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Research Article

Determination of Shore D Hardness Value and Surface Roughness Parameters in Okan (*Cylicodiscus gabunensis* [Taub.] Harms) Wood

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Abstract: In this study, changes in surface roughness parameters (R_a, R_z and R_q) and the shore D hardness value of okan wood (*Cylicodiscus gabunensis* [Taub.] Harms) used in various areas such as garden furniture and carving and turning, against different numbered sandpapers (80, 100, 120, 150, and 180) commonly used abroad, were investigated. According to the obtained results, variance analyses exhibited significant outcomes for all parameter values. R_a, R_z and R_q values showed a decreasing trend with an increase in sandpaper number. R_a values were found to be 8.806 µm for 80 grit, 7.335 µm for 100 grit, 6.186 µm for 120 grit, 5.290 µm for 150 grit, and 4.092 µm for 180 grits. Additionally, the hardness value was determined to be 73.80 HD.

Keywords: surface roughness; shore D hardness; *Cylicodiscus gabunensis*

Okan (*Cylicodiscus gabunensis* [Taub.] Harms) Ahşabında Shore D Sertlik Değerinin ve Yüzey Pürüzlülüğü Parametrelerinin Belirlenmesi

Öz: Bu çalışmada, yurt dışında başta bahçe mobilyaları ve oyma ve tornalama gibi alanlarda kullanılan okan (*Cylicodiscus gabunensis* [Taub.] Harms) ahşabında kullanılan farklı numaralı zımparalar (80, 100, 120, 150 ve 180) karşısında meydana gelen yüzey pürüzlülüğü parametrelerine (R_a, R_z ve R_q) ait değişimleri ve shore D sertlik değeri araştırılmıştır. Elde edilen sonuçlara göre, varyans analizleri bütün parametre değerleri için anlamlı sonuçlar sergilemiştir. R_a, R_z ve R_q değerleri zımpara numarasının artmasına bağlı olarak azalan sonuçlar vermiştir. R_a değerleri zımpara numarasının artmasıyla 80 kum için 8.806 µm, 100 kum için 7.335 µm, 120 kum için 6.186 µm, 150 kum için 5.290 µm ve 180 kum için 4.092 µm olarak bulunmuştur. Buna ek olarak, sertlik değeri 73.80 HD olarak belirlenmiştir.

Anahtar Kelimeler: yüzey pürüzlülüğü; shore D sertlik; Cylicodiscus gabunensis

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1. Introduction

Okan (*Cylicodiscus gabunensis* [Taub.] Harms) (Mimosaceae) (synonym = *Erythrophleum gabunensis* Taub.) is a large tree growing in the tropical rainforests of West and Central Africa [1]. This species is a heliophilic species of great socio-cultural and economic importance [2]–[4]. It is common in rainforests from Sierra Leone to Cameroon and Gaboon. Occurs in the Mano River area in the southwestern part of Liberia [5], [6]. It is the sixth most exploited species in the Congo Basin [7]. Like other light-demanding species, it seems to face the challenge of regenerating naturally in dense forests [3], [8], [9].

Often called Denya (Ghana), Edum (Gabon), Adoum, Bokoka (Cameroon) and Bouemon (Ivory Coast), it is a large tree with a cylindrical trunk [10]. Since 2008, this tree species has been one of the five most used BC species for timber production [11]. A few years ago, the species was little known in timber markets [12]. In 2010, it was the most exported species in Cameroon [13]. The okan tree is a large tree native to the tropical rainforests of West and Central Africa, growing up to 60 m tall with a straight trunk up to 24 m long [1]. The root of the okan tree is more or less pyramidal with widespread branches. The bark has a strong co-coat. The flowers are 2-5 mm long and 2-3 mm wide [14].

The base of the plant is roughly pyramid-shaped with branches that spread outwards. The bark emits a distinct, strong odor. The leaves are compound, lacking a central stem, arranged alternately, and have a subtle asymmetry. The flowers are clustered on the branches and are diminutive, measuring 2-5 mm in length and 2-3 mm in width. The seed pods are lengthy, pendulous, reaching up to 1 meter in length and 4 cm in width, featuring a pointed base and tip [15]. The sapwood is 2.5 to 5 cm wide and is very different from the heartwood. It is very light brown with a decidedly pink tint, and the heartwood is a deep golden colour, often with a greenish cast. When exposed, the sapwood turns reddish brown and the darker areas create a striped effect with golden coloured wood. The wood has a moderately high gloss. The texture is moderately coarse and the fibers are often interlocked. The wood is hard and very heavy [16].

