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Fiber Length, Specific Gravity, and Chemical Constituents of Two Tropical Hardwood Peeler Logs

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Abstract. Studies of specific gravity, fiber length, and the summative chemical analysis of *Aucoumea klaineana* and *Khaya ivorensis* plywood peeler cores (PPC), yielded holocellulose contents of 78 and 79 percent, alpha-cellulose values of 49.7 and 49.6 percent, pentosan of 17 and 19 percent, lignin contents of 27.5 and 29.4 percent, caustic soda solubles of 10.3 and 12.1 percent, hot-water solubles of 7.1 and 11.6 percent, alcohol-benzene solubles of 2.1 and 2.7 percent, ash contents of 0.75 and 0.79 percent, specific gravity values of 0.43 and 0.51, and average fiber length measurements of 1.27 and 1.57 mm, respectively. Based on the parameters of fiber length, specific gravity, and chemical composition it can be said that PPC retained from the rotary-cut veneer method (as wood wastes) of the previous wood species are suitable for pulp production.

Introduction

Okoume' (*Aucoumea klaineana*) is undoubtedly one of the most important African timbers with respect to production volume and utilization. The logs are, however, readily converted to veneer by either rotary or slicing procedures. Okoume' is used in the Middle East countries as in the United States of America only in the form of veneer for plywood, which obviates the difficulties that may be encountered in seasoning and machining in the solid form.

Khaya invorensis is an important timber for furniture and indoor decoration especially in the form of veneer or plywood.

Peeler cores produced from the rotary cut veneering are considered as wood wastes under the Middle East practices. Due to current fiber shortage in countries like Egypt complete log utilization becomes a necessity [1]. These cores can be used, however, as a raw material for pulp if available in large quantities. Hence, the objective of this investigation was to evaluate fiber length, specific gravity, and selected chemical constituents of these wood wastes (cores) as indicators of their potential utilization in pulp production.

Materials and Methods

Eight logs were used for the fiber length, specific gravity and the chemical constituents determinations. They were base logs of Okume' (*Aucoumea klaineana* Pierre) and Acajou d'Afrique (*Khaya ivorensis* A. Chev.). Both timbers were imported from the West Africa State of Gabon by the Egyptian Wood Company (WOODCO) of Alexandria. Logs were previously steam treated in steam vat at 100°C for at least 24 hr. They had no visible defects and were 4 m in length and 90 cm in diameter. A 15 cm-thick disc was cut at midlength of each log before peeling for fiber length, chemical and physical analyses of solid wood (Fig. 1). Samples (240 for each pecies) were obtained for specific gravity determinations using the maximum-moisture content method of Smith [2]. The equation is:

$$\text{Specific gravity} = \frac{1}{\frac{Ws-Wo}{Wo} + \frac{1}{1.53}}$$

where:

Ws = saturated weight of wood specimen.

Wo = oven-dry weight of wood specimen.

and 1.53 = assumed to be the specific gravity of cell-wall substance.

Expected diameter of the left-over peelers were marked on the logs cross sections. Thus analyses were obtained from parts representing the cores (four samples from each species) and outerwood (eight samples from each species). Samples for chemical analyses were converted to thin shavings to facilitate the granding process. These were ground separately in a Wiley mill to pass through a 40-mesh screen and be retained on 60-mesh screen. Moisture contents on 0.5 g subsamples were then determined.

Fiber length analyses were done using a tropical hardwood developed method by Kandeel *et al.* [3]. Samples for fiber length measurements (24 samples for each species) were macerated in a 1:1 solution of glacial acetic acid and 30% hydrogen

