Papermaking Properties on Barks of *Quercus crispula*, *Castanea crenata* and *Fagus crenata*.

Kōji MURAKAMI and Yōko SHISHIDO

ミズナラ・クリ・ブナ樹皮の製紙特性

村 上 浩 二・宍 戸 葉 子

Résumé

As a way of defining the characteristics in bark pulp quality and strength for individual wood species, a pulping study was made on Mizunara (*Quercus crispula* Blume), Kuri (*Castanea crenata* Sieb. & Zucc.) and Buna (*Fagus crenata* Blume). Of three species investigated, Mizunara and Kuri contain thick-walled bast fibers, and can be expected to be an additional fiber resource. Although the presence of undispersed bundles of thin-walled sieve tube members and parenchyma in the bark pulps tends to cause semitransparent spots on the sheet, it could be destroyed to disappear by lightly beating. Sufficient improvement in sheet strength was also obtained by beating. Buna that lacks in fiber was the lowest in pulp yield, and gave a sheet having low tear factor.

要　　旨

樹皮パルプの製紙特性を明らかにする目的で，ミズナラ・クリ・ブナ樹皮のパルプ化試験を行った。供試した3樹種のうち，ミズナラとクリの樹皮は厚壁のじん皮繊維を含み，繊維原料としての期待ができる。薄壁の師要素及び柔細胞は解繊困難でシート表面に半透明の斑点を生じたが，これらは叩解によって消失し，紙力の向上も認められた。一方，じん皮繊維を欠くブナはパルプ収率が低く，比引裂き強さの弱いシートを与えた。

1. Introduction

As a result of the extensively worse wood supply, whole-tree chipping has increased rapidly in recent years[1),2)], and pulp mills are receiving substantial quantities of wood chips that contain higher percentages of bark[3)]. It is well known, in general, that there are large differences between wood species in morphology and chemical constituents of the bark. Consequently, individual species show the characteristic behavior in the pulping process[4),5)]; some species have virtually no problems as the papermaking material, while others cause some trouble on papermaking processes and paper qualities. Harder, Einspahr and Parham[6)] determined bark fiber contents for 42 wood species grown in North

America, and reported that most hardwood barks contain fibers and should be more attractive for additional papermaking material than softwood barks.

The present paper is one of a serial study to accumulate more bark pulp information and to know whether the presence of bark cause any troubles on papermaking. Papermaking properties of three hardwood barks, Mizunara, Kuri and Buna, were investigated in relation to morphological characteristics of the pulp elements.

2. Experimental

A sample of the bark was collected from three wood species, Mizunara (*Quercus crispula* Blume), Kuri (*Castanea crenata* Sieb. & Zucc.) and Buna (*Fagus crenata* Blume), grown in the University Forest in Ashu, Kyoto University, and divided into inner and outer barks. According to TAPPI Stndards, ash, alcohol-benzene and hot water extractives were determined.

In order to determine the proportion of fibrous and non-fibrous elements of the bark, holopulp was prepared by sodium chlorite-acetic acid treatment[7], and classified on a dynamic drainage jar with a serial mesh of screen. The elements of each fraction was monitored by a light microscope.

Kraft pulping test in laboratory scale was made under the following conditions; 25% total chemicals, 24.9% sulfidity and 5 : 1 liquor to wood ratio at the maximum temperature of 170°C for 2h. After screening, the pulp was delignified by sodium chlorite-acetic acid treatment. The never-dried pulp was beaten in PFI mill. Handsheet test was made according to TAPPI Standards.

3. Results and Discussion

3.1 Bark components

Of three wood species studied, the barks of Mizunara and Kuri are quite similar in their tissue components. The inner bark of them contains substantial amount of thick-walled bast fibers in addition to sieve tube members, parenchyma and sclereids, while Buna inner bark lacks in bast fibers. The outer bark of three species, however, comprises the cells formed by a phellogen such as cork cells in addition to the components of the inner bark.

The results of classification test for the bark holopulp that prepared carefully to avoid any loss of fines are shown in Table 1. The barks of Mizunara and Kuri contain considerable amount of fibrous materials in comparison with that of Buna. While non-fibrous, fine elements presented much more in the outer barks of Mizunara and Kuri than in corresponding inner bark, and this may be due to the presence of the cells formed by a phellogen.

