Making Paper by Hand in Japan

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TODAY, AS IN EARLY DAYS, making paper by hand in Japan is often carried out as an off-season source of income by those small-scale farmers who live in the mountain villages, where there is little land for cultivation of rice but an abundance of good clear water in the streams. When the end of the year comes around and the harvesting of rice is done, such farmers invariably engage in papermaking. ¶ In a sense, the work is hereditary, being performed on a small scale in the home by the able members of each family. The methods employed are age-old and have been passed through succeeding generations with little change. ¶ The season for papermaking differs according to the localities in which paper is made. It usually begins, however, late in November or early in December and ends in April or May of the following year. And by this time of year, those farmers who engage in papermaking as a sideline find themselves too busy for that work, for they have much to do in transplanting rice sprouts and raising silkworms.

Raw Materials for Japanese Paper

Whether handmade or machine-made, many Japanese papers make use of vegetable fibers as raw materials. Among these fibers, *gampi*, *kozo*, and *mitsumata* constitute the primary triad of materials. Gampi paper is thought to be noble and dignified; kozo, masculine and strong; mitsumata, gentle, effeminate, and elegant. ¶ In this article, however, an account will be given only of the papermaking techniques that employ kozo as a raw material. Kozo fiber is sinewy and tough and is derived from the kozo tree, which belongs to the same family as the mulberry. The general shape of the kozo and the shape of its leaves are so similar to those of the mulberry that one can hardly distinguish between the two when looking at both of them growing in the same field.

A Species of Kozo and Its Cultivation

Kozo is a rather loose term applied to at least three plants whose inner bark is used for papermaking. The species, or variant, that grows in a wild state and has been cultivated for centuries throughout the mainland of Japan is *Broussonetia kajinoki*, which bears ovate and five-serrated leaves with silky hair on both sides. Because of the difference in the color of the bark and also in the arrangement of markings on the trunk of kozo grown in different localities, the variants are known by different names. They are classified as *aka-kozo* (red), *kuro-kozo* (black), and *shiro-kozo* (white). There is another variant that grows in mountainous parts of the country, for which reason it is called *yama-kozo*, yama meaning mountain. This tree yields only about half as much fiber as the others, but the strength of the fiber is far superior. ¶ The season for setting out young plants of kozo is spring, and a mountain slope facing south is best suited for their growth. About nine plants per *tsubo* (a 6-foot square) are planted at regular intervals so that they may have equal access to the sun and air and can be easily fertilized. ¶ One year's growth of bark is not thick enough for papermaking, but growth from the second year on is suitable. In a period of four or five years, the tree bears eight or more shoots each year, but after the passing of twenty years, the tree is too old to be of any use, and has to be replaced by a young plant.

Gathering Kozo

Kozo shoots are usually cut in autumn when the trees have shed their leaves. The bark of kozo cut in autumn is called *akikawa*, or autumn bark, while that of the trees cut in February or March of the following year is called *harukawa*, or spring bark. As a matter of record, autumn bark makes better paper. ¶ The shoots are cut into lengths varying from about 14 inches to 2½ feet and are then bound together into conveniently handled bundles. The bundles are placed in a

cauldron in an upright position and forced tightly into it by pounding them with a wooden hammer. The shoots thus prepared for steaming are called raw kozo.

Steaming Kozo

The process of steaming raw kozo varies somewhat according to the localities in which paper is made. Usually, however, kozo is placed in a big iron cauldron of about 28 inches in diameter, which is then sheathed in a cone-shaped tub of about 57 inches in diameter, and heated for an hour or two by a fire underneath the cauldron. When the bark becomes so soft that it peels and exposes the white of the shoots, the steaming is done. The lid is then removed from the cauldron and water poured in so that the bark may come off more easily. The steaming of kozo is often a cooperative venture and neighborhood farmers get together on an appointed day, as many hands are required. After the raw kozo is steamed, the bark is stripped and dried. This dried bark is called *kuro-kawa*, or black bark.