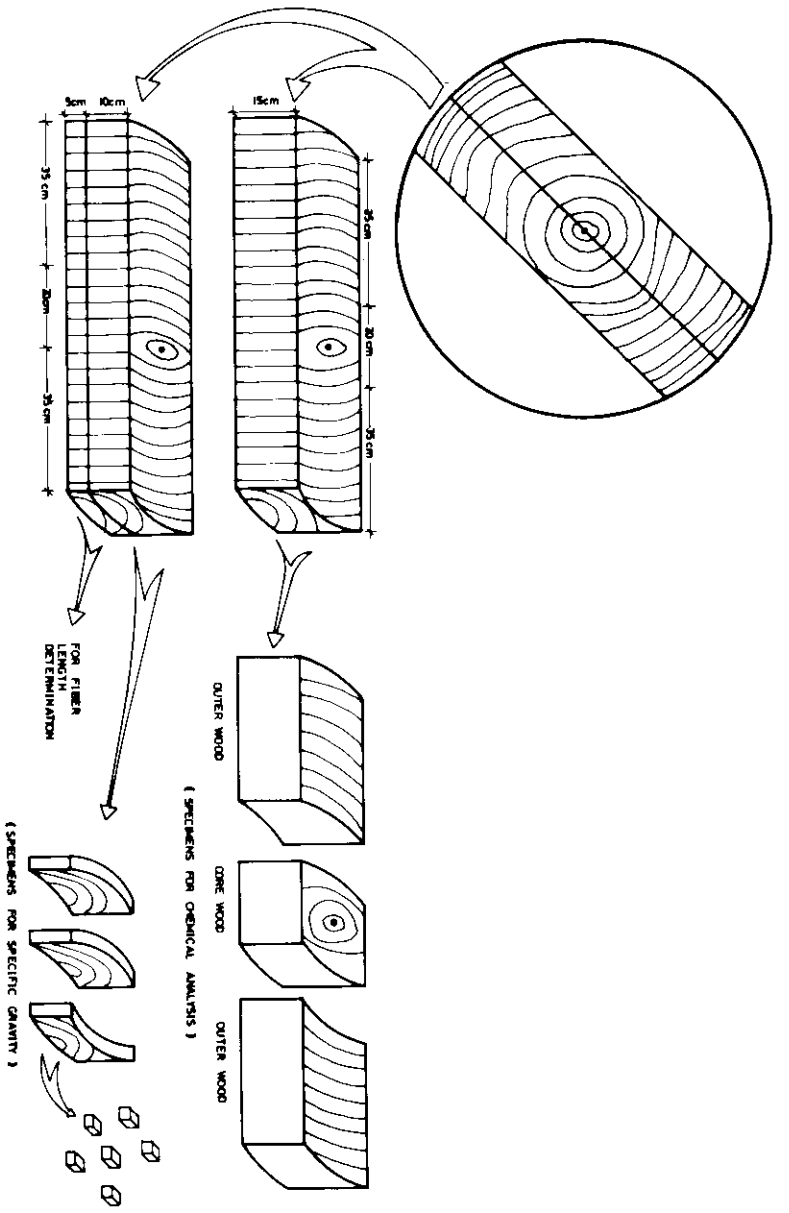

Fig. 1. Sampling procedure for fiber length, specific gravity and chemical analysis

peroxide at 60°C, then rinsed 3 × 30 minutes in distilled water [4]. For each sample, a drop of macerated tissue was placed on a microscope slide, stained with safranin, and covered. The slide was placed in a slide holder and projected onto a screen. Fifteen whole fibers per sample were measured to the nearest 1 mm at 50 × magnification. The number of fibers needed for a reliable estimate (sample size) was calculated (n = 8) using a two-stage sampling principle [5,3].

Debarked extraction samples were prepared according to TAAPI Standard [6]. Extraction time was 8, 8, and 4 hr. for benzene-ethanol, 95% ethanol, and hot-water, respectively. The samples were oven-dried to constant weight at 103°C and weighed after each successive solvent extraction. Extractive contents were determined based upon initial oven-dry mass.

Holocellulose was determined according to Yundt and Bradway [7]. Briefly, 0.3 g of extractive-free wood in a buffered solution was treated with a total of four additions of sodium chloride solution at 70°C to 80°C. At the end of 240 minutes, delignification was stopped by adding a small amount of ice water and immersing the flask in an ice bath. Residues were filtered and washed subsequently with 1% acetic acid, water, bicarbonate solution, cold and hot-water, and acetone. Holocellulose samples were air-dried followed by drying at 60°C in a vacuum oven over P_2O_5. The dried holocellulose samples were stored in glass vials in a desiccator.

