials, ramie and the less known Hawaiian oloná. The cultivation of true hemp has been followed from the earliest ages in India and Persia, and it is now grown extensively in S. Russia, Hungary, S. Europe, Asia, China, tropical Africa and S. America, where it flourishes well in altitudes of from 4000 to 10,000 feet; but as the production of good fibre demands careful and liberal attention and a rich soil, it is unlikely that hemp will ever be grown commercially in Hawaii. The preparation of the fibre follows the general lines of that required for other bast varieties. Although innumerable patents have been issued to inventors of hemp-preparing machinery none have been entirely successful, and its manufacture is still chiefly by hand and as a rule expensive.

Forty years ago the United States produced 75,000 tons of hemp which in 1895 had fallen to about 5000. This decline is due chiefly to over-production and the competition of the less expensive though somewhat inferior Manila and Sisal hemps. As a cordage material true hemp is unrivalled, and its use is chiefly directed to the various manufactures associated with this term and to the weaving of sail cloth and canvas of different textures, which

latter article derives its name from the Greek word *cannabis*. The following reference is to hemp: "I never heard the like termes given to any simple as you give to this; you call it neckwede."

In India the well known intoxicating liquor "bhang" or "hasheesh" is prepared from cannabis and is used by all classes, Moslems and Hindus alike being said to indulge in its insidious intoxication to a great extent.

JUTE.

EXOGEN. BAST FIBRE. *Tiliaceæ. Corchorus capsularis.*

Jute is derived from a shrub which grows wild throughout India where it has been cultivated from early times. It has been introduced successfully to favorable parts of the United States and would probably grow well in these Islands; but its culture here is unlikely in view of the very many superior fibrous plants readily adaptable to this climate. The culture of jute, however, is stated in the Cyclopedia of India to be easier and more profitable than that of rice. The chief commercial jute manufactures are sacking (Bengali, *gòni*, which suggests the word "gunny") and packing cloth. It is also used extensively in admixture with wool and other articles in the production of an inferior kind of carpet.

BAMBU.

ENDOGEN. STRUCTURAL FIBRE. *Gramineæ.*

Among the important fibre plants of the world is bambu, the most gigantic of the grasses, which varies from the size of a slender reed to that of a small palm. The climate of Hawaii is adapted to many of the bambus,[2] but no attempt is made to take advantage of this commercially. Many varieties would flourish among the deep moist valleys of these Islands where little else of value could grow, and their slender poles and stems should find a ready use not only among our oriental population, but in the general manufacture of varied domestic articles. The number of uses to which the bambu is applied in China and other eastern countries is indefinite. The useful "India paper" is made from the leaves and shoots; its strong upright posts are used for the framework of houses, while other parts

[2] *Bambusa vulgaris* is found wild on all the larger Hawaiian islands, and perhaps eight or more species are found here in gardens.

of the plant furnish the walls, floors and thatch. It is employed in the construction of ships and bridges, and for every conceivable article of household furniture. Ropes, ladders, water conduits, outriggers, baskets, fans and hats only suggest some of the uses of this invaluable plant. The process of paper making from the bambu in China is simple. A thin layer of split stems is placed in a tank, and upon these a layer of lime. Alternate bambu and lime layers are continued until the tank is full, when water is admitted and the whole allowed to remain till the bambu is thoroughly disintegrated. The pulp is then pounded in a mortar and spread in layers to dry.

The papyrus, another useful grass, grows well in this climate and is found in many gardens. The paper of the Egyptians was prepared by removing the central pith from the stalk and laying the strips side by side; another layer was placed at right angles to the first and the whole soaked in water, pressed and dried.

BOW STRING HEMP.

ENDOGEN. STRUCTURAL FIBRE. *Liliaceæ. Sansevieria zeylanica.*

This remarkable fibrous plant belongs to the same order as New Zealand flax and the Yuccas. It grows extensively in India, Java, Guinea and China, and the tenacity and durability of its fibre has commended it to the natives of many countries for their bow-strings. The plant is a stemless perennial bearing a rosette of radical leaves, smooth, erect, linear-lanceolate, copiously maculated on each side with a lighter shade of green. Its florescence is racemose, resembling the agaves.

The fibre of *Sansevieria* possesses in an eminent degree those properties demanded of a successful textile or cordage material. It is white, fine, soft, pliant and lustrous, resembling pineapple fibre in many of these attributes. Its elasticity is great, and its resistance to moisture is more pronounced than that of hemp. In tenacity this fibre is about equal to Sisal, which it surpasses in most other qualities. The cultivation of sansevieria is simple, as it requires no care. The gardens of Honolulu contain many evidences of the plant's adaptability to this climate. The propagation is by division of the rhizomes or the leaves may be cut in lengths and inserted two inches deep in boxes, when after a few weeks they will develop fibrous roots and suckers will be put forth. The

plants soon become well established and a full crop may be harvested in about two years. By judicious arrangement of the plants in succession of growth the output of fibre may be made continual, and a plantation worked through twice a year. After each cutting the growth becomes denser, and it is said that the plant will in time eradicate everything else. A plantation may be cropped for many years without renewal, and need fear no extremes of rain or drought, as sansevieria appears indifferent to either.

The preparation of this fibre is similar to that of sisal, the native hand method consisting of removing the parenchyma with a blunt instrument and the usual process of washing and drying. Forty pounds of leaves from three to four feet long are said to yield one pound of dry fibre; and two crops, consisting in all of about 3500 pounds, may be expected from an acre of about 3000 plants. An experiment conducted under favorable circumstances on a small scale yielded a proportion of 13 tons per acre. The value of sansevieria may be taken as greater than that of sisal. The introduction of the cultivation of sansevieria fibre to these Islands appears to be one of exceptional promise. The adaptability of this plant to the Hawaiian climate, its rapid continuous and vigorous growth, its quick and abundant harvest, its easy production and value assure it a promising future and the consideration of enterprising capitalists.