The drying of timber is slow. The deterioration is not severe, but the wood shows a stable tendency to split and check. It also recommends kiln program B for this wood [5]. Its wood is very resistant to rot. Sapwood is susceptible to attack by powder post beetles, but the wood is resistant to termites. Heartwood is highly resistant to preservative treatment and even sapwood is resistant[5]. The wood is very durable and is used for heavy construction such as marine construction and bridges, heavy flooring, joinery, vehicle bodies, mines, and shipbuilding, especially for decking, garden furniture, sports equipment, agricultural implements, railway sleepers, carving, and turning. In Nigeria, it is used to make pontoons. It is also used as firewood and for charcoal production [17].

In okan (*Cylicodiscus gabunensis* [Taub.] Harms) wood; fresh state moisture content 52.00%, oven dry specific gravity 0.790 g/cm^3, drying time index 1.095, wet weight 1.201 kg/m^3. Equilibrium moisture content was 8.99% for sapwood and 9.68% for heartwood, compressive strength was 20.15 N for sapwood and 48.27 N for heartwood, modulus of elasticity was 10740.00 N/mm^2 for sapwood and 15573.00 N/mm^2 for heartwood, flexural strength was 120.00 N/mm^2 for sapwood and 192.00 N/mm^2 [18] for heartwood and ash content was 0.76% [18].

The tree is traditionally known for its medicinal use. The bark of the tree is used to prepare medicines for headaches, filariasis, rheumatism and gastrointestinal disorders [14]. The leaves are also soaked and softened and used against migraine. A decoction of the bark is used to treat abdominal pain and as an anodyne against vomiting, venereal diseases, malaria, psoriasis and rheumatism. The leaves of the tree are grazed by sheep and goats. The bark of the tree is used instead of soap and as a fish poison [17].

This study determined shore D hardness and surface roughness parameters of okan (*Cylicodiscus gabunensis* [Taub.] Harms) wood against different sanding numbers.

2. Experimental

2.1. Wood Material

The samples of okan (*Cylicodiscus gabunensis* [Taub.] Harms) wood was taken in sufficient numbers to measure 100 × 10 × 2 cm. Acclimatization treatments (ISO 554, 1976) were performed on the samples.

2.2. Sanding Process

80, 100, 120, 150 and 180 grit sandpapers were applied to 10 x 10 x 2 cm test samples.

2.3. Determination of Surface Roughness

According to ISO 16610-21 (2011), surface roughness measurements were determined on a JD 520 model roughness tester. The test was performed in the direction perpendicular to the fibers. In addition, the device was adjusted so that the number of sample lengths (cut-off) was 5 and the sample length was 2.5 mm. 10 measurements were taken from each sample. The parameters Ra, Rz and Rq values were determined.

2.4. Determination of Shore D Hardness

Using the ASTM D 2240 (2010) standard, shore D hardness tests were determined by taking 10 measurements with a load of 5 kg on the shore meter device.

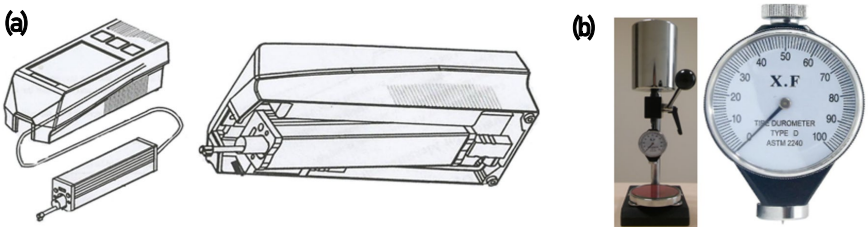

Figure 1. (a) Surface roughness tester; **(b)** shore meter.

2.5. Statistical Analysis

A statistical program was used to calculate means, minimum measurement values, maximum measurement values, homogeneity groups, standard deviations, multivariate variance analysis, and percentage (%) change rates.