The alpha-cellulose amount in holocellulose was determined by the method of ASTM D 1103-60 [8]. Holocellulose samples were treated at 20°C with a 17.5% sodium hydroxide solution for 45 minutes followed by 8.3% sodium hydroxide solution for 60 minutes. The solution was then filtered, and the residue was subsequently washed with 8.3% NaOH, 0.1% acetic acid, water, alcohol, and ether. The alpha-cellulose fraction was dried at 60°C in a vacuum oven over P_2O_5.

Pentosan content in wood was determined according to TAPPI Standard method [9]. A pentosan calibration curve was prepared using pure xylose sugar (Fig. 2).

Lignin content was determined according to TAPPI Standard method [10]. Briefly, 1 g of oven-dry extractive-free wood was treated with 15 ml of cold (15°C) 72% sulphoric acid for two hours at 20°C ± 0.1 with frequent mixing. Distilled water (560 ml) was then added and the mixture boiled for four hours under a reflux condenser. After allowing the insoluble matter to settle, it was filtered through a weighed RA 360 Alundum Crucible, washed thoroughly with hot distilled water, dried, then weighed and calculated as percent of the extractive-free wood base.

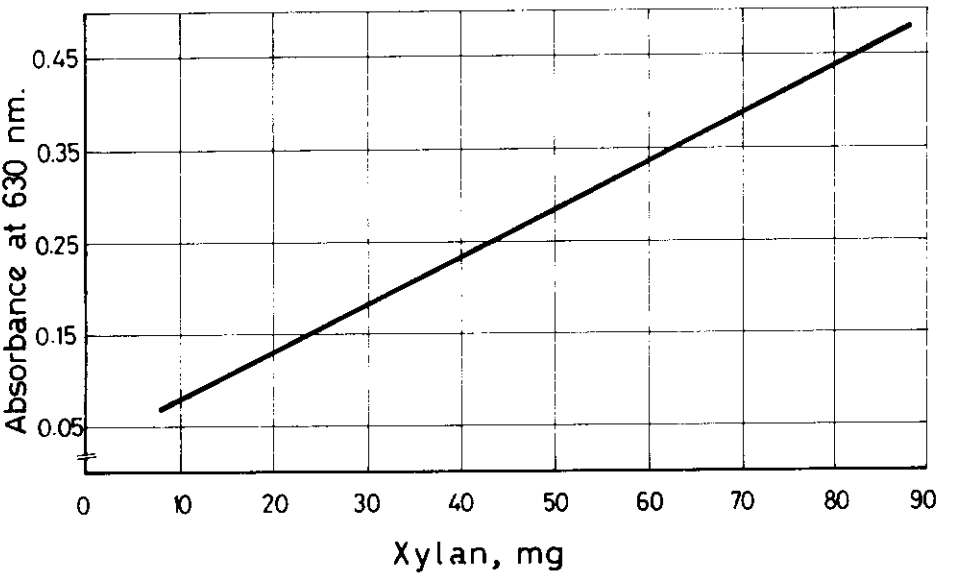

Fig. 2. Calibration curve for pentosan determination

One percent sodium hydroxide solubles were determined using TAPPI Standard T4M-59 [11], and ethanol-benzene extractives were removed according to TAPPI Standard T12M-59 [12]. The solubility in hot water was determined TAPPI T1m-59 [13] on a separate sample (2g) of ground wood. The sample was heated with distilled water (100 ml) in a flask immersed in a bath of boiling water.

After 3 hr. the wood was filtered on a tared filtering funnel of fritted glass or Alundum, washed with several small portions of hot water, dried at 100–105°C, and weighed in a stoppered weighing bottle. The loss in weight of the dry wood was calculated as percent solubles in hot-water [14, p. 384].

