DOI: https://doi.org/10.26682/ajuod.2020.23.2.18
Journal of University of Duhok., Vol. 23, No.2 (Agri. and Vet. Sciences), Pp 146-152, 2020

STUDY OF SOME WOOD-CHARCOAL CHARACTERS PRODUCED FROM SOME TREE SPECIES OF DUHOK PROVINCE

DILGASH **F**AYEQYASEEN[*], **M**OHAMMEDAMIN **Y**ASIN **T**AHA[*], **H**ASAN **S**ALEEM **N**ABI[**] and **A**BDULAZIZ **J**AMEEL **Y**OUNIS[*]
[*]Dept. of Forestry, College of Agricultural Engineering Science, University of Duhok, Kurdistan region- Iraq.
[**]Dept. of Horticulture, College of Agricultural Engineering Science, University of Duhok, Kurdistan region- Iraq

(Received: August 16, 2020; Accepted for Publication: September 13, 2020)

ABSTRACT

This investigation was done in the laboratory of college of