COIR.

ENDOGEN. STRUCTURAL FIBRE.. *Palmæ. Cocos nucifera.*

Coir is a fibre produced in the husk surrounding the fruit of the coconut palm. This plant is said to be indigenous to Southern India, but it is found extensively in all tropical countries. The fibre is in general use throughout the Pacific, India and the West Indies, where it is used by the natives for matting, cordage and other purposes. In the native preparation of coir the husks are removed from the almost ripe nuts by tearing them on an iron spike fixed upright in the ground. One man is said to be able to shred by this means one thousand nuts a day. The husks are thrown into pits to disintegrate by maceration and decomposition, a process occupying in some cases as long as two years. The fibre is finally separated from other matter by scraping, beating and washing. The coir produced in the Laccadive Islands is considered the

best, and its preparation is said to be almost exclusively in the hands of women. The husks are there soaked for but a few days and the fibre is separated by gentle beating and scraping. When dry the coir is arranged into a loose roving which is stated by Watt to be twisted by hand in an ingenious way which yields two strands simultaneously.

The quality of coir fibre depends partly upon the maturity of the nut at the time of gathering and partly upon the care bestowed upon its preparation. It is used commercially in the manufacture of ropes, cables, matting, coarse carpet, brushes and brooms, and is a good substitute for oakum for caulking ships. In strength coir cordage is greatly inferior to Manila hemp, but surpasses it in elasticity. It is remarkable that the preparation of such a marketable commodity as coir is neglected in Hawaii. With care a good revenue might be derived from the coco-palm, as besides coir a valuable oil is yielded. The leaf stalk when split and drawn through perforated steel plates yields a clean durable material well suited for basket work.

COTTON.

EXOGEN. SURFACE FIBRE. *Malvaceæ. Gossypium.*

Cotton fibre consists of fine tubular hair-like appendages which surround the seed of various species of *Gossypium*. It is of a clear white color and occurs irregularly contorted. Cotton furnishes clothing to millions of people in India, and is the chief fibre manufactured for ordinary clothing fabrics. Its cultivation has been established from the earliest times, and its product has always found a place in the markets of the world. Before the conquest of Mexico by Cortez that country produced upwards of 100,000,000 pounds of cotton annually, but its culture was neglected and ultimately abandoned under Spanish lethargy. In the United States the rapidity of the increase of the cultivation of this article is remarkable. At the beginning of last century about 10,000 bales per annum were produced, which at the close of the century had grown to about 8,000,000 bales. The magnitude of the cotton industry may be estimated when it is known that the value of the raw fibre produced in the United States is about $160,000,000, which is converted by manufacture into material approximating $300,000,000 in value. The quality of cotton consists chiefly in

the length of the filaments, "long staple" measuring from one to one and a half inches, and "short staple" averaging less. The climate of these Islands is well suited to the growth of cotton, *Gossypium tomentosum* and *G. drynarioides* being both indigenous to these Islands, but of little commercial value on account of their short staple.

During the War of the Rebellion considerable quantities of cotton were grown in Hawaii and exported to America, but for many and obvious reasons it will probably never again rank among the exports of this territory. It grows well on most soils, but not equally so on all and requires a summer long enough for it to mature. The strong cortical fibre of the cotton plant has lately been the subject of experiment, and for some time it was fondly imagined that an additional profit would be derived from this source by plantations devoted to the cultivation of surface cotton. The failure of these attempts is generally admitted, as no machine can operate upon the tough, gnarled stems of the plant grown for ordinary cotton. To derive commercial bast fibre from this plant would demand an entirely different culture, entailing the rapid growth of straight long stems from closely set seeds.

HIBISCUS.

EXOGEN. BAST FIBRE. *Malvaceæ.*

The hibiscus is a very large group of plants belonging to the *Malvaceæ*, an order remarkable for its fibres, which include cotton and okra. They are widely spread over the warmer regions of the globe and are very generally used by the native races for cordage, mats and allied manufactures. The florescence of the various species of *Malvaceæ* is generally large and showy, the different whorls being arranged in divisions of five. The flowers of the cotton, garden hibiscus, hau, hollyhock, mallow and marshmallow are well known. The most generally known tree of this genus is probably *Paritium tiliaceum*, which occurs abundantly in the Pacific and is the native *hau* of these Islands. It is now grown chiefly for its generous shade and is often seen trained to form lanais and arbors. Its fibre is tough and pliant and was formerly used extensively by the natives for mats and cordage, while its light wood afforded the *iako* of their canoes and the handles of their adzes.

Hau fibre is not equal in strength to hemp, or even good jute, but its tenacity is greatly increased by moisture. It may easily be obtained by beating, maceration and washing.

Hibiscus sabdariffa is in general cultivation in India and has been introduced to these Islands. Its fibre is known as Rosella hemp, and samples prepared at the Museum were found to be soft, fine and pliant, and slightly superior in strength to those of hau. The fruit of this plant ripens freely in Honolulu and makes a delicious sauce, resembling cranberry in appearance, color and flavor. Its leaves are said to be used in India for salads. Neither of these plants is likely to repay culture for fibre in Hawaii. *Hibiscus esculens*, see Okra.

MAGUEY.

