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7DETERMINATION OF HEATING VALUE OF *QUERCUS AEGILOPS* AND *POPULUS NIGRA* GROWING IN KURDISTAN-IRAQ FOR AN EFFECTIVE WOODY BIOMASS UTILIZATION

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ABSTRACT

The heating value in two hardwood species and their lignin content had been carried out to determine the best species for woody biomass utilization in Amedi District/Duhok/ Kurdistan Region of Iraq. The study aimed to find out the relationship between the species, diameter of trees and the parts of tree with the heating value, lignin content, basic density and moisture content. 18 trees were felled and the number of samples were 54. The values of heating value ranged from 10.08 MJ/kg from the bark of a large diameter tree in *Populus nigra* to 22.69 MJ/kg from the branch of a large diameter tree of *Quercus aegilops*. The study revealed a significant differences in the means of heating value in species, classes, and parts of trees (P< 0.05). The mean of lignin was higher in the branches followed by the wood and bark which gave close values. Accordingly, residual biomass, broken branches, limbs, and barks of trees are the best resources for an effective utilization of woody biomass.

KEYWORDS*: Basic density, Firewood, Heating value, Lignin content, Moisture content, Utilization, Woody biomass.*
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1. INTRODUCTION

Woody biomass is the most important renewable energy resource available in the world especially if sustainably used for its contribution in a cleaner environment by reducing the amount of harmful gasses emitted to the atmosphere associated with fossil fuels. Woody biomass is a carbon neutral because less amount of carbon is added to the atmosphere while burning. These are what makes it globally an international goal (Krajnc, 2015). Wood has been used by humans since ancient times for cooking and heating. From that time, as the number of populations increased and their economies grew, the value of the forests and the uses of wood have been increased greatly as it was the main source of energy and is globally still in use in many households (Risbrudt, 2013).

The opportunities in the utilization of woody biomass have been increased due to the projects of restoration and fire hazard reduction where the forest fires considered as the main contributor in the increasing of the proportion of carbon dioxide in the atmosphere as well as the consumption of the natural resources. Furthermore, the increasing of the costs of firefighting and the attempts to diminish the effects of climate changes, led to emphasize the interest on this source of utilization (Nielsen-Pincus and Moseley, 2009). The chemical composition of the wood can determine the best woody biomass for providing energy, lignin has the highest amount of energy among other wood components such as cellulose and hemicellulose hence the higher lignin content, the higher heating value provided from the fuelwood (Nguyen *et al.*, 2016).

Amedi District had been selected which is distinguished by its mountainous topography and a harsh weather during winter. Recently, this area suffered from an increase in the illegal cutting of trees by the local citizens that may lead to forest degradation and deforestation if continuously occurs without control. In addition to that, the reduction of the forest coverage will have a negative impact on the environmental pollution in the area, since trees have a great contribution in the carbon sequestration that will be diminished by removing them (Eklund, 2018).

The reasons beyond this illegal cutting of trees are within indispensable need to provide a source of heating especially in the low-income families that are unable to provide another source of heating especially nowadays where the supply process of fossil fuels for the citizens are insufficient during this era of the disputes around the fossil fuels. Despite this manner of the illegal cutting of the trees is against the sustainability in the utilization of trees which will reduce the ratio of forest coverage (Mustafa, 2016).

The objectives of this study are:

1- To determine the amount of lignin in the tested species and relate it to the best diameter class of trees for an effective woody biomass utilization.
2- To find the relationship between the lignin content with the basic density, MC and the height of trees.
3- The results from this study will assist in the determination of the best species to be utilized for woody biomass in the study area through providing the indigenous quality criteria for firewood.
4- In addition to filling some gaps in the forest information of the study area.

2. MATERIALS AND METHODS

2.1. Sampling procedure

Amedi District, which has been selected for the study, is located at (latitude 37º05´33˝ N and longitude 43º 29´14˝ E). This area is distinguished by its mountainous topography and a harsh environment during the winter season. Furthermore, it has the maximum value of vegetation coverage within Duhok Governorate (Figure 2.1) according to the estimation project carried out in 2014 (Mustafa *et al.*, 2015). It is worth mentioning that this area has been subjected to forest fires for different reasons, which has a negative effect on both natural and artificial forests in addition to rangelands and private farms (Yousif, 2015).