As seen in Fig. 1, the fibrous materials of Mizunara and Kuri retained on 60 mesh screen includes of bast fibers and strip-like shaped bundles of sieve tube members and parenchyma with a small amount of clumps of chambered crystalliferous cells. While bast

Table 1 Size distribution of bark elements defibrated by sodium chlorite-acetic acid treatment (% in weight)

Fraction, mesh		>60	60-100	100-200	<200
Mizunara	Inner	71.2	8.1	5.0	15.7
	Outer	32.2	11.4	5.7	50.8
Kuri	Inner	76.3	13.7	2.5	7.4
	Outer	49.9	0.9	3.4	45.8
Buna	Inner	26.2	2.7	22.0	49.0
	Outer	22.9	8.0	2.9	66.2

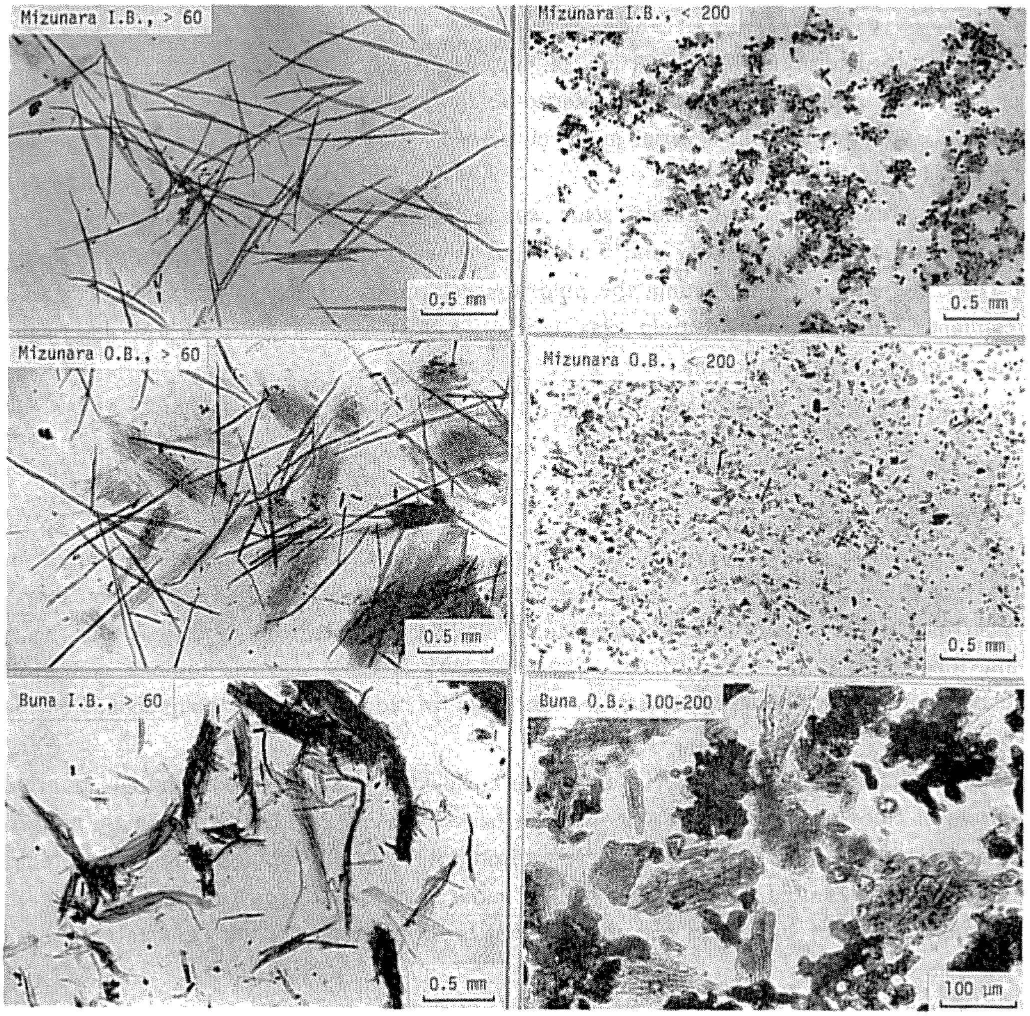

Fig. 1. Holopulp elements classified

fibers are absent in the bark of Buna. The bast fibers are thick in the cell wall and small in the lumen diameter, and have about 0.9 mm of fiber length. The sieve tube members and parenchyma are difficult to defibrate even in a strong kraft cooking condition (Fig. 2), and remain as the strip-like bundles in the holopulp. No essential differences are found between the fibrous elements of inner and outer barks. The non-fibrous fractions passed through 200 mesh screen are composed of very small, fine cells which will be lost in large part during washing procedure in a conventional pulping process.