ENDOGEN. STRUCTURAL FIBRE. *Amaryllidaceæ. Agave americana; A. mexicana.*

Various species of *Agaves* occurring in Mexico and Central America of use as fibre-producers have received the generic native name of Maguey, the products of the two above named being perhaps the best known. It is important to distinguish these fibres from the more valuable pita, the product of *Furcraea gigantea*, with which they are popularly but erroneously associated. *Agave americana*, the American aloe, or century plant, is often grown in gardens for its decorative effect, but its true fibrous qualities are greatly impaired by a too generous soil, which a rigorous habitat fully develops. *A. mexicana* yields the intoxicating beverages pulque and mescal, the former of which is prepared in Mexico in the following manner. When the leaves commence to become yellow a small aperture is made at the base of the leaf into which a tubular gourd is inserted from which the air is exhausted and the sap removed by suction. The fluid is then emptied into sheep or pig skins and fermented in vats, where it assumes an opaque white color. Its taste is at first unpalatable to white people, although they are said to overcome their distaste in time. Watt estimates, in 1889, that 50,000,000 bottles of pulque were annually consumed in the city of Mexico, and that 20,000 mules and donkeys laden with this beverage entered the city monthly. Squier describes the preparation of pulque in a different manner, and, writing in 1863, says that the central stalk, just before florescence, is cut away and a

reservoir formed by scooping, into which the sap exudes. He relates that one plant will afford beverage for two months, and will furnish in all between two and three hundred gallons of pulque.

The fibres obtained from these agaves are of good quality. Their cultivation and preparation closely resemble those of pita and sisal, to which fibres they are similar but rather inferior. They have been cultivated with fair results in various countries, but in view of the better grades of similar fibres, above mentioned, it is improbable that they will ever be widely grown.

MANILA HEMP.

ENDOGEN. STRUCTURAL FIBRE. *Scitamineæ. Musa textilis.*

Of all substitutes for true hemp the fibre extracted from the wild banana or plantain is probably the most important. In the Philippines, where the plant is indigenous, a large industry is carried on in the manufacture of "abaca" cloth from the finer qualities of banana fibre, the coarser material only being reserved for export. A rich volcanic soil is best suited to the culture of the abaca, the most satisfactory results being produced on high land subjected to a regular rainfall, as drought is most detrimental to the crop. In the Philippines the manufacture of the fibre is almost entirely by hand, one man preparing about twelve pounds a day, for which he receives one-half. From one to two tons of fibre are obtained from an acre of land, according to the method of preparation, which is, on the whole, wasteful, as only about one pound is obtained from each plant. The fruit, being inedible, is not allowed to ripen, the flower being removed as soon as protruded. When the plant is once cut it is important to remove the fibre without delay. The discolored outer petioles are first removed and discarded, and the successive ones are placed upon a flat board and the inner side scraped with a blunt instrument. When all the pulp has been removed the strip is turned and the scraping continued on the other side. Repeated washings and scrapings free the fibre from extraneous matter, and it is then hung in the wind to dry. Crude apparatus, consisting of a fixed horizontal knife upon which the fibre is pressed by a parallel bar, is also in use in some parts. Manila hemp is of great strength and durability and has earned for itself the first position as a cordage fibre. A substitute for horse hair is

manufactured from this fibre dyed with copper and logwood—a deception also practiced with coir. The excellent paper known as "Manila" is made from the waste fibre of the abaca.

The banana grown in these Islands for fruit is chiefly *Musa paradisica* and its varieties, and experiments have been undertaken at the Museum to ascertain the value of the fibre yielded by this plant. A quadrant longitudinal section of an eight-foot trunk was immersed in water and samples of fibre were extracted at different periods of maceration. The first sample was prepared before immersion and the fibre obtained was of a beautiful glossy white color. As the process of maceration continued the fibre gradually lost its lustre and whiteness till after ten days, when the last was taken, the color had assumed a dull grayish brown. The same deleterious effect was noticeable in the strength of the fibre, although by no means to so pronounced an extent; a marked deterioration, however, was apparent in this respect between the first and last samples. The fibre was also found to vary in texture according to its position in the trunk, that occupying the outer verticils being coarser, the finer being reached by regular graduation towards the centre. The strength also varied in this respect as regards separate filaments, although a yarn of the fibre was of at least equal strength to one of the same size made from the coarser. The strength of this fibre was determined to lie between that of pita and jute, and it should be well suited for coarse cloth, binding twines and paper. The experiments resulted in the production of almost four per cent. of good length fibre, with the addition of about one per cent. of shorter and inferior waste, of use for tow and packing material. The variations of strength and size of the filaments, which has been remarked, is also to be found in the market samples of Manila hemp. This, as has been stated, is chiefly due to the position in the plant from which it has been taken, and careful manufacture should obviate these differences and produce fibre of more uniform quality. The contrast between Manila hemp and sisal in this respect is remarkable.

The chief conclusion deduced from these experiments was that the banana growers of these Islands are wasting large quantities of saleable fibre. As an additional product to the fruit, the harvesting of the fibre should be profitable. Probably the most practical means of dealing with the question would be to establish a fibre

mill in the banana growing district. Arrangements could no doubt be made with the growers for the purchase of their waste stems at a nominal sum. Hawaii at present offers a most promising field for a mill of this kind, as it would not only have at its disposal the banana stems, but also the trash of the cane fields and the waste sisal pulp, all of which are most excellent paper materials. An opportunity such as this cannot for long be ignored, and a paper mill must surely soon be established to utilize these almost limitless resources. A hybrid between *Musa textilis* and *M. paradisica* would probably yield useful results in both fibre and fruit, but it would be most difficult to secure. The same objections which are urged against this dual object in the case of the pineapple do not appear to apply to the banana. It may be remarked that *Musa textilis* produces a quantity of well developed seed from which it may readily be propagated.[3]

NEW ZEALAND FLAX.