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For each species, an area of 12m radius were selected including at least (12-15) trees and all their trees were registered upon

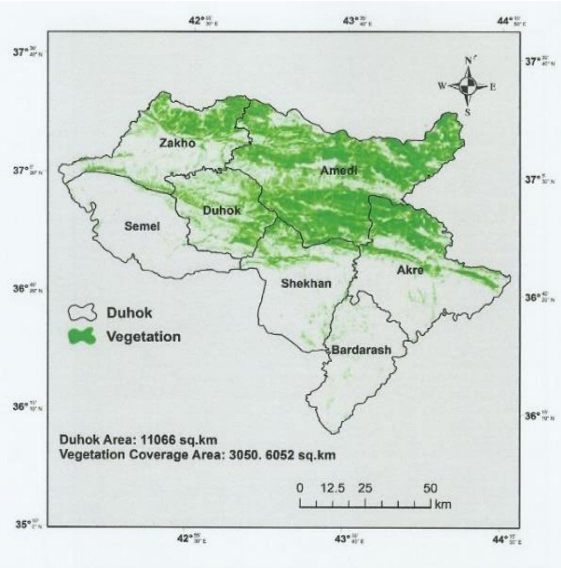


Figure 2.1 Vegetation coverage at Duhok Governorate including Amedi District, (Mustafa *et al*., 2015).

their Diameter at Breast Height (DBH). Trees were divided into three diameter classes: (large, medium, and small) (Table 2.1). From each tree class, one tree was felled with a replication of three tree per species, and samples from three parts of trees were taken: wood, branch, and bark. The wood samples and barks were taken from a 5cm disk at DBH. While the branch samples were taken from the lowest one (Dibdiakova *et al.*, 2014). It is worth mentioning that the samples were collected during August (summer season).

Table 2.1 Classes of trees based on their diameters

#	Diameter class	DBH (cm)
1	Large diameter tree class	30-40
2	Medium diameter tree class	19-29
3	Small diameter tree class	8-18

*DBH: Diameter at Breast Height

2.2. Measurements

Following measurements were carried out to find the amount of heating value, lignin content, the basic density, and MC of each tree:

2.2.1. Moisture content (M.C. %)

The wet weight of bark and branch samples were freshly measured in the field using a sensitive electronic balance and the wood samples were kept in plastic bags and directly in the mill their wet weight were measured and recorded. Next, the specimens were oven dried at 105 ± 2º until they reach a constant weight and their dry weight were recorded then used in the following formula in order to measure the moisture content according to American Society for Testing and Materials (ASTM D4442-07):

$$\text{MC \%} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Dry weight}} \times 100 \qquad (1)$$

2.2.2. Basic density

The wet volume of regularly shaped specimens with dimensions (20 × 20 × 60) mm were measured by multiplying the width by the length by the height. In the other hand, the volume of irregular shaped specimens as bark were calculated from the effect of displacement of the specimen by water (Archimedean principle)(Figure 2.2), in order to measure their basic density according to Association French Normalization Organization Regulation (AFNOR 1942) for small dimensions of wood using the following formula:

$$\text{Basic density} = \frac{\text{Dry weight}}{\text{Wet volume}} \ \text{g/cm}^3 \qquad (2)$$

Figure 2.2 Measuring of wet volume (Archimedean principle)

2.3. Chemical composition

The following two steps were carried out to find the amount of lignin in each sample:

2.3.1. Extracting the extractives

The oven dried samples were grinded to pass a 0.4 mm sieve and settle on 0.6mm sieve. Then 2 g of each samples were soxhlet extracted to remove the extractives and this is done by using four solvents: water, ethanol, chloroform, and then acetone for eight hours per solvent. The resulted samples represent the lignocellulose (Fukushima and Hatsfield, 2004) and (Diehl, 2014).

2.3.2. Isolation of lignin from lignocellulose

The process of lignin isolation involved two steps of hydrolysis. The first hydrolysis was by adding 15 ml of 72% H_2SO_4 to 1 gram of each extractive-free sample and stirred by a glass rod every 15 minutes, to ensure the dissolving of sample in the acid, for two hours at 20Cº. The second hydrolysis was diluting the concentration of H_2SO_4 to 3% by adding 560 ml of distilled water to each sample and boiling them in a water bath at 100Cº to complete the hydrolysis with periodical stirring. After that, the samples were filtered by glass crucible filters and the residues that represent acid-insoluble lignin were washed with hot water many times, to remove the remaining of the acid. Then the crucibles were oven dried at 105 ± 2Cº until reach to constant weight. It is worth mentioning that the crucibles were oven dried before the filtration process and their constant weight were recorded so the weight of Klason lignin can easily be determined by subtracting the total weight of crucible and the residue from the crucible weight, the results gave the amount of lignin (Lin and Dence, 2012). Then the lignin content in the tested samples were calculated for each determination according to TAPPI-222 (2006) as follows:

