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Calorific value variation in coconut stem wood *

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Summary. Fuelwood quality parameters such as calorific value, siliceous matter and basic density of coconut stem wood were determined. The material examined was from non-diseased senile palms of age around 70 years and root-wilt diseased palms of age group 55–65 years, 35–45 years and 15–25 years. Average calorific value of coconut stem wood in air-dry condition was found to be about 16.3 MJ/kg and it compares fairly with that of hardwoods. A highly positive correlation ($r = 0.96$) was obtained between density and calorific value per unit volume. Also, a highly negative correlation was obtained between siliceous matter and calorific value. Upper half of the mature and over-mature palms and full length of young palms which have been affected by root-wilt disease could be used as a fuelwood of adequate heating value or converted into charcoal.

Introduction

Calorific value of wood as determined by bomb calorimeter is defined as the number of heat unit liberated by unit mass of wood when burned in an atmosphere of pure oxygen gas in a sealed enclosure. This is a measure of the usable heat released when wood is burned and this is an important indicator of the fuelwood quality of a species.

Calorific value of wood depends on its chemical composition and quality and nature of deposits of other organic and inorganic matter. There is wide variation in calorific value between species, within a species and even within a single tree. Wood from different portions or height levels may possess different calorific values. The calorific value of heartwood and sapwood could be different to the extent of 2.3 MJ/kg (Krishna, Ramaswamy 1932). For practical purposes, factors like moisture content, density, smoke produced, ease and completeness of combustion, rapidity of burning, ease of splitting are also important.

Phytosanitary precautions call for massive replantation of root-wilt diseased coconut palms in Kerala. Due to availability in plenty and low cost, coconut stem wood

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is now utilized as firewood in brick kilns. Generally, only the upper half to one-third of the mature palms, which is not suitable for conversion to sawn sizes, will be available for fuel purpose. In the case of young palms, whole length will be suitable for fuel purpose. This study determined the calorific value variation along the height of coconut stem wood of both non-diseased and diseased palms in order to assess its fuelwood potential.

Material and methods

Non-diseased senile palms, about 70 years old (Group I), root-wilt diseased palms of different age groups such as 55–65 years (Group II), 35–45 years (Group III), and 15–25 years (Group IV) were selected for this study. Four palms were selected randomly from each age group and each palm was divided into three portions, i.e. base, middle and top. A transverse disc of about 5 cm thickness was cut from each portion and a radial sector was cut from the disc for determining the average disc density. The remaining portion of the disc was chipped and powdered in a Wiley mill and the fraction passing through 60 mesh and retained in 80 mesh sieve was used for calorific value determination. The powder was air-dried and the moisture content determined. About 2 g of the air-dried powder was pressed into pellet. The calorific value of the pellet was determined in an isothermal oxygen bomb calorimeter (Adair, Dutt & Co).

Results

Moisture content

The moisture content (MC) of the air-dried powder of samples of all the groups ranged from 7 to 10 percent. As the MC varied in the limited range, its influence on the calorific value was taken as negligible for comparison purposes.

Calorific value

The calorific values are given in Table 1. The base portion of the palms of Group I had the lowest average calorific value of 13.2 MJ/kg and the middle portion of the palms of Group II had the highest average of 17.9 MJ/kg. Analysis of the data showed that there was significant difference in calorific values between groups and height levels (Table 2). The interaction between these two factors was also significant and this is understandable because of the lack of any clear trend (Fig. 1 a).

Siliceous matter

The samples from the base portion of the palms of Group I which had the lowest calorific value were seen to have the highest average siliceous matter (27.0%). Also, the samples from the middle portion of the palms of Group II which had the highest