3. Results and Discussion

The result of the Shore D hardness value is presented in Table 1. The Shore D hardness value was determined as 73.80 HD and it was observed that the values varied between 76.00 - 72.00 HD (Table 2).

Table 1. Determined for Shore D hardness (HD) values.

Mean (HD)	Number of Measurements	Standard Deviation	Variation Coefficient	Minimum	Maximum
73.80	10	1.32	1.78	72.00	76.00

The results of surface roughness values (R_a, R_z and R_q) are shown in Table 2. The highest results on R_a, R_z and R_q parameters were obtained on specimens treated with abrasive No 80, while the lowest results on R_a, R_z and R_q parameters were obtained on specimens treated with abrasive No 180 (Table 2).

The results of the analysis of variance are given in Table 3. According to these results, it is seen that the sanding number is significantly determined by all parameters (Table 3).

Table 2. The results for surface roughness parameters (*Ra*, *Rq* and *Rz*).

Test	Sandpaper Number	Number of Measurements	Mean (µm)	Variation Coefficient	Homogeneity Group	Standard Deviation	Minimum	Maximum
Ra	80	10	8.806	4.38	A*	0.39	8.225	9.267
	100	10	7.335	2.67	B	0.20	7.085	7.622
	120	10	6.186	0.30	C	0.02	6.154	6.204
	150	10	5.290	5.79	D	0.31	5.000	5.962
	180	10	4.092	0.66	E	0.03	4.024	4.118
Rq	80	10	11.433	1.99	A	0.23	11.016	11.896
	100	10	10.007	2.49	B	0.25	9.666	10.300
	120	10	8.694	0.26	C	0.02	8.649	8.719
	150	10	7.596	2.47	D	0.19	7.220	7.981
	180	10	5.796	1.43	E	0.08	5.592	5.882
Rz	80	10	53.995	3.06	A	1.65	51.524	56.425
	100	10	50.528	0.20	B	0.10	50.410	50.756
	120	10	42.268	1.44	C	0.61	41.204	43.213
	150	10	40.127	1.45	D	0.58	39.543	40.872
	180	10	33.208	1.47	E	0.49	32.784	34.308

* Maximum value.

In the literature, dibétou [19], mahogany [20], nutmeg [21], spindle [22], sessile oak [23], ipê wood [24], avocado [25], peach wood [26], angelim vermelho, murici, angelim pedra, breu vermelho, piãozinho [27], tulip [28], Slash Çamı, eucalipto [29], lati, western red cedar, movingui, american walnut [30], slash pine, eucalipto [31], Maltese plum, lemon, tiama, movingui, red american oak [32], yellow pine, ash, alder, birch, spruce [33], ash, birch [34], sapelli, doussié, teak [35], pine, kapur, meranti [36], ayous [37], birch [38], magnolia [39], alder [40], fig [41], monkey pod [42], beech, birch, sessile oak, In studies conducted on spruce [43], pine, white oak and nyatoh [44] and siberian [45] wood species, it was reported that roughness values decreased with increasing sanding number.

Table 3. The results for variance analysis.

Test	Variance Source	Sum of Squares	Degree of Freedom	Mean Square	F Value	$\alpha \leq 0.05$
Ra	Sandpaper Number	132.497	4	33.124	587.671	0.000*
	Error	2.536	45	0.056		
	Total	2146.043	50			
	Adjusted Total	135.033	49			
Rq	Sandpaper Number	188.331	4	47.083	1505.573	0.000*
	Error	1.407	45	0.031		
	Total	3978.903	50			
	Adjusted Total	189.738	49			
Rz	Sandpaper Number	2769.705	4	692.426	940.651	0.000*
	Error	33.125	45	0.736		
	Total	99713.829	50			
	Adjusted Total	2802.830	49			

* Significant.

4. Conclusions

In this study, the following results were found for the R_a, R_z and R_q parameters and shore D hardness value determined after the application of different numbered abrasives (80, 100, 120, 150, and 180) on the surfaces of oak wood;

- Shore D hardness value was obtained as 73.80 HD.
- Analysis of variance was found to be significant.
- R_a, R_z and R_q values decreased with increasing sanding number.

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