Lignin% = A 100 / W (3)

Where
A= Weight of lignin in grams
W= Oven-dry weight of tested samples in grams

2.4. Determination of heating value

The heating value (H.V.) or calorific value is the amount of energy released during the burning of the fuel (Adegoke and Mohammed, 2002). The heating value for the tested specimens were measured by using the bomb calorimeter (GALLENKAMP Auto bomb). Where the calorimeter was first calibrated with benzoic acid. Then 1 gram of each non-extracted oven-dried samples that passed a 0.6mm (60-mesh) sieve was connected to the cotton thread which is connected to the firing wire in the crucible. The bomb was filled with oxygen and the calorimeter vessel was filled with water (2 liters of water). The bomb placed inside the vessel which in turn placed into a water jacket. Then the bomb calorimeter operated for about 10-15 minutes (Turinawe *et al.*, 2014); (Ojelel *et al.*, 2015). The first temperature which is recorded by a sensitive thermometer is considered as initial temperature of water then after bombing the final temperature was recorded and the heating value was calculated using the following formula (Swarnalatha *et al.*, 2009):

$$Q=MC\Delta T \quad (4)$$

Where:
Q= Heating (calorific) value (J/g)
M= weight of sample (g)
C= capacity of the bomb calorimeter (12601.76)
$\Delta T = FT - IT$ (Cº)
FT= Final Temperature
IT = Initial Temperature

2.5. Statistical analysis

The study had been applied as factorial experiment in a Randomized Complete Block Design (RCBD). And the comparison between the means were carried out according to ANOVA test and Duncan's multiple test ($P<0.05$) were used for testing significant differences between average tested parameters. In addition, Pearson correlation analysis between the tested parameters were accomplished by using a computerized program of Minitab program (Minitab18).

3. RESULTS AND DISCUSSION

3.1. Moisture content

The highest value of moisture content (181.7%) was from the wood part of a large diameter class of *Populus nigra* where the water was continuously flowing during the cutting process; whereas the lowest value was (17.5%) from the bark of a medium diameter class of *Quercus aegilops* (Table 3.1). The results show highly significant differences in the means of MC% in all study factors ($P<0.001$) as shown in Table 3.2. It is worth mentioning that MC% of wood differs from season to season and also depends on the storage conditions, as it is a hygroscopic material. Furthermore, the MC% reduces the heating value, since some of the energy evaporates during the burning process. So, the lower the sample's moisture content the higher the heating values for energy targets (Demirbas, 2002).

3.2. Basic density

The values of basic density ranged between (0.33 g/cm^3) for the wood of a large diameter tree of *Populus nigra* to (0.82 g/cm^3) for the branch of a small diameter tree of *Quercus aegilops* (Table 3.1). The means of basic density has a strong significant difference in species ($P<0.001$) where the *Quercus aegilops* was denser than *Populus nigra*. Likewise in the means of basic density in parts of tree ($P<0.001$) where the denser part was branch, bark, and then wood. While the means of basic density in the diameter classes of trees was not significant ($P>0.05$) as shown in table 3.2. Many reasons are beyond the variation in basic density including tree species, environmental factors and size of trees (Yeboah *et al*., 2014).

3.3. Lignin content

The highest value of lignin found in the bark of a medium diameter tree of *Quercus aegilops* (34.5%) , while the smallest value (13.5%) found in the wood sample of the medium diameter tree of *Populus nigra* (Table 3.1). Furthermore, there was a highly significant difference in the means of lignin of species, diameter classes, and parts of tree ($P<0.001$), which indicate to the preference of *Quercus aegilops* over *Populus nigra* due to its higher lignin content (Table 3.2). The results predilection in woody biomass utilization to the bark, branch, and then wood owing to their values of lignin content, because the highest lignin content will give a highest heating value (White, 2007; Telmo and Lousada, 2011; Dibdiakova *et al*.,2014). Moreover, the results show that the mean of lignin content in *Populus nigra* 23.6% is close to the value from previous studies conducted by (Guerra *et al*., 2013) which was 24.6% and to the results of the study conducted by (Mustafa, 2004) which was 25.65%, the slight difference may be due to the geographical location of the samples taken for the study. At the same time, the results of *Quercus aegilops* 27.07% agree with previously reported results by (Bodirlau *et al.*, 2007) which was 26.83% for *Q. sessiliflora.* As well as, the results found by (Ahmed and Mustafa, 2011) which was 24.835% and 25.918% for Q. aegilops and *Q. infectoria* respectively.