3. 2 Pulp yield and quality

Table 2 shows the result of chemical analysis in contrast to the kraft pulp yield. Ash content of the barks is in several percentages, and these values are remarkably higher than those of wood. The bark has also more extractives than in wood. The inner barks of Mizunara and Kuri containing bast fibers gave the kraft pulp yield of around 40%, and

Table 2 Chemical analysis and pulp yield

	Ash, %	Alcchol-benzene solubles, %	Hot water solubles, * %	Kraft pulp yield, %
Mizunara, whole	3.89	9.3	7.3	39.5
Kuri, inner	5.73	12.6	8.8	43.4
” , outer	4.94	8.8	8.1	23.8
Buna, whole	6.31	7.0	2.8	14.9

* After extraction with alcohol-benzene

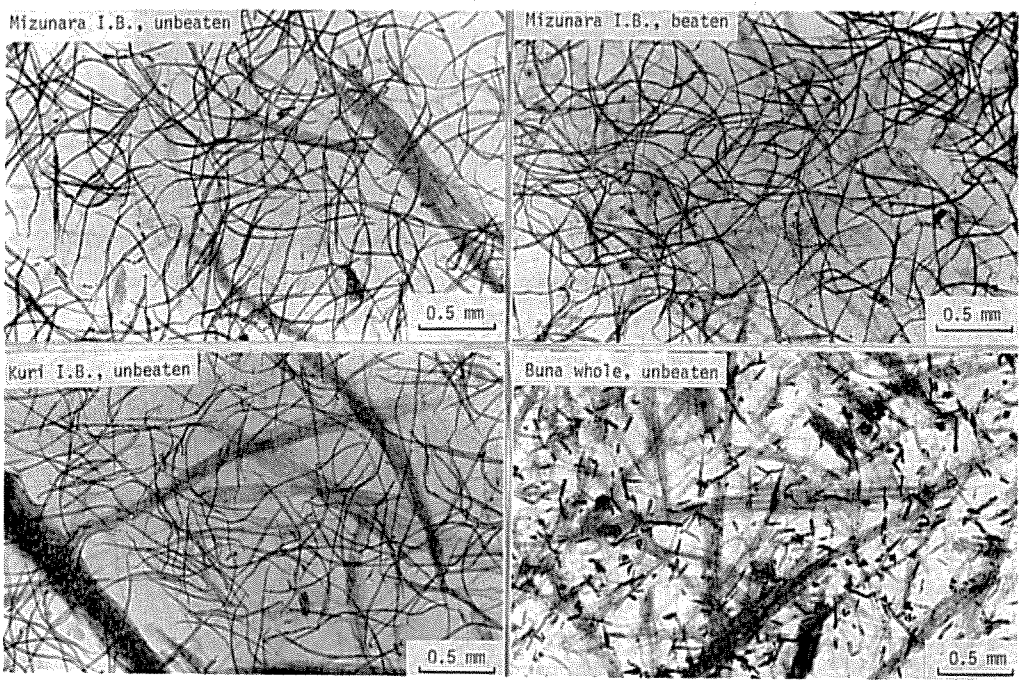

Fig. 2. Kraft pulp elements

this suggests that these barks can be expected to be an additional fiber resource. However, the outer bark of these species was low in kraft pulp yield because of loss of fine cells formed by a phellogen during washing and screening procedures. The whole bark of Buna was the lowest in kraft pulp yield because of the lack of bast fibers.

As seen in Fig. 2, kraft pulp elements of the inner barks of Mizunara and Kuri are quite similar to the fibrous fraction of these holopulp, but thick-walled bast fibers have curled shape in kraft pulp. Unbeaten kraft pulp from the inner bark gave a bulky sheet with semitransparent spots. It was found that the spots originated from the presence of large, strip-shaped bundles of sieve tube members and parenchyma on the sheet surface such as seen in Fig. 3. The bundles can be destroyed by light beating action such as 1000 rev. in PFI mill (Fig. 2), and no semitransparent spot was found in the sheets. The kraft pulp from whole bark of Buna gave a dense, semitransparent sheet even in unbeaten state similar to that from Akamatsu inner bark[8] (Fig. 3).