ENDOGEN. STRUCTURAL FIBRE. *Liliaceæ. Phormium tenax.*

This flag-like plant, bearing a flower stalk like the aloes, is native to various parts of Australasia, especially to New Zealand whence it derives its name. Captain Cook first introduced this useful fibre to Europe, which he describes as "of the nature of flax or hemp, but superior in quality to either." It may perhaps be due to these words that the term flax has unfortunately been applied to the fibre of this plant, an altogether erroneous term, the true flax being a bast fibre. A very extensive use is made of New Zealand flax by the Maoris. From the flowers they derive a pleasing beverage; the base of the leaves affords a gum which is of value commercially; the pith is used as tinder and to convey fire; the leaves are used entire to write upon with a sharp instrument, and split to form straps, and to make excellent baskets. The fibre is manufactured into garments and mats.

[3] An interesting account of the cultivation and manufacture of Manila hemp has, since the above was written, been published by Mr. W. M. Giffard of this city, which is well worthy of attention from all interested in this subject. A bulletin recently issued by the Philippine Bureau of Agriculture, and reprinted for this Territory by Mr. Jared Smith of the Agricultural Experiment Station, should also be read. The conclusions derived from the above mentioned articles, and indeed all literature on Manila hemp, are that the conditions of soil, situation and climate in Hawaii are eminently favorable to the successful introduction of the cultivation of this fibre on a large scale. Mr. Smith considers that the sites most suited for this purpose are the windward districts, and mentions in particular Hanalei, Kauai; Nahiku, Maui; Hilo, Puna, Olaa, and portions of Kau and Kona on Hawaii.

In New Zealand this plant grows spontaneously in almost any soil or locality, the best fibre being dependent upon a favorable site, free from excessive moisture. It has been introduced to many countries and is said to grow readily as far north as Scotland. California seems well suited to New Zealand flax, and it also adapts itself well to these Islands. The Cyclopedia of India states that it is particularly suitable for growing on old coffee land. The fibre of this plant is strong, flexible and of a clear white color. The preparation is by maceration, but a better article is produced by scraping, so applied as not to injure the cells. The human thumb nail has not yet been surpassed for this purpose. This fibre is suitable for manufacturing into almost all kinds of cordage and textiles, a cloth being prepared from it resembling linen duck.

OKRA.

EXOGEN. BAST FIBRE. *Malvaceæ. Hibiscus esculens.*

The Okra or edible hibiscus is a native of the West Indies, belonging to the same natural order as cotton and the native hau. It is grown in the Southern states for its pods, which afford the "gumbo" of culinary fame. The plant flourishes well in the Hawaiian Islands, and on account of the reputed value of okra as a fibre, enquiry has been made as to the possibilities of its profitable culture. The value of okra fibre has, however, been greatly over-estimated, and efforts to cultivate it have been productive of no satisfactory result. It is found to be brittle and inferior to that of other mallows in tenacity, possessing only half the strength of hemp. There is apparently no literature on the subject, and okra is known commercially chiefly by its unenviable reputation as an inferior adulterant of jute. It seems well proved that many plants can be grown more easily than okra whose fibre possesses much greater value; a paper called "banda" is, however, made entirely with this material.

OLONÁ.

EXOGEN. BAST FIBRE. *Urticaceæ. Touchardia latifolia.*

The most important of the native fibres, and indeed one of the best in the world, is Oloná. Allied to ramie, true hemp and the paper mulberry, it also enjoys the distinction of being the sole

species of its genus. The plant is a shrub of from four to eight feet in height which is found sparsely throughout the deep ravines of all these Islands. Oloná is greatly prized by the natives and its fibre is of extreme tenacity and value, resembling in most characteristics the remarkable ramie or China-grass. A varied assortment of native products of this fibre are in this Museum, chiefly in the form of fishing nets, differing greatly in design and size. The smaller ones were used by hand, and the largest for encircling large shoals of fish which were enclosed from canoes. The natives prefer oloná nets to any of foreign manufacture.

Oloná does not occur in sufficient quantities indigenously to permit its being gathered profitably in commercial quantities. There is no doubt that a ready market at high prices awaits this fibre, as its wonderful qualities render it invaluable in special instances. In the time of Kalakaua it was sold to European Alpine clubs and was in great request on account of its extraordinary tenacity. The plants are best cut when a little over a year old and their thick stems stripped of the loosely adhering bark. The natives spread the ribbons of bark on a long, narrow board and scrape away the extraneous pulp with a blade, usually of tortoise bone, shaped like a broad chisel. Oloná flourishes best in a deep shade with hardly any clearing, so that the plant might be easily propagated at small expense in most of the woods which occur at a sufficient altitude—from 1000 to 5000 feet being the most suitable height. An advantageous combination of the oloná and ramie industries could be made by planting the latter in open fields and the former in the uncleared woods. The adaptability of machinery for both of these fibres, and its comparative cheapness make such a venture accessible to small farmers. Ramie, oloná and coffee culture may fitly be classed together and termed white man's industries. They furnish an economic foundation for his existence and prosperity and flourish at altitudes which afford a salubrious climate. If these Islands be at all destined to become a white man's country such industries as these must be given most earnest attention. Experimental plantation of oloná is being made in many of these Islands, particularly in the woods of Olaa, and samples of the stem, bark and fibre have lately been forwarded for examination to the Agricultural Department at Washington.

PAPER-MULBERRY.