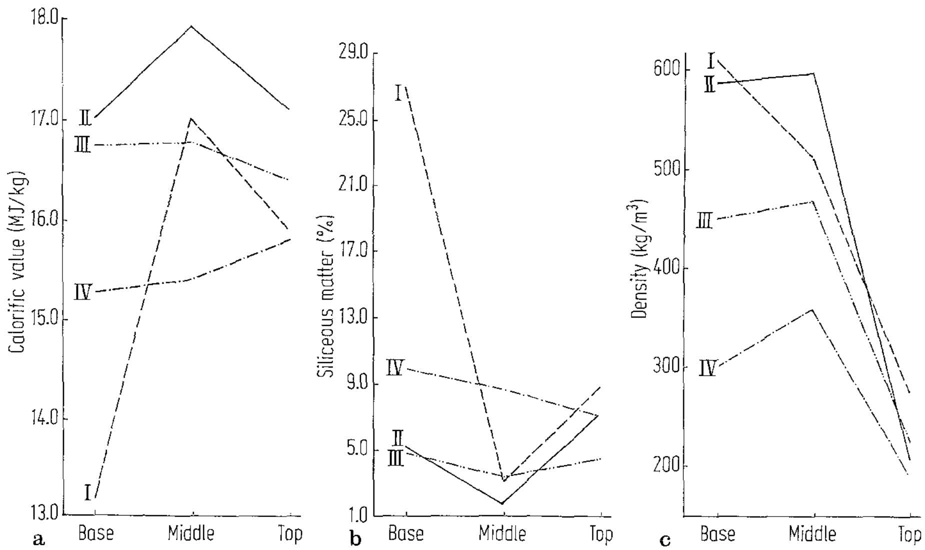

Fig. 1 a–c. Variation along the stem of **a** calorific value, **b** siliceous matter and **c** density

Table 1. Calorific value, siliceous matter, density and height of coconut stem wood of different groups (mean of 4 samples). The coefficient of variation in parenthesis

	Position	Group			
		I	II	III	IV
Calorific value, MJ/kg	Base	13.19	17.00	16.74	15.24
		(13.9)	(6.1)	(5.8)	(12.8)
	Middle	17.00	17.94	16.76	15.38
		(3.2)	(2.0)	(4.4)	(7.6)
	Top	15.91	17.12	16.39	15.78
		(6.4)	(2.1)	(3.8)	(4.0)
	Mean	15.36	17.35	16.63	15.47
Siliceous matter, %	Base	27.0	5.2	4.8	9.9
		(34.4)	(122.3)	(102.9)	(86.0)
	Middle	3.1	1.8	3.4	8.7
		(55.0)	(51.2)	(85.6)	(84.5)
	Top	8.8	7.2	4.6	7.1
		(74.5)	(67.1)	(40.6)	(45.8)
	Mean	13.0	4.7	4.2	8.6
Density, kg/m^3	Base	611	590	451	301
		(22.7)	(4.7)	(25.4)	(26.2)
	Middle	514	598	469	359
		(8.7)	(10.0)	(23.3)	(31.7)
	Top	277	210	226	193
		(9.7)	(13.8)	(30.6)	(26.2)
	Mean	467	466	382	284
Height, m	Mean	12.25	15.35	11.00	6.65

calorific value were seen to have the lowest average siliceous matter (1.8%). Analysis of the data showed that there was significant difference in siliceous matter between groups and between height levels (Table 2). As in the case of calorific value, the interaction between groups and height levels was also significant. Figure 1 b also shows that there was no clear trend.

Density

The pooled group means show that there is increase in density with age. The over-mature palms (Groups I and II) had the values of about 466 kg/m^3 and the young palms (Group IV) had a density of 284 kg/m^3 (Table 1). Statistically, there was significant difference in density between groups and between height levels (Table 2). As the interaction of these two factors was not significant, one-way ANOVA was carried out on the data to facilitate comparing the means. Top portion of trees of all the age groups did not differ in density significantly (Table 3). Also, the difference in density between base and middle portions of the stem of all the four age groups was not significant (Table 3). In the first three groups, the top portion had significantly lower density than the other two levels. These conclusions are evident from Fig. 1 c also.