3.4. Heating value

The heating values ranged from 10.08 MJ/kg from the bark of a large diameter tree in *Populus nigra* to 22.69 MJ/kg from the branch of a large diameter tree of *Quercus aegilops.* Statistically, there was a highly significant difference ($P<0.001$) in the mean of heating values in species where *Quercus aegilops* 20.44 MJ/kg was greater in their heating value compare to *Populus nigra* 17.29 MJ/kg. The results of *Populus nigra* was in line with previous studies by (Álvarez-Álvarez *et al.*, 2018) as they reported the mean of heating value of poplar tree was 18.18 MJ/kg. In addition to that, the findings show significant differences in the mean of heating value in both classes of trees and parts of trees ($P<0.05$) where the smaller classes show less heating value compare to the large and medium classes. Furthermore, the greater value found in branches followed by a slight difference between wood and bark.

Table 3.1 Descriptive statistics for the effect of the main factors on the studied parameters in hardwoods

Factors	MC% Mean±SD (Min.-Max.)	Basic density (g/cm^3) Mean±SD (Min.-Max.)	Heating value (MJ/kg) Mean±SD (Min.-Max.)	Lignin% Mean±SD (Min.-Max.)
Species				
Q. aegilops	45.83±14.2(17.5-65.5)b	0.69±0.07(0.4-0.8)a	20.44±1.08(18.9-22.6)a	27.07±4.1(21.2-34.5)a
P. nigra	99.46±33.6(51.3-181.6)a	0.40±0.07(0.3-0.6)b	17.29±2.28(10-21.1)b	23.61±5.1(13.5-34.2)b
Classes				
Large	85.05±51.4(21.3-181.7)a	0.536±0.1(0.33-0.74)a	18.87±3.36(10-22.6)ab	26.87±4.5(21.6-34.2)a
Medium	65.65±29(17.5-121)b	0.556±0.1(0.30-0.74)a	19.4±1.47(16.1-21.1)a	24.56±5.8(13.5-34.5)b
Small	67.23±24.3(21.3-107.7)b	0.559±0.1(0.31-0.82)a	18.32±1.88(13.8-20.9)b	24.59±4.1(16.1-31.8)b
Parts of tree				
Wood	93.44±45(49.8-181.7)a	0.504±0.17(0.30-0.72)b	18.54±1.89(13.8-21.4)b	21.31±3.9(13.5-27)c
Branch	70.62±24.8(46.5-115.9)b	0.612±0.13(0.43-0.82)a	19.53±2.11(15.1-22.6)a	24.35±1.4(21.3-26.7)b
Bark	53.88±29(17.5-106.7)c	0.535±0.16(0.33-0.78)b	18.53±2.99(10-22.4)b	30.36±3.5(22.3-34.5)a

Means in columns for each factor sharing the same letters are not significantly different (P>0.05).

Table 3.2. the effect of interaction between species and classes on tested parameters

Species	MC%			Heating value (MJ/kg)			Lignin %		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Q. aegilops	45.88c	44.25c	47.37c	21.45a	20.20b	19.67bc	26.98a	27.77a	26.45a
P. nigra	124.23a	87.05b	87.10b	16.29d	18.60c	16.97d	26.75a	21.34b	22.73b

Means in columns for each factor sharing the same letters are not significantly different (P>0.05).

3.5. The interaction effect between the main factors on the studied parameters

The first interaction was between species and diameter classes of trees which reveals the following results: The statistical analysis shows a strongly significant difference (P<0.001) in the means of each of moisture content, lignin, and heating value through the interaction between species and diameter classes of trees. Whereas the mean of basic density was not significant in this interaction (P>0.05). In particular, the results of heating value was higher in *Q. aegilops* classes than *P. nigra* and the values elevated from the small diameter class to larger classes, while in *P. nigra* the medium class shows greater heating value than other classes as shown in Table 3.2. The values of moisture content was higher in the large diameter class of *Populus nigra* with slight difference between medium and small diameter class followed by smaller class of *Quercus aegilops* which shows higher moisture content than other two classes. Moreover, the value of lignin content was higher in larger classes of *Quercus aegilops* than *Populus nigra*.

The next interaction between species and parts of tree was strongly significant (P<0.005) in the means of moisture content and lignin. Where the higher MC found in the wood of *Populus nigra* then branches and finally the bark as well as for the *Quercus aegilops*. Besides, the barks of both species shows higher lignin content followed by branches then the wood. On the other hand, there was significant differences in the means of both density and heating value (P<0.05). Where the branches in both species have higher density than barks and woods with prevailing of *Q. aegilops* over *P. nigra*. Similarly with the results of the parts of trees, where the higher heating value was from the branches then barks and finally wood as shown in Table 3.3.