EXOGEN. BAST FIBRE. *Urticaceæ. Broussonetia papyrifera.*

The Paper-mulberry yielded the tapa or kapa cloth of the Polynesian races. Its cultivation was formerly conducted with great care, and the manufacture of the cloth was in the hands of the women. The plant is a small tree with large heavy leaves. For the preparation of the best cloth the tree was allowed to grow about twelve feet, when the bark was stripped and its external surface removed by steeping and scraping. The clean inner bark was then macerated and beaten upon a log of hard wood with a wooden mallet. The different strips of bark were welded together at the edges by beating, and the cloth was dyed, figured with pleasing designs and sometimes perfumed with aromatic plants. The whole process was an elaborate one, and the degree of texture obtained, the brilliancy of coloring, and the effective ornamentation are remarkable. This cloth in its various manufactures was an excellent substitute for wool or cotton. Its manufacture has now ceased in the Hawaiian Islands, and indeed throughout Polynesia. In Japan and Java the paper-mulberry is used to make a tough, durable paper; and *Morus alba* is used as a textile material in Italy.

PANDANUS.

ENDOGEN. STRUCTURAL FIBRE. *Pandanaceæ. Pandanus odoratissimus.*

The Lauhala or Hala of the natives belongs to the Screw-pines, so called on account of their spirally arranged leaves and the resemblance of the fruit to a pine cone. The family is dispersed throughout the Pacific, and also is found in the East African islands. The fibre of this plant is obtained from the leaves and is well suited for matting and sacking, but is little used for cordage. The leaves are first divested of their dorsal and marginal spines and then divided into strips. These are scraped with a blunt knife or shell and cleaned by immersion in water. Further careful scraping removes any roughness and gives the fibre a pleasing lustre. The fusiform aerial roots of the Pandanus contain a stronger fibre than the leaves, useful for basket work and whitewash brushes.

Many of the canoe sails, or rather mats, of the Pacific Islanders were made from this fibre, and also a great variety of mats, cordage, hut covering and netting.

PINEAPPLE.

ENDOGEN. STRUCTURAL FIBRE. *Bromeliaceæ. Bromelia sylvestris.*

One of the most useful and beautiful fibres is that yielded by the Pineapple, an almost stemless plant bearing a rosette of tenacious lanceolate leaves. The lustre, texture and strength of this fibre place it in the first rank with ramie and flax, and enable it to be woven into every quality of fabric from durable table cloths to the most delicate lawns. The celebrated Piña muslin or Batiste d'ananas of Manila is woven from this fibre and sometimes confused with China-grass cloth, from which it may be distinguished by its untwisted yarn. The pineapple is said, by some authorities, to be indigenous to Assam, and by others to Brazil. It was introduced to Europe early in the sixteenth century, and the rapidity with which its propagation spread is unparalleled in the history of fruit. The plant which affords the fibre of commerce differs in appearance from the edible variety chiefly in the unmassed ovaries of its fruit. In preparing the fibre by hand the operator sits astride a low stool and scrapes the leaves with a two-handled blade of bambu. When the fibres are exposed they are gathered together and detached with a steady pull. After washing they are placed upon bambu frames to dry and bleach. Pineapple fibre lends itself readily to a diversity of uses, and being impervious to moisture and consequent rotting, is particularly applicable to the manufacture of fishing lines and for stringing necklaces.

The culture of the pineapple for fruit is carried on with much success in Hawaii, the product of these Islands being conceded by some connoisseurs to be the best in the world. Much speculation has been turned to the possibility of utilizing the fibre from the waste leaves of the fruit plantations. It appears dubious whether any great measure of success will reward the endeavor to secure two so diametrically opposed ends as the simultaneous production of fruit and fibre from this plant, whose fibres penetrate not only the leaf but also the fruit. That the fibre of plants grown for the table could be used is certain, but its short length and comparative

low tenacity render it unsuited to most manufactures, except that of paper; but whether the installation of fibre-extracting machinery would prove remunerative is a problem that only experience will prove. On the whole the evidence goes to show that it would not, unless a more fibrous and longer-leafed variety of plant could be secured—a quality probably detrimental to the fruit; and the alternative appears to lie between either the simultaneous growth of poor fruit and poor fibre or an excellent quality of either produced separately.

PITA.

ENDOGEN. STRUCTURAL FIBRE. *Amaryllidaceæ. Furcraea gigantea.*

Furcraea gigantea is closely allied to the agaves and occurs throughout Central America. Its valued fibre, known as "Pita," has given rise to much confusion among authorities as to its origin; both Watt and Balfour attribute it to *Agave americana*, and a host of later writers have helped to perpetuate the error. This confusion may in part be attributed to the loose manner in which the word "pita" (as our own term "hemp") has been misused and applied to fibres of widely divergent origin; but it is highly desirable to restrict it to its legitimate use. In Mexico the cultivation of this plant antedates the Spanish conquest, and its fibre is still in use there for various cordage purposes, coarse cloth and sacking, and excellent netting hammocks and harness. In Mauritius its introduction has proved very successful, its yield there being about one and one-half tons of fibre per acre. Little attention has been given to this plant in the United States, although its excellent commercial possibilities merit it greater recognition. Specimens of the leaves of *Furcraea gigantea* about ten feet long were obtained from Professor Brigham's residence in this city, and yielded fibre of great length and excellent quality, of a beautiful glossy white color, well adapted to the better class of cordage manufacture. The fibre was prepared in a similar manner to other structural ones and resembled sisal in appearance, although its general qualities were perhaps superior to the latter. *F. gigantea* will flourish readily in these Islands, and in view of its success in Mauritius, Tobago and Trinidad, there appears every reason to believe that its cultivation on poor lands in Hawaii would at least be as remunerative as that of sisal.

PULU.