Stripping the Black Bark

When the steamed shoots are taken from the cauldron, they are laid on straw mats and stripped of their bark while still warm. Stripping is started from the lower part of each shoot, and is accomplished without any great effort. The stripping of the bark is one of the things which the people in papermaking districts enjoy, for it is a time when the young and the old of both sexes join in the work. The bark is then hung from poles in the sun in order to dry thoroughly, and this is ordinarily accomplished in three days, but sometimes in a single day when it is windy. The dried bark is then bundled and stored until the day when papermaking begins. The shoots that remain are bundled and used as fuel.

Making White Bark

The dried bark may be stored either as black bark or as white bark. In order to make paper, black bark must be turned into white bark. Since the black bark in storage becomes quite dry and very hard, it is necessary to soak it in water so that the outer coat may be easily removed. In some primitive papermaking villages, a simple and older method is employed. Black bark that has been soaked in water is laid on a flat stone in shallow running water and is then thoroughly trodden upon until the outer coat is entirely removed. ¶ After the black coat has been removed, the second coat is scraped off with a knife. This is then thoroughly washed in running water to remove the glutinous substance which may sometimes remain. Bark that has been subjected to these processes is then put in the sun for three or four days until it becomes thoroughly dry. The bark is now called white bark.

Boiling White Bark

In order to make paper, white bark is soaked in water for about half a day, after which it is placed, strip by strip, into a cauldron of boiling water. When the white bark has been boiled for some time, lye obtained from wood ashes is added and boiling is continued for one hour, the contents of the cauldron being stirred all the while. When the white bark becomes so soft that it can be easily crushed between the fingers, the fire is extinguished, the cauldron tightly covered with a lid, and left for several hours to steam thoroughly. By this time the water will have become dark brown, a proof that the chemical constituents of the bark, such as starch, fat, and tannin, are in a state of solution. ¶ Cauldrons for boiling bark vary in size. The smallest contains about 28 gallons of water, and the largest about 48 gallons. ¶ Within the past fifty years, chemicals such as soda ash or caustic soda have been used to soften the bark instead of lye, because it is easy to remove the alkaline matter after boiling. Their use is economical and results in a fine finish. In other words, if strong alkaline materials are used, the purity of the fibers will be increased, and the water in the stuff will drain more easily. Resorting to the use of such chemical compounds, however, weakens the kozo fibers. Therefore, the advisability of using such means to obtain superficial beauty at a sacrifice of natural fiber strength is questionable.

Bleaching White Bark

When the white bark has been boiled, it is taken from the cauldron and placed in a bamboo basket, which is then immersed in running water to

remove the lye or alkaline material, after which bleaching begins. ¶ Chemicals are sometimes used in the bleaching, but in order to bring out all the natural beauty of Japanese paper the technique of *kawa-zarashi*, or steam bleaching, must be used. This method is primitive but ideal because not only does it leave the fiber intact, but it also brings out the natural brightness as well as the strength of the fibers. It is largely due to this ideal method of bleaching that some Japanese paper has been well preserved for more than a thousand years. ¶ In steam-bleaching, a flat place in a river bed having no large stones is chosen. This place is then surrounded by a small dike so that all dirt and other impurities may be kept out. Clear water is let in, and by changing the water within the dam from time to time, bleaching and washing are accomplished. ¶ Another method of natural bleaching is known as *ko-arai*, or small bleaching. According to this method, the wet bast, or "half stuff" prepared by stream-bleaching, is laid on broad, thick boards of hard wood, and transformed into an even, pulpy, fibrous mass by beating it repeatedly with rods for a long period of time. The stuff is then put into a basket and covered with a piece of cloth, or placed in a cloth bag, and washed in clear running water until it becomes soft and white, after which it is used as material for such high-quality Japanese paper as *tengu-jo*.