Table 3.3 the effect of interaction between species and parts of trees on tested parameters

Species	MC%			Lignin %			Basic density (g/cm^3)			Heating value MJ/kg		
	wood	branch	bark	wood	branch	bark	wood	Branch	bark	wood	branch	bark
Q. aegilops	58.56d	49.50d	29.44e	24.10c	24.78c	32.33a	0.67b	0.73a	0.68ab	19.76b	20.87a	20.70ab
P. nigra	128.32a	91.74b	78.32c	18.52d	23.92c	28.38b	0.33e	0.49c	0.38d	17.32cd	18.19c	16.35d

Means in columns for each factor sharing the same letters are not significantly different (P>0.05).

The interaction effect between diameter classes of trees and parts of trees on tested parameters (Table 3.4) shows a strongly significant differences in the mean of moisture content (P<0.001) where the wood of large dimeter classes are moister than other parts followed by branches then barks. It is worth mentioning that branches are moister in larger diameter classes than smaller one and these results agree with previously reported study conducted by (Castro *et al.*, 2017). In addition to significant difference in the means of both density and heating value (P<0.05) where the branches was the denser part that reduces with the increasing of diameter classes followed by the barks then the woods. Also the results of heating values was higher in the branches of medium and large diameter classes. On the contrary, the mean of lignin was not significant (P>0.05). This indicate the occurrence of the variation in density when parts of trees are taken from different diameter classes of trees as well as the moisture content.

Table 3.4 interaction effect between diameter classes and part of tree on studied parameters

Class	Basic density (g/cm^3)			MC%			Heating value MJ/kg		
	Parts of tree			Parts of tree			Parts of tree		
	wood	branch	bark	wood	Branch	Bark	wood	Branch	bark
Large	0.51cd	0.53cd	0.61abc	119.72a	81.50b	53.94de	18.86bcde	19.91ab	17.86de
Medium	0.49d	0.61ab	0.55bcd	85.45b	66cd	45.5e	19.20abc	20.42a	18.58bcde
Small	0.50cd	0.66a	0.51cd	75.15bc	64.36cd	62.19d	17.55e	18.26cde	19.15abcd

Means in columns for each factor sharing the same letters are not significantly different (p>0.05).

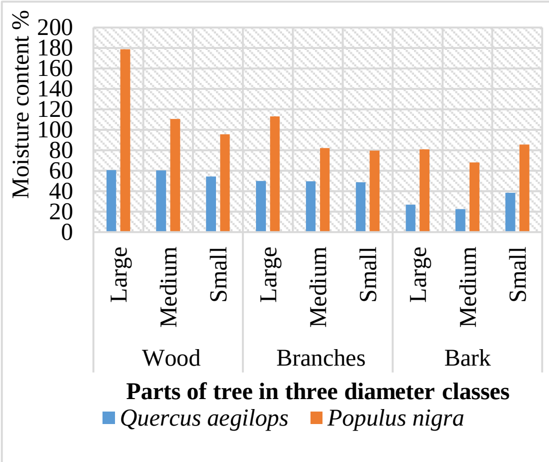
The interaction effect between all tested factors on the tested parameters (Table 3.5) showed a strong significant difference in the mean of moisture content and heating value (P<0.005). Where the wood part of large diameter classes of *P. nigra* was higher in its MC, followed by the other parts; the part which had lowest MC was the bark of a medium diameter class of *Q. aegilops*. Also, a higher heating value Figure 3.2 was obtained from the branches followed by the bark of a large diameter class of *Q. aegilops*, while the results of *P. nigra* showed smaller values. Whereas this interaction was not significant for the means of all other factors (P>0.05).

Specifically, data from Figure 3.1, showed the values of moisture content which is higher in *Populus nigra* in comparison with *Quercus aegilops* especially in the wood part of trees. Typically, the higher the moisture content, the lower the energy released by the burning of the firewood as reported in previous studies (Kakitis *et al.*, 2015; Bhatt and Tomar, 2002; Dibdiakova *et al.*, 2014). According to the results of this interaction, the bark of *Quercus aegilops*, which has lower moisture content and higher lignin content, will have the priority in the utilization of woody biomass for energy purposes, because it will provide higher heating value.