Ash content was determined using a ground 1 g composited sample according to ASTM D1102-50T [15].

The t-test in pairs was used to compare the means of specific gravity and chemical constituents for cores and outerwoods in both wood species.

Results and Discussion

Tables 1 and 2 give the mean values obtained in this study for fiber length. The average values of fiber length for *Aucoumea klaineana* and *Khaya ivorensis* were 1.27 mm and 1.57 mm, respectively. The difference was highly significant. These

data indicate satisfactory fiber length for use for pulp production as a hardwood short fiber supplement [1] for either species.

Table 1. Fiber length, specific gravity and chemical composition[1] corewood and outerwood of *Aucoumea klaineana*

Parameter	Outerwood	Corewood
Holocellulose, %[2]	79.01 (0.01)	78.00 (0.55)
Alpa-cellulose, %[2]	53.00* (0.94)	49.70* (0.71)
Pentosan, %[2]	13.00** (0.03)	17.00** (0.02)
Lignin, %[2]	24.79* (0.67)	27.54* (0.82)
1 % NaOH solubles, %	10.00 (0.18)	10.33 (0.09)
Hot-water solubles, %	7.13 (0.16)	7.14 (0.16)
Benzene-thanol solubles, %	0.93* (0.14)	2.13* (0.37)
Ash content, %	0.56* (0.08)	0.75* (0.02)
Specific gravity	0.41 (0.01)	0.43 (0.01)
Fiber length, mm	1.27 (0.17)	

[1] All results of chemical constituents are averages of eight replicates for each portion of the log.
[2] Based on extractive-free wood weight.
* Significant at 5 percent probability level.
** Significant at 1 per cent probability level.
Values between brackets are the standard deviations of the means.

Table 1 illustrates the specific gravity and the chemical constituents as well as the fiber length of *Aucoumea klaineana* wood. There were significant differences between corewood and the outerwood portions, especially regarding the alphacellulose, lignin content, benzene-ethanol solubles, and the ash content. On the other hand, there was a highly significant difference in pentosan content between corewood and outerwood. No significant differences were noted between the two portions of wood in holocellulose content, 1% NaOH solubles, hot-water solubles, or specific gravity.

The present findings indicated that *Aucoumea klaineana* corewood contains 78% holocellulose, 49.7% alpha-cellulose, 17% pentosan, 27% lignin, 1% NaOH solubles content of 10.33%, 2.13% benzene-ethanol solubles, 0.75% ash content, and specific gravity of 0.43. These results are in agreement with previously published research which indicated that Okoume' wood has an above-average cellulose yield for tropical hard-woods and hence it is suited for making kraft papers [16, 17, p. 426].

The specific gravity of Okoume' varies from 0.41 to 0.43 for outerwood and corewood, respectively. These values were in line with the findings of previous studies by [18, p. 243, 19].

Table 2. Fiber length, specific gravity and chemical composition[1] corewood and outerwood of *Khaya ivorensis*

Parameter	Outerwood	Corewood
Holocellulose, %[2]	81.00* (0.31)	79.34* (0.41)
Alpa–cellulose, %[2]	51.00** (0.30)	49.60** (0.08)
Pentosan, %[2]	18.00 (0.02)	19.00 (0.02)
Lignin, %[2]	28.45 (0.28)	29.36 (0.84)
1 % NaOH solubles, %	11.77 (0.16)	12.26 (0.26)
Hot-water solubles, %	11.73 (0.40)	11.62 (0.45)
Benzene-thanol solubles, %	2.38 (0.30)	2.69 (0.34)
Ash content, %	0.7 (0.06)	0.79 (0.04)
Specific Gravity	0.50 (0.01)	0.51 (0.02)
Fiber length, mm	1.57 (0.24)	

[1] All results of chemical constituents are averages of eight replicates for each portion of the log.
[2] Based on extractive-free wood weight.
* Significant at 5 percent probability level.
** Significant at 1 per cent probability level.
Values between brackets are the standard deviations of the means.