Table 3 indicates the results of handsheet test for the bark kraft pulp. With increasing in beating degrees, strength properties of the sheets from the inner barks of Mizunara and Kuri were improved gradually and become close to those of the sheets from common hardwood pulp. Tear factor also increased continuously even at 5000 rev. in PFI mill. This may be attributed to the presence of thick-walled bast fibers. The kraft pulp from

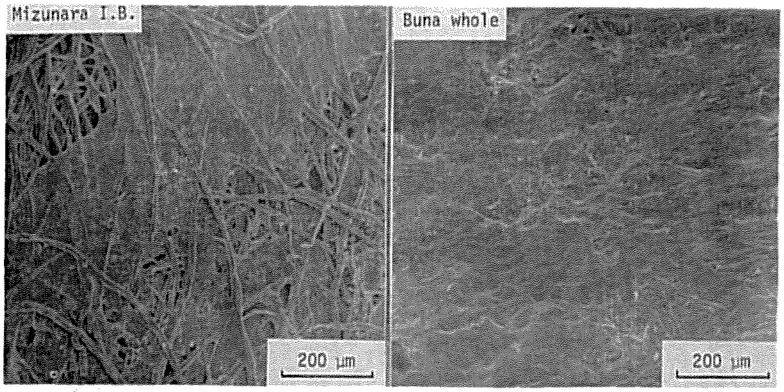

Fig. 3. Surface image of bark handsheets from never-dried, unbeaten kraft pulp

Table 3 Quality of bark kraft pulp

	PFI mill rev.	Sheet density, g/cm^3	Breaking length, km	Burst factor	Tear factor	Folding endurance (MIT)
Mizunara, inner	0	0.43	3.51	0.96	47.4	3
	1000	0.49	5.20	1.11	68.6	20
	5000	0.53	6.02	1.15	79.5	51
Kuri, inner	0	0.47	3.76	0.86	45.3	4
	1000	0.52	5.72	1.08	70.9	35
	5000	0.53	5.85	1.12	74.3	68
Buna, whole	0	0.59	6.50	1.07	15.6	2

Buna whole bark has poor drainage even at unbeaten state, and gave a sheet having sufficient breaking length but low tear factor because of the lack of fibers.

4. Acknowledgement

The authors express their appreciation to Professor Saburo Kawanabe and the stuffs of the University Forest in Ashu, Kyoto University, for their kind collection of the bark used, and also to Dr. Hiroki Nanko, Department of Wood Science and Technology, Kyoto University, for his valuable discussion on bark tissues.

References

1) Powell, L. N., Shoemaker, J. D., Lazer, R., and Barker, R. G.: Whole-tree chips as a source of papermaking fiber, Tappi, **58**, 7, 150-155, (1975)
2) Marton, R., Amidon, T. E., and Koeppicus, R.: Origins of some problems in whole-tree pulping, Tappi, **59**, 12, 107-112, (1976)
3) Einspahr, D. W., and Harder, M. L.: Increasing hardwood fiber supplies through improved bark utilization, Tappi, **63**, 9, 121-124, (1980)
4) Wiedermann, A.: Kraft pulping of several unbarked European hardwoods, Tappi, **55**, 8, 1209-1211, (1972)
5) Einspahr, D. W., and Harder, M. L.: Hardwood bark properties important to the manufacture of fiber products, Forest Products Journal, **26**, 6, 28-31, (1976)
6) Harder, M. L., Einspahr, D. W., and Parham, R. A.: Bark fibrous yield for 42 pulpwood species, Tappi, **61**, 11, 121-122, (1978)
7) Browing, B. L.: Methods of wood chemistry, vol. II, 394-396, John Wiley & Sons, Inc. (1967)
8) Murakami, K., Hirako, H., Araya, K., and Imamura, R.: Fundamental study on whole-tree pulping of *Pinus densiflora*, Bulletin of the Kyoto University Forest, **51**, 12, 267-273, (1979)