Removing Impurities

Kozo, having been bleached, is now subjected to a final process known as *chiri-tori*, or "removal of impurities." This work is carried out mostly by middle-aged women. The bast may be floated on running water or placed in a wooden pail filled with water, and pieces of coarse bark, hard fibers, and other impurities are picked out by hand. Small impurities that cannot be picked up with the fingers are removed with the aid of pins. On a warm spring day the women engaged in this work have a happy-go-lucky look, but on a cold winter day they need much patience, and their task may be harder than that of the men employed in making paper. ¶ After impurities are removed and the kozo becomes as white as snow, the stuff is made into balls about the size of a melon. The process is called *kozo-shibori*, or kozo squeezing.

Beating Kozo

The balls of kozo are now laid individually on a hard wooden board or a flat stone, and beaten with rods of oak or other hard wood to crush all of the fibers. Neither the length nor the width of these rods is uniform, differing according to locality; but each rod is made so as to be easily grasped. In some places, wooden hammers are used instead of rods. While the kozo is being beaten a small quantity of water is poured over the mass from time to time. This work is generally performed by women, and at night after the day's work is done. It may be accomplished by one person; sometimes by two or four working at the same time, facing each other on each side of the board. When the fibers of kozo are crushed well enough, they have the look of wet cotton and will float individually on water. In order to make the finest paper, great care must be taken in beating kozo. Travelers who happen to put up at an inn in some papermaking village in the mountains on a winter night will hear the monotonous sound of this pulp-beating until nearly dawn. ¶ Lately, the process of beating pulp has been greatly shortened by the introduction of mechanical beaters which are run by water or electric power. For the mass production of paper, the beating must be done by machinery, but the natural beauty of Japanese paper can hardly be brought about in this way.

Mucilaginous Material

In order to make Japanese paper, it is usual to make use of a vegetable mucilaginous material, which is commonly called *neri*. ¶ There are several kinds of neri, the most common of which is known as *tororo-aoi* or *tororo*, a substance derived from the roots of the first-year growth of the tororo plant. There are two variants of this species, one having a blue stem, and the other a red one. The latter has large roots and yields more material than the former. Tororo-aoi is an annual of Chinese origin. It has large, alternate, palmate leaves, and its flowers resemble those of cotton. Some variants are planted in gardens for the beauty of their large yellow flowers. Tororo,

however, is grown chiefly for its roots, and, except for the purpose of getting seeds, the flowers are picked while in the bud. Sowing takes place in the rainy season, which begins in June, and harvesting of the roots is done at the end of November. The roots, shorn of the stems, are dried in the shade and stored in a dry, airy place. Roots vary in length from 8 to 12 inches and contain a great deal of transparent, sticky material. ¶ After being soaked in water for about twenty-four hours and beaten in a mortar, the roots are put in a cotton bag, and pressed so that the vegetable glue is squeezed from them. This is mixed with kozo in the vat. If there is a shortage of tororo, other materials may be substituted. ¶ When the tororo is mixed with kozo, a mucilaginous paper stock results. The role of tororo is to make the fibers float uniformly on water; without uniform floating the fibers might gather together, making it impossible to obtain paper of unvarying thickness. Another function of neri is to slow the speed of drainage so that a better-formed sheet of paper will result.

Importance of Water

In papermaking, a most important factor to be considered is water. If there were no good water, it would be impossible to make good paper. Accordingly, Japanese papermaking locations are, without exception, in the mountainous districts, where clear streams abound. The first requisite of water for papermaking is that it does not contain minerals such as iron and manganese. If these materials are present, the paper will lose its clarity, or the color of the paper will be spoiled and, after a time, brown spots may appear on the surface of the sheet. ¶ The second requisite is that the water be free from all extraneous floating material. Inorganic substances such as dust and sand may easily be filtered, but organic substances may contain bacteria which are liable to cause dark spots on the surface of paper. ¶ The third requisite is that water for making paper must be low in temperature: the lower the temperature the better will be the paper produced. Water at high temperature lessens the effect of neri. Paper made in winter is welcomed, because during the cold season water contains fewer impurities and also because neri may be utilized to its maximum advantage.