SURFACE FIBRE. *Cibotium chamissoi.*

A tree fern affords the soft glossy down, or vegetable silk, known as Pulu, which appears surrounding the base of the fronds. This fibre has been used extensively in California and Australia by upholsterers instead of feathers for stuffing mattresses and pillows. It has also been used to a limited extent in surgery in staunching bleeding. Pulu is gathered from the growing plant by hand and dried in the sun, a somewhat tedious operation. Twenty-five years ago Honolulu exported nearly a quarter of a million pounds of this fibre annually, but the industry has long since entirely ceased.

RAMIE.

EXOGEN. BAST FIBRE. *Urticaceæ. Boehmeria nivea*, China-grass, White ramie; *B. tenacissima*, Green ramie, Rhea.

Boehmeria is indigenous to India, and also probably to China. The *Boehmerias* are allied to the true nettles, from which they differ in possessing no stinging hairs. *Urticaceæ* especially abound in fibrous plants, yielding not only ramie or rhea, but also true hemp and the Hawaiian oloná. Certain external affinities, such as the arrangement of their closely serrate and hairy foliage are possessed in common by this order, the *Tiliaceæ* and the *Malvaceæ*, which together yield the majority of bast fibres. Much misconception is prevalent as to the varieties of *Boehmeria* yielding the fibre of commerce known as ramie, and there is great conflict of opinion in the literature upon this subject. It is highly desirable that an authoritative work be prepared on the various *Boehmeria* fibres, as attempts have in some instances been made to produce a fibre to compete with China-grass, from an entirely wrong species, and like mistakes have been made which have greatly retarded the development of the industry. The two chief varieties useful to commerce appear to be *Boehmeria utilis* or *tenacissima* and *Boehmeria nivea*. The latter is a temperate plant and has been cultivated from the earliest times in China, and is probably the true China-grass plant. The preparation of this fibre is entirely by hand and quite simple, but on account of the extreme tenacity of the filaments and their adherence to one another the process of man-

ufacture is tedious in the extreme. *Boehmeria tenacissima* is a tropical variety of the above and its fibre, often confounded with China-grass, should probably more correctly be known as rhea. This latter variety is well suited to the climate of these Islands, and is said to grow well in parts of southern Europe, while *Boehmeria nivea* is cultivated extensively in more northern latitudes. Of the fibres yielded by these two plants it is difficult without actual experience to determine which is better, although each has its enthusiastic supporters. For the sake of convenience the term ramie or China-grass will be used to include both of these varieties.

In many respects ramie may be regarded as the most remarkable of all commercial fibres. It is almost impervious to moisture; its strength exceeds that of all other vegetable fibres, and its fineness and lustre are surpassed by none. It has been used with good results in admixture with wool and silk, and in some cases is an excellent substitute for either of these materials, to which in its better qualities of manufacture it has sometimes been compared. Fabrics manufactured from ramie may be prepared to equal in durability and pliancy any made from either flax, jute, cotton or hemp. The capacity of this fibre for bleaching and taking dyes is excellent, and it will assume any desirable color. A collection of ramie manufactures in the Bishop Museum cover a wide range of uses and show that whatever has been achieved with other vegetable fibres may be equalled or excelled by this. The occurrence of a resinous gum in the stalks of ramie renders the separation of the fibre very difficult and requires abundant cheap labor. The production of the fibre has in consequence been limited to countries where such can be procured. Attempts at the manufacture of ramie in Egypt, Italy, France and America have never gone far beyond the experimental stage. The successful production of this fibre in commercial quantity has in consequence in these countries depended upon the invention of an economically practical decorticating machine, and the absence of such a device has brought the manufacture of ramie to a standstill. It now appears certain that the problem of successfully decorticating ramie in large quantities has been solved by a well known French engineer, who has invented a practically automatic and entirely successful machine. The decortication is said to be thorough without injury to the fibre. A field of ramie has been planted near Limoges (France) and the

stalks will be harvested and the decortication publicly conducted next July. An agency for these Islands has been established. The machine costs locally in France about $1200.

The adaptabilty of ramie to Hawaii has long since been proved, and with a satisfactory machine available the industry should soon establish itself here. It is confidently expected by many authorities that at no distant date this fibre will be the most important in the market.

SISAL.

ENDOGEN. STRUCTURAL FIBRE. *Amaryllidaceæ. Agave rigida sisalana.*

The Sisal belongs to a very large group of endogens familiarly known as Agaves. Its valued fibre is in consequence structural and is found permeating the fleshy leaves. The well known Century plant is another species of this genus. The Agaves are chiefly found in Central America, and their use was well known to the Aztecs who manufactured from the *Agave mexicana* a paper said to resemble the papyrus of the Egyptians. The sisal fibre of commerce is produced by the *Agave rigida sisalana*, a plant which has been popularly confounded with many others, particularly with *Agave decipiens*, whose chief claim to recognition is the persistence with which it has been mistaken in Florida and the Bahamas for the true sisal. This is remarkable, as many well defined characteristics separate the two species, of which may be mentioned the well developed footstalk of the false plant, and the sharp serrations of its leaf edges which render it difficult to approach. The leaves of the true plant are deficient of these spines except a very acute and obtrusive spur at the extremity, capable of inflicting a painful wound, which is removed to facilitate handling at the time of harvesting. The very young plants of the true sisal, however, show a well defined serration which entirely disappears as the plant matures, and which may suggest an interesting inquiry as to the evolution of the species. In this respect it is of interest to remark that the false sisal is found in the most inaccessible districts, whereas the true plant is not met with far from human habitation.