Discussion

The average calorific value of coconut stem wood varied from 15.4 to 17.4 MJ/kg. Compiling information from the literature on 402 species of wood, Harker et al. (1982) reported that calorific values ranged from 15.6 to 23.7 MJ/kg for hardwoods and from 18.6 to 28.5 MJ/kg for softwoods. Singh and Kostecky (1986) determined calorific values of four hardwoods and six softwoods in oven-dry condition and reported that the values ranged from 18.7 to 19.7 MJ/kg for hardwoods and from 19.7 to 20.8 MJ/kg for softwoods. Ser and Tan (1985) concluded that the average calorific value of 45 air-dry Malaysian timbers (hardwoods) was about 18.0 MJ/kg. It is seen that coconut stem wood has little lower calorific value than hardwoods. The difference in chemical composition of monocot (coconut palm) from that of dicot and conifer might explain this.

As the lower half of the mature and over-mature coconut palms can be used for structural purposes, only the upper half will be available for firewood or charcoal making. However, as the wilt-diseased young palms may not be suitable for structural components, the whole palm can be converted into charcoal or used as firewood. Excluding the calorific values of base portion of Groups I to III, the pooled average of the rest works out to about 16.3 MJ/kg. This value is fairly comparable with that of hardwoods.

It is generally presumed that high density wood will have high calorific value. Ser and Tan (1985) did not find any meaningful correlation between density and calorific value. Sastry and Anderson (1980) also found poor correlation between density and gross heat of combustion among different clones of Populus hybrids. Regression analysis of the data of this study (Table 4) also showed that the relationship between density and calorific value was very poor ($r = 0.074$). However, if we take unit volume

Table 2. Two-way analysis of the variance of calorific value, siliceous matter and density

Source of variation	Degrees of freedom	Variance ratio		
		Calorific value	Siliceous matter	Density
Group	3	7.37 [b]	4.76 [b]	10.37 [b]
Position	2	4.11 [a]	5.54 [b]	41.43 [b]
Interaction	6	2.43 [a]	3.53 [b]	2.13 (ns)

ns: not significant; [a] significant at 5% level; [b] significant at 1% level

Table 3. One-way analysis of variance on the effect of different groups and height levels on density

Height level	Group			
	I	II	III	IV
Base	a [a]	a b	b	c
Middle	a	a	a b	b
Top	a	a	a	a

[a] Groups with same alphabetic letter are not significantly different

Group	Base	Middle	Top
I	a [a]	a	b
II	a	a	b
III	a	a	b
IV	a b	a	b

[a] Height levels with the same alphabetic letter are not significantly different

Table 4. Correlation of density, siliceous matter and calorific value

x	y	Regression equation	r	r^2
Density, kg/m^3	Calorific value per unit weight, MJ/kg	$y=3805.76+0.164x$	0.074	0.005
Density, kg/m^3	Calorific value per unit volume, MJ/m^3	$y=-0.0181+3.884x$	0.96	0.92
Siliceous matter, %	Calorific value per unit weight, MJ/kg	$y=4189.29-41.64x$	-0.92	0.85

of wood, dense wood will have more heating value than light wood. Heating value per unit volume has more practical significance than per unit weight. Ser and Tan (1985) obtained a highly positive correlation ($r=0.988$) between density (kg/m^3) and heating value per unit volume (MJ/m^3). In this study also, a high r-value of 0.96 was obtained (Table 4). This shows that 92 percent ($r^2=0.92$) of the variation in calorific value per unit volume can be explained by the variation in density.

One would expect that if siliceous matter increased, the heating value will be decreased. A simple linear regression analysis showed that there was a highly negative correlation ($r = -0.92$) between siliceous matter and calorific value per unit weight (Table 4). This shows that 85 percent ($r^2 = 0.85$) of the variation in calorific value per unit weight can be explained by the variation in siliceous matter.

It can be seen from Table 1 that the average siliceous matter was high in Groups I and IV (13.0 and 8.6% respectively). This shows that age of the palm may not be a factor in the quantity of siliceous matter present. The site in which the palms grow may have strong influence on the siliceous matter. The coefficient of variation was also seen to be high (Table 1).

Upper half of the mature and over-mature palms and full length of young palms which have been affected by root-wilt disease could be used as a fuelwood of adequate heating value or could be converted into charcoal.

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