Table 3.5 interaction effect between species, diameter classes, and parts of tree on studied parameter

		Basic density g/cm^3			Lignin content (%)			MC (%)			Height (m)		
		Parts of tree			Parts of tree			Parts of tree			Parts of tree		
Specie	**Class**	**wood**	**branch**	**bark**	**wood**	**branch**	**bark**	**wood**	**branch**	**bark**	wood	branch	bark
Q. aegilops	**Large**	0.69b	0.66b	0.72ab	22.80d	25.20cd	32.96ab	60.77ef	49.97fg	26.89h	20.15bcd	22.19a	22.02ab
	Medi	0.67b	0.73ab	0.66b	25.10cd	24.50cd	33.73a	60.37ef	49.64fg	22.75h	20.09cd	20.37abc	20.15bcd
	Small	0.65b	0.80a	0.66b	24.40cd	24.66cd	30.30b	54.54efg	48.88fg	38.68gh	19.03cde	20.04cd	19.94cd
P. nigra	**Large**	0.33e	0.45cd	0.34e	22.40d	25.33cd	32.53ab	178.67a	113.03b	80.99cd	17.57efg	17.62efg	13.69h
	Medi	0.31e	0.50c	0.44cd	18.70e	22.63d	25.96c	110.549b	82.36cd	68.26de	18.31def	20.48abc	17.02fg
	Small	0.34e	0.51c	0.36de	17.73e	23.80cd	26.66c	95.76bc	79.84cd	85.69cd	16.08g	16.48fg	18.35def

-Means from each column of each factor that do not share a letter are significantly different ($P<0.05$).



Fig,3.1 Moisture content of the part of tree in the study's three diameter classes

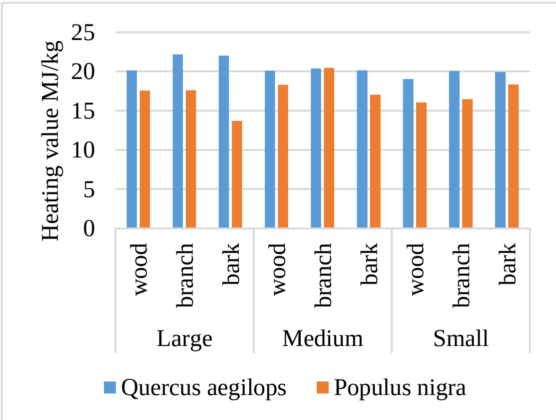


Fig. 3.2 Heating value of the part of tree in the study's three diameter classes

On the other hand, lignin content in Figure (3.3) showed a variation between the parts of tree in the three diameter classes of both tested species. Where the bark of *Quercus aegilops* has the highest amount of lignin regardless to the diameter class of tree indicating the likelihood of its preference for biomass utilization followed by the branches particularly from the large diameter classes of both tested species. These results encourages the utilization of branches and barks from the forests as residual biomass. Consequently, improving the forest health in addition to reducing the forest fire risks.

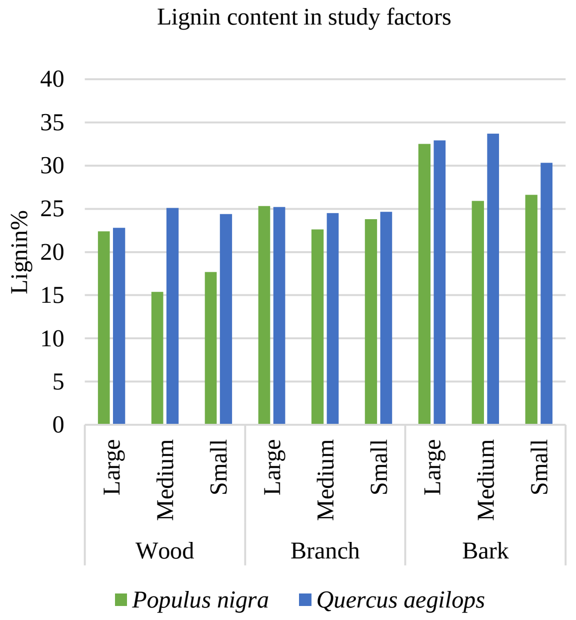


Fig. 3.3 the interaction effect between the study factors and lignin content

Furthermore, the results of basic density in this interaction show that the branches (which were grinded with their barks) are denser than other parts of tree in the study for both tested species with the majority in *Quercus aegilops* (Figure 3.4). Above all, the denser samples, the higher the energy content which make it more preferable for biomass utilization especially for firewood because the energy content in a unit volume of wood depends mainly on its dry mass (Filipe dos Santos Viana, 2018; Nix, 2019). In addition to that, the denser samples will be slower in burning so providing longer time of heating.