Sisal hemp cultivation was introduced to Florida from Yucatan in 1834, and subsequently to the Bahamas where considerable areas of otherwise unproductive land have been brought into cultivation and a lucrative commerce has been built up. The Bahaman

fibre is said to be in superior demand, and the industry is subsidized by a government bounty.

A well established sisal plantation and mill are in full operation near Honolulu and afford every indication of permanent success. Altogether about six hundred acres are cultivated and the industry is under the management of Mr. A. H. Turner, to whose energy the inception of the introduction of sisal fibre culture to these Islands is due. The fields exhibit every period of growth, from the nursery stage to plants four years old in an active state of production. A small plot of ground is also devoted to plants of about eight years growth, but these are older than the plantation and are among the first grown in these Islands. The sisal is propagated either by suckers or "pole" plants. Suckers spring from the root, but pole plants originate in the florescence, and exhibit a distinct form of development. At the age of about eight years the parent plant throws up a central stalk or "pole" sometimes to the height of twenty feet. On this a multitude of blossoms are produced, from each of which as it matures there develops a minute sisal plant which finally becomes detached and falls to the ground. Two thousand such plants may be obtained, at a moderate estimate, from one parent, and in some cases many more. During the last year the plantation in question has supplied about a quarter of a million pole plants to other growers. Besides these two ordinary methods of reproduction poles that have been cut down and allowed to wither have, when moistened by rain, put forth a number of new plants. Sisal exhibits remarkable reproductive power and vitality, and young plants which have been exposed to the sun unplanted for many months root quickly and vigorously as soon as set out.

Each successive stage of development is allotted its particular section of the plantation, which when visited had recently placed its first harvest of fibre upon the market. Japanese laborers were at work severing the leaves close to the stem of the plant and tying them into bundles of one hundred, after first removing their terminal spur. The leaves spring from the parent stock close to the ground and radiate upwards from a central crown. Those more nearly horizontal possess the most mature fibre, but all leaves which come within an angle of sixty degrees with the ground yield commercial fibre. Care is taken to separate leaves of under three feet length from those above, as a standard of two and a half feet

distinguishes the market limit of short and long fibre. After cutting, the bundles of leaves are drawn by mules to the mill where they are placed separately upon the bed or table of the machine by a Japanese who removes their binding cord. Another man lays the leaves in a row and guides them under the feeding chains which grip them at the centre and carry them beneath the first heckling wheel. This consists of a six foot wheel running at the rate of about 160 revolutions per minute, whose broad tire is crossed by transverse flanges or scrapers which crush and remove the pulpy mass from the leaf. A stream of water directed from above assists in this process and thoroughly cleanses the fibre. In this way one-half of the leaf is reduced to fibre, the other half having remained intact, held by the guiding chains. The part of the leaf first treated is now gripped by the chains and the half just released comes beneath another heckling wheel similar to the first and situated on the opposite side of the bed of the machine. The whole leaf is thus divested of its pulpy matter, and a woman stationed at the end of the bed receives the fibre as it is presented by the machine and places it ready to be carried to the drying ground. The whole process of extracting the fibre is concluded in a few seconds. About four per cent. of fibre is obtained, the remainder of the leaf consisting of fluids and heterogenous green pulp containing a proportion of short and inferior fibre. This is removed in carts, but it is intended soon to carry it away by a flume. At present no use is made of this waste which is considered to be of value as manure, or for the manufacture of paper. The short discarded fibre should make a good packing tow.

The Dictionary of the Economic Products of India (vol. i, 142) states: "The juice is made into soap. For this purpose it is expressed and evaporated either by artificial heat or simple exposure to the sun. On its reaching a thick consistency it is made into balls with lye ash. This soap lathers with salt as well as with fresh water. A gallon of sap yields a pound of soft extract." This interesting fact is supported by the Cyclopedia of India, which also states that "the split leaves are employed to sharpen razors, owing to the silica they contain. The roots are diuretic and antisyphilitic."

Upon arrival at the drying grounds the fibre is exposed to the action of the sun to dry. The most authoritative fibre literature lays stress upon conducting bleaching and drying in the shade and protected from the rays of the sun. It is found, however, at the

plantation that a good sun materially assists these processes. Whether the fibre may be injured by this means, in texture or some other property, is yet to be determined. A very ingenious method of exposing the fibre to the air is in use. A wooden rail framework has been erected at about five feet from the ground, and across this are stretched lines of doubled cord. Each line is firmly held at one end but is free to revolve from the other by attachment to a revolving swivel. In exposing fibre to dry a whisp is placed between the double line at the fixed end which is given a half turn and another whisp inserted. The process is continued the entire length of the line; by this means the fibre is securely held against wind or other accident and is easily removed by pulling. When dried the fibre is placed in a press capable of exerting a weight of a hundred tons, and packed into bales of about 500 pounds. Before the weight is removed from the bale the door of the press is opened and through grooves in the top and bottom wire is run and the bale securely bound. It is finally covered with gunny cloth, and is then ready for shipment. The mill is at present capable with one machine of an output of about a ton of fibre a day under favorable circumstances, such as when working on good length leaves. An ordinary day's work falls somewhat short of this.

With this evidence it seems safe to predict that the future of the sisal industry in Hawaii is assured.[4] Its abundant reproductiveness, its easy culture and adaptibility to apparently useless wastes, the simplicity of its preparation, and its value in the markets of the world, give it pre-eminence over many rivals. As a cordage material it is inferior only to Manila hemp.

Besides the sisal plantation near Ewa there are already several others in contemplation. The Kona Sugar Co. has about sixty acres devoted to this purpose, from which fibre of exceptional quality has been obtained; and many coffee growers are commencing to convert their land to the growth of sisal.