Table 2 illustrates the specific gravity and the chemical compositions of Acajou d'Afrique (*Khaya ivorensis* A. Chev.). There were significant differences between the corewood and the outerwood portions, especially in the holocellulose and alpha-cellulose contents. On the other hand, no significant differences were noted between corewood and outerwood regarding the pentosan, lignin, 1% NaOH solubles, benzene-ethanol solubles, and ash contents, as well as the specific gravity. These results are in agreement with studies by Ghelmeziu [17, p. 426] and Rozmarin *et al.* [20].

Regarding the specific gravity, *Khaya ivorensis* wood had specific gravity averages of 0.50 and 0.51 for outerwood and corewood, respectively. These findings are in agreement with the results of previous investigations [18, p. 243, 19].

From Tables 1 and 2, it can be noted that corewood contained higher pentosan, lignin, benzene-ethanol solubles, and ash contents, especially in the case of *Aucoumea klaineana* wood, than outerwood. On the other hand, corewood contained a significant lower alpha-cellulose content in both wood species than outerwood.

Comparing the two wood species, *Khaya ivorensis* had a higher benzene-ethanol solubles, and specific gravity than *Aucoumea klaineana* wood.

Conclusions

On the basis of the present results the following conclusions can be drawn:

1. Peeler cores produced from *Khaya ivorensis* had a higher specific gravity than those of *Aucoumea klaineana* (0.51 and 0.43, respectively). The overall mean values of fiber length in *Aucoumea klaineana* and *Khaya ivorensis* were found to be 1.27 mm (0.17) and 1.57 mm (0.24), respectively.

2. Peeler cores produced from *Aucoumea klaineana* by rotary cut veneering method are not significantly different from the outerwood for holocellulose, 1% NaOH solubles, hot-water solubles, or wood specific gravity. On the other hand, they significantly differed in the alpha-cellulose, pentosan, lignin, benene-ethanol solubles, and ash contents.

3. In the case of *Khaya invorensis* peeler cores, there were significant differences between corewood and outerwood in the holocellulose and alpha-cellulose contents, while the other parameters were not significantly different.

4. Based on the chemical characteristics it is possible to say that the peeler cores produced from the rotary- cut veneering method (as wood wastes) can be used as raw material for pulping.

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طول الألياف والثقل النوعي والمكونات الكيميائية لأخشاب الجذوع المتخلفة عن صناعة القشرة والأبلكاج من نوعين من الأخشاب الصلدة المدارية

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ملخص البحث. تم دراسة الثقل النوعي وطول الألياف والتحليل الكيميائي لبقايا أخشاب الجذوع المتخلفة عن صناعة القشرة والأبلكاج من أخشاب الأوكومية وأخشاب الكايا المستوردة من غرب أفريقيا.

هذا ولقد وجد أن كمية الهولوسيلولوز (الكربوهيدرات الكلية) ٧٨٪، ٧٩٪ ـ الألفاسيلولوز ٤٩ر٧٪ و ٤٩ر٦٪ ـ البنتوزان ١٧٪ و ١٩٪ ـ اللجنين ٢٧ر٥٪ و ٢٩ر٤٪ ـ المواد القابلة للذوبان في الصودا الكاوية ١٠ر٣٪ و ١٢ر٣٪ ـ المواد القابلة للذوبان في الماء الساخن ٧ر١٪ و ١١ر٦٪ ـ المواد القابلة للذوبان في مخلوط الكحول والبنزين ٢ر١٪، ٢ر٧٪ ـ الرماد ٧٥ر٠ و ٧٩ و ٠٪ ـ الثقل النوعي ٤٣ر٠ و ٥١ر٠ ـ طول الألياف ٢٧ر١مم و ٥٧ر١مم لكل من أخشاب الأوكومية وأخشاب الكايا على التوالي.

على ضوء النتائج السابقة يمكن القول بأن المخلفات الخشبية الناتجة عن طريقة القطع الدائري في مصانع القشرة والأبلكاج تصلح كمادة خام لانتاج لب الورق.