3.6. The correlation between studied parameters

The results from Person correlation analysis (Table 3.6) show a strong and negative intercorrelation (P<0.001) between basic density and moisture content (Figure 3.5). The result of MC correlation with basic density is similar to that conducted by Dibdiakova *et al.* (2014). Besides, the findings of heating value show a strong positive correlation with basic density (P<0.001), and a strong negative correlation with MC (P<0.001). Furthermore a strong and negative correlation between Lignin content and moisture content (P<0.001) as shown in Figure 3.6. Also the results revealed a strong positive correlation between lignin content and basic density (P<0.05) as shown in Figure 3.7, which is the same as previous studies by (Vale *et al.*, 2010). Figure 3.8 show the interaction between heating value and basic density.

Table 3.6 Pearson correlations between studied parameters

	Heating value	Basic density	Lignin%
Basic density	0.654		
	0.000		
Lignin%	0.159	0.349	
	0.250	0.010	
MC%	-0.459	-0.742	-0.540
	0.000	0.000	0.000

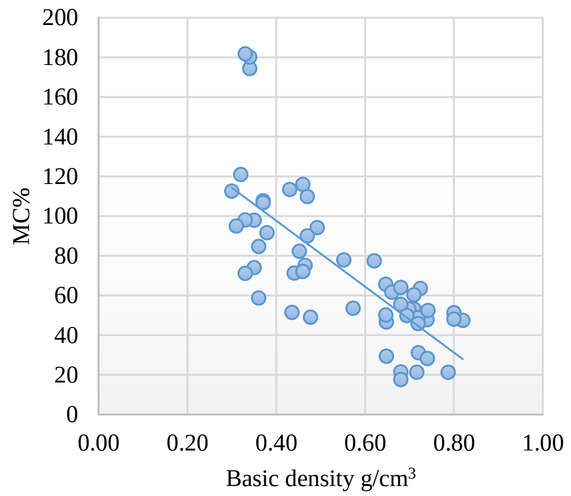


Fig. 3. 5 Pearson correlation between basic density and moisture content

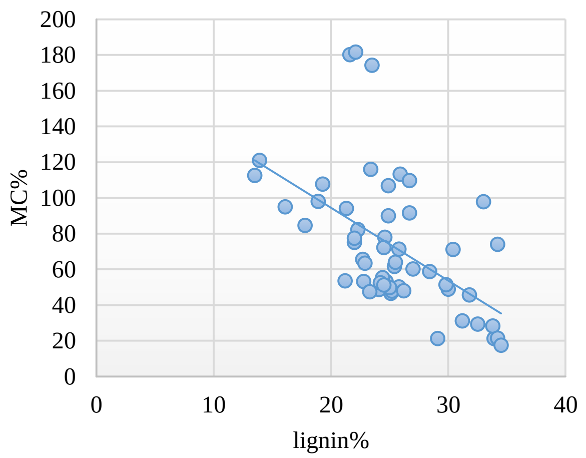


Fig.3. 6 Pearson correlation between lignin content and moisture content

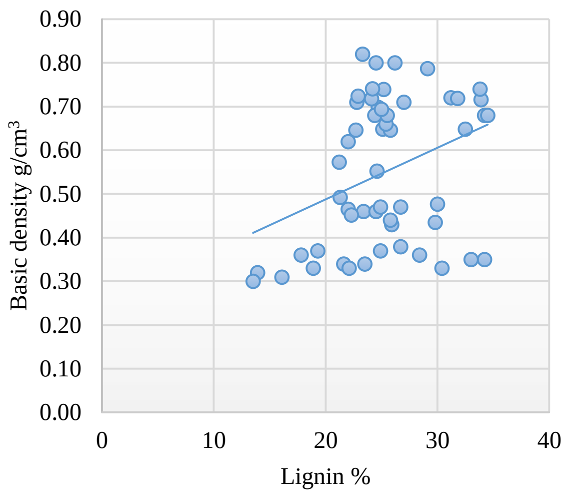


Fig.3. 7 Pearson correlation between lignin content and basic density

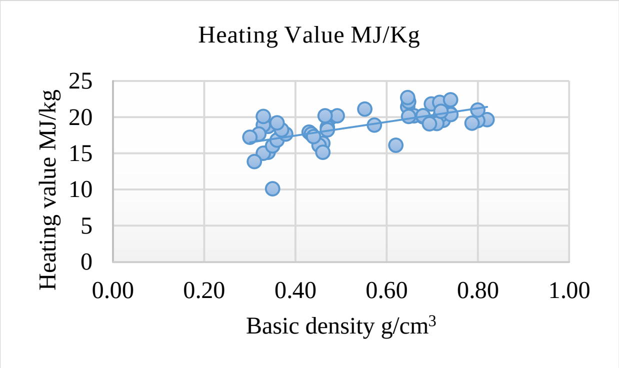


Fig. 3. 8 Pearson correlation between heating value and basic density

CONCLUSION

There was considerable variation between the values of the parameters taken in the study where the heating value strongly varies between species, and between classes and parts of trees As well as, lignin content strongly varies between tested species, parts of trees, and diameter classes of trees. In addition to its variation through the interaction between study factors like species with classes and species with parts of trees. The values of basic density strongly differ between species and between parts of trees. Moisture content was very strongly and negatively correlated with both basic density and lignin content whereas a strong and positive correlation found between basic density and lignin content. The results tend to prefer *Quercus aegilops* over *Populus nigra* as a valuable energy source for the utilization of woody biomass in Amedi District especially its barks because of their higher quantity of lignin content through its interaction with all study factors. No doubt the pruning of branches will provide a good quality of woody biomass since they were very close in their means of basic density to the means of barks and it is greater in lignin content than wood parts in addition to its MC% that is less than its amount in the wood so the collection of all these properties in the branches makes it a better source for woody biomass utilization.

Accordingly, considering the results of this study, the combination of studied parameters: lignin content, heating value, and basic density within two tested factors: barks and branches will be most appropriate in determining the suitability of woody biomass utilization in the study area.

RECOMMENDATIONS

The knowledge on lignin content in different local species is still limited, so this subject require more researches and investigations. In addition to that, understanding of the chemical composition of each species and how they are affected by different factors such as environment, location, their anatomy and even their genetic structure will assist in further recognition of these species.

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پوختە

ڤەكولینەك لسەر نرخێ سوتنێ د دوو جورێن دارێت رەق(hardwood) و رێژا لكنینی دا هاتە كرن بو دەستنیشانكرنا باشترین جور ژبو بكارئینانا وێ بو وەبەرهێنانا داری بو بایوماسی لدەڤەرا ئامیدیێ. مەرەم ژ ڤێ ڤەكولینێ دیاركرنا پەیوەندییا دناڤبەرا جورێ دارا و تیرێ دارا و هەروەسا پارچێن دارا دگەل نرخێ سوتنێ ورێژا لكنینی و تیراتی , ورێژا شە هێ. ژمارا دارین بری بونە 18 دار و 54 سامپل. رێژا نرخێ سوتنێ دناڤبەرا 10.08 MJ/kg د تیڤلێ دارەكا تیرا مەزن ژ سپینداری بو 22.69 MJ/Kg ژ چقێ دارەكا قەبارە مەزن یا بەریێ. ڤێ ڤەكولینێ هەبونا جیاوازیین ئاماری دیاركرن د تیكرایا نرخێ سوتنێ دا دا دناڤبەرا جورین دارا, وتیرێن دارا و پارچێن دارا وهەر وەسا پیوەندیەكا ب هێز د ناڤبەرا تێكرایا نرخێ سوتنێ دگەل رێژا لكنینی (P<0.05) . بەرزترین رێژە بو لكنینی د چقا دا دەركەفت و پاش د داری و تیڤلێ دارێ دا كو رێژێت وان نزیكی ایك بون. پشتبەستن بڤێ چەندێ تیڤلێ دارا و وچەڤێن شكەستی و تاییێت دارا و بەرمایكێن دارستانا دهێنە هژمارتن وەك باشترین وەبەرهێنانا چالاك ژبو بایوماسێ داری.

الخلاصة

تم إجراء دراسة لايجاد القيمة الحرارية لجنسين من الاشجار الصلدة ومحتواها من اللكنين لمعرفة اي الجنسين هو افضل لغرض استثمارها ككتلة حيوية في منطة آميدي. الهدف من الدراسة هو ايجاد العلاقة بين الاجناس, اقطار الاشجار, والاجزاء المأخوذة من الاشجار مع القيمة الحرارية, محتوى اللكنين,الكثافة والرطوبة النسبية. مجموع الاشجار المُسقِطة 18 شجرة و 54 عينة . تراوحت القيم الحرارية مابين 10.08 MJ/kg في قلف شجرة كبيرة من القوغ الى 22.69 MJ/kg لغصن شجرة كبيرة القطر من البلوط. كشفت الدراسة عن وجود علاقة قوية بين متوسطات القيم الحرارية للاجناس, الفئات القطرية, واجزاء الشجرة (P<0.05).اعلى قيمة للوسط الحسابي للكنين ظهرت في الاغصان وتلتها الاخشاب والقلف والتي اعطت قيم مماثلة . استنادا الى ذلك, المخلفات العضوية, الاغصان المكسورة, الافرع, والقلف للاشجار هي الافضل لغرض الاستثمار الفعال للكتلة الحيوية.