[4] Since the above was written Mr. B. F. Dillingham, of the Hawaiian Fibre Co., has issued a report which gives detailed statistics of the expenditure of the company since its inception in December, 1898. Exceptional importance attaches to this report as the company is the first of its kind in these Islands, and the results were achieved during the experimental stage of the industry and at a time of widespread commercial depression throughout the Territory. The report will remain an important guide to future sisal planters, and marks a distinct advance in the development of Hawaii. Mr. Dillingham shows in brief that sisal fibre has been grown at a total cost of $98 per ton, which sold for $150 to $160 per ton. He also affirms that the experience already gained will enable a great economy to be at once practiced on all items of expenditure, and that the cost of production will be reduced to not more than $74 per ton.

SUNFLOWER.

EXOGEN. BAST FIBRE. *Compositæ. Helianthus annuus.*

The Sunflower is a robust annual, indigenous to the western states of North America, sometimes attaining in cultivation a height of twelve feet. The plant is valued in many countries chiefly for its oil, and is grown extensively in Russia and Germany. Many attempts have been made to grow the sunflower as a fibre plant, but little is recorded of the result of the undertakings, probably on account of their non-success. Specimens of fibre prepared at the Museum from plants cultivated for flower, were found to vary exceedingly. Taken as a whole they were white, thick, coarse and strong. In this last quality a wide divergence was noticeable, some specimens being extremely tenacious and capable of sustaining considerable torsion, and others remarkably brittle. This variation was probably due to the different ages of the plant, which before the production of the seed yields a tougher and more pliant filament, some samples even exceeding sisal fibre in strength.

The products of the sunflower are varied. Its oil has obtained a reputation in the manufacture of soap, although its value for painting, lubricating and table use is exaggerated. Its seeds are an excellent food for poultry, and make splendid oil cake for cattle. Bees are eagerly attracted by its flowers, which yield a pleasing honey, and its fibre is well suited for cordage and paper. Although it does not promise to ever take a prominent place among fibre-producing plants, its growth would probably be remunerative in small quantities when allied with the raising of bees and poultry. This plant yields its products in a few months and is well suited for producing rapid vegetation upon undesirable swampy land.

In conclusion, it appears well proved that the majority of useful fibre-yielding plants may be grown in Hawaii, but not with equal success from a pecuniary standpoint. With its advantages of climate this Territory is able to select its vegetable products in a way possible to few other countries, and the inferior and less remunerative class may thus be ignored. As with most other industries, however, the absence of cheap labor offers great obstacles to the production of those fibres depending chiefly upon manual preparation. The fibres which will be most successful in Hawaii

under the present conditions are therefore those of high value commercially for which perfected machinery is already procurable. Although the number of such is very restricted their cultivation in these Islands is full of promise.

Among the best quality of fibres adapted to Hawaii, ramie and oloná rank high, but the machinery for their preparation is not yet available, and their manufacture in large quantity is in consequence impracticable; they may, however, in a few years find a place among our exports when their quality will find them a ready market. It is well to remember that ramie grows readily in many parts of the globe and is already planted extensively in S. Europe where better machinery only is needed to develop the industry: in this respect ramie does not appear to entirely fulfil the requisites of a successful Hawaiian product.

To immediate planters, the fibre most worth attention is sisal, the cultivation of which has already established itself among the lucrative enterprises of these Islands; but although the present market value is high, it seems unlikely that this will continue indefinitely, as large areas are now being devoted to sisal in California and elsewhere, and Hawaiian fibre may have eventually to seek a more distant market. At present there appears no prospect of over-production of this article, but this contingency will probably arise in the future. It is satisfactory to know that Hawaiian sisal is superior to any other. Planters of this fibre would do well to experiment with sanseveiria and perhaps pita, the general cultivation and manufacture of which are similar to sisal, and the same machinery well adapted to all three. Of these sanseveiria is in some respects superior, sisal appearing in general value to hold a middle place.

Pineapple fibre grows readily in Hawaii and is now receiving some attention. It is one of the most valuable fabric materials, and the areas suited to its growth are more limited than those of many others. The general cultivation and process of manufacture are somewhat similar to those of sisal, and piña appears to fulfil most of the conditions necessary for successful introduction to Hawaii.

As the best substitute for true hemp and the most valuable cordage fibre, Manila hemp should also have an assured future in Hawaii. It grows readily in these Islands and has preponderating qualities over sisal, but the absence of satisfactory machinery at

the present time gives the latter the advantage. Much improvement is hoped to be made in this direction, when it is quite possible that abaca fibre will be grown in Hawaii to the exclusion of all other cordage materials.

A great stimulus should take place during the next few years to the production of fibre in Hawaii, which with allied industries may eventually rank in value as the second commercial resource of the Territory. Among the enterprises of the future the growth of abaca and piña fibres, together with a great development of sisal production, the establishment of a cordage and sacking factory to supply with home-grown and manufactured products the enormous demand of the sugar and other industries, and of a paper mill to utilize the waste of the fibre mills, will assuredly hold an important place.

The following table represents the comparative strength of the various fibres prepared and tested for this paper, ramie being taken as the standard of tenacity:

Ramie (supplied by Dr. Nicholas Russel)	1.00
Olonâ	.84
Pineapple (not Hawaiian-grown)	.78
New Zealand Flax (not Hawaiian-grown)	.60
Manila (Philippine fibre)	.57
Bow-string Hemp	.49
Sisal	.48
Pita	.45
Cotton Bast	.37
Jute (not Hawaiian-grown)	.36
Sunflower	.35
Coir	.34
Rosella	.30
Hau	.29
Okra	.21

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