Making Paper Stock

Paper stock is made of fresh, wet balls of pulp, or hand-beaten kozo, which is mixed with water in the rectangular vat, the proportions being 30 percent and 70 percent. The contents of the vat are stirred with an agitator until the solution becomes even in thickness and its color becomes dull white like the water drained from Japanese rice, or until, in some cases, it becomes like fairly thick milk. The thickness of this liquid differs according to the temperature, the nature of the stock, the condition of the screen, and the particular method employed in making paper. These factors are taken into consideration and adjustment is made accordingly.

Methods of Japanese Papermaking

There are two traditional methods of Japanese papermaking, namely, *nagashi-zuki* and *tame-zuki*. ¶ Nagashi-zuki is the traditional Japanese method of making paper, and today most Japanese papermakers employ it. It consists of making a sort of emulsion by mixing mucilage with the pulp and water, which is scooped up onto the screen and allowed to run back and forth over the face of the mould, lengthwise and breadthwise, over and over again. Through this manipulation, the fibers at the bottom of the mould, as water filters through the screen, become entangled and form a thin film that adheres to the surface of the screen. When the desired thickness has been attained, the surface stock is cast away. ¶ By means of the tame-zuki, or Western, method, enough stock is scooped from the tub into the mould to make a sheet of the desired thickness. After shaking, this is left for a while, allowing the water to drain from the pulp. Wet sheets thus formed are piled one on another, each layer being separated with a piece of cloth. No neri is used with this method, although size or clay is sometimes employed. ¶ Nagashi-zuki, being the method peculiar to Japan, finds no parallel in any other country in the world, and is especially suited to the making of thin paper, while tame-zuki results in thick paper.

it is an art which must be learned through experience over many years. An advantage of using neri is that the pile of wet sheets may be readily separated even when great pressure is applied to the sheets in pressing.

Drying Wet Sheets of Paper

After the correct amount of water has been drained away in the pressing, the sheets are taken one by one from the pile and put upon a drying board, and all wrinkles are smoothed out with a brush. The brushing must be carried out in the direction of the fibers or the surface of the sheet would be roughened and its natural lucidity might be lost. And it must be done as lightly as possible and uniformly over each sheet. ¶ As soon as the sheets are dry, they are taken from the boards, one by one, and are sorted roughly into three classes, the lowest class having some injury or defect. ¶ The drying boards bearing sheets are placed in the sun; on a fair spring day, even if there is no breeze, the paper will dry in an hour. ¶ Today those who make paper as their chief occupation resort to the use of iron steam-heaters set up indoors, since sun drying depends entirely upon the mercy of weather conditions. It is needless to say, however, that the really fine Japanese paper is made not by artificial heating but exclusively by the old and simple outdoor method. ¶ The sheets of paper are now subjected to the final sorting. The points considered in the sorting are that each sheet must have a suitable color, a certain weight and thickness, and be free from any spots or injury. ¶ Trimming the finished paper is an art as difficult as that of papermaking. When a papermaker is about to trim the paper he has made, he will no doubt feel in his heart an unutterable joy—a joy probably deeper than any that anybody in his household is aware of. It may be likened to the joy the farmers experience at the harvesting of their rice crops.

Soda Ash

Soda ash is used by hand papermakers to break down various cellulose materials as a means to prepare them for beating. It is the most common chemical used for cooking fibers and is less harsh in its effects than caustic soda. Soda ash should be used at the rate of 18 to 20 grams for every 100 grams of dry fiber.

Health Hazards Information

Keep Out of Reach of Children

Inhalation. Inhalation of soda ash dust may irritate throat and lungs.

Ingestion. Although low in toxicity, ingestion can be harmful. Consult physician.

Skin. Prolonged contact may cause skin irritation.

Eyes. May irritate or burn eyes.

First Aid Measures

Ingestion. Drink large quantities of water to dilute the material. Do not induce vomiting.

Skin. Wash with plenty of water.

Eyes. Flush with plenty of water for at least 15 minutes and get medical attention.

Personal Protective Equipment

Respiratory Protection. Use a respirator approved by NIOSH for product dusts.

Eyes and Face. Goggles or other eye protection should be worn to protect eyes. Do not wear contact lenses.

Hands, Arms and Body. Wear long sleeves, trousers, and gloves when mixing solutions. Avoid splashes. Gloves should be impervious to solutions of soda ash, i.e. rubber gloves.

Precautions and Procedures for Soda Ash

Use local exhaust if dusty conditions prevail. In normal handling, avoid eye contact or prolonged skin contact. Avoid breathing dust. When dissolving, add to water cautiously while stirring. Solution can get hot.

Storage. Store in a cool, dry place away from acids. Prolonged storage may cause product to cake from atmospheric moisture.

Spills. Spills of dry soda ash should be shoveled into an empty container. Flush residue with plenty of water.

Disposal. Dissolve in water using caution, as solution can get hot. Neutralize with acid and flush to sewer with plenty of water.

Special Precautions

Avoid simultaneous exposure to soda ash and lime dust. In the presence of moisture, the two materials combine to form caustic soda (NaOH) which may cause burns.

Technical Information: Trade name–soda ash. Chemical name–Sodium Carbonate, Na_2CO_3.

Physical Data:

Melting Point–854 ° C.

Specific gravity–2.533 ($H_2O=1$).

Solubility in water (% by weight)–17% at 20° C.

pH–1% solution; pH=11.3

Contact with acids releases carbon dioxide gas.

{From: Lee S. McDonald, Fine Papermaking Equipment, P.O. Box 264, Charlestown, MA 02129}

Formation Aid

PNS and PMP formation aid are offered for use in nagashizuki or Oriental papermaking. They act to deflocculate or separate the longer bast fibers in making very thin sheets, and also slow down drainage during the formation. The formation aid is a synthetic substitute for the tororo-aoi plant. When mixed, it turns pure water into a thick, slippery, stringy, viscous substance. The formation aid is an indispensable and very magical agent for papermaking.

Mixing Instructions

One gram of PNS or PMP is mixed with one liter of cool water, 8 to 24 hours before papermaking. Less accurate proportions are ½ to one teaspoon of formation aid to one quart of water. In emergencies it can be mixed several hours before use, though it may contain clumps that have not dissolved. It is necessary to mix the solution intermittently. The formation aid has a higher specific gravity than water and will sink if not well mixed. If this happens, the settled clumps at the bottom of the bucket must be strained before making paper.

The best way to mix the formation aid is by introducing the powder into a stream of water, and stirring with a stick or paint mixer attached to a drill. Only a gallon of this concentrated mixture will be required to get a small (15 gallon) vat going. The white water (water drained from the vat, still containing the formation aid) can be saved and reused.

Storage

The powder should be stored away from heat exposure and moisture. The formation aid has a very long shelf life in dry form, but should be used within a few weeks after being mixed with water for maximum effect.

Precautions

PNS and PMP formation aids are polyacrylamides which are, generally speaking, of low toxicity. Any concern over toxicity would be that the polyacrylamide might be contaminated by residual monomers which are more toxic. The Japanese manufacturer has assured us that these are non-toxic. They are non-irritating to the skin under normal use conditions, while frequent or prolonged exposure to the skin should be avoided. As a general precaution, rubber gloves should be worn when mixing stock solutions and working in vats.

If any irritations develop, use should be discontinued and medical attention received. The formation aids are mild eye irritants and precautions such as safety glasses should be used when mixing to avoid contaminating eyes. If this occurs, flush the eyes with flowing water. If irritation persists, medical attention should be obtained. Other standard chemical handling procedures, including precautions against inhalation of dusts and ingestion of the compound should be observed.

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Papermaking Implements

The implements for making Japanese paper have remained much the same over the centuries since the very beginning of papermaking in this country. The chief implements are the vat, agitator, screen, frame, brush, and drying boards. ¶ The vat is rectangular wooden vessel. Its size varies according to the size of the sheet of paper to be made. The agitator is used for stirring the stock in the vat and is made of bamboo splints arranged like a comb and set in a wooden frame. ¶ The screen is a fine-textured one made of small split pieces of bamboo tied together with silk threads. Slender rushes are sometimes used in place of bamboo, depending upon the kind of paper required. Lacquered silk gauze may be used instead of bamboo screen. ¶ The frame is a rectangular wooden one, consisting of two moveable parts, the upper and the lower. The screen is placed on the lower part, upon which the upper part is placed so that the screen is firmly held. When the solution is scooped onto the screen, the frame prevents the stock from running off. The depth of the frame is usually about 1¼ inches. ¶ The brush, which is used for spreading wet sheets upon the drying board, is made of either straw or horsehair. The former is used for coarse paper; the latter for fine paper. ¶ Japanese paper sometimes has streaks upon the back of each sheet. This is due to the stroking given the sheets with a brush when they are spread upon the drying boards. ¶ The drying boards are for drying wet paper in the sun. The width of the boards differs according to the size of the sheet of paper. Pine wood is generally used for this purpose.

Making the Paper

In order to make Japanese paper by using the traditional nagashi-zuki method, the mould is held with both hands, slanting toward the maker, and then is dipped into the vat to take up a sufficient quantity of pulp. Then the mould is leveled so as to spread the stuff evenly, while allowing the water to drain away from the pulp in order to form a sheet of paper. The process is repeated two or three times or more, until the desired thickness is reached. The stuff scooped from the vat is shaken from side to side and front to back over and over again so that the fibers may adhere to one another. ¶ When a sheet is thus formed, the upper frame is removed, and the screen with the sheet of paper upon it is placed upside down upon a wooden board. The screen is then lifted away and replaced in the frame. By repeating this manipulation, sheets of paper are made one by one. ¶ If a thick sheet of paper is required, the mould is dipped deeply into the vat, but for a thin sheet of paper, it is dipped lightly into the vat. This dipping, or scooping, requires skill, which may be acquired through long practice. Ordinarily, to make a thick sheet of paper is comparatively easy, but making a thin sheet requires skill as well as care. ¶ The amount of paper that can be made by one person varies according to the size of paper, and runs from 300 to 600 sheets per day.

Pressing Wet Sheets of Paper

The wet sheets of paper are piled one layer upon another on a wooden board and are left overnight. Pressing, or squeezing, the water out of the wet sheets takes place on the next day. ¶ When piling the wet sheets, one corner of each sheet is folded over a little so that the sheets may be readily separated. Papermakers sometimes use pieces of linen string, which are inserted at a corner between the sheets for the same purpose. ¶ There are two methods of pressing the wet sheets: one is a very old and simple lever device. A board is put upon the pile of wet sheets, and upon this board are placed crossbars. By pressing a lever the water is squeezed out of the sheets. In the other method, a screw press is used. ¶ The old method is generally resorted to by those farmers whose papermaking is a sideline, while the mechanical device is used by those whose main occupation is papermaking and who do their work on a large scale. ¶ If very wet sheets are squeezed quickly, they adhere so closely that it is difficult to separate them; therefore, the pressing must be done gradually. And if pressed too hard, too little water would be left in them. On the other hand, if the pressing is too light, too much water would remain in the sheets and might injure the paper. ¶ One of the difficulties of papermaking lies in this pressing;

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Combine white bark (1 KG dry fiber) with water (14-15 liters) and soda ash (sodium carbonate NA_2CO_3). Soda ash should be added in the proportion of 200 grams (20% of ash) to the dry fiber weight mentioned above.

Cook 2 hours. Turn every 10 minutes.

For very tough bark, use lye (NaOH).

Strain and wash 4 times.

Separate into equal parts (per person) and pick out trash contaminants from the bark.

Beat 1½ hours, adding a few drops of water each 5 minutes.

Add quarter-size wads of bark into tub of water. Slosh furiously with your hand. Add formation aid* (PMP, PNS, or tororo-aoi) 2 cups per vat.

Soak su and geta 10-15 minutes

Form sheets with repeated dippings

Couch on dampened felt (flat)

Thread

Repeat

Press

Remove sheets and place on flat, smooth surface to dry

*1 gram dry powder to 1 liter cold water. One ounce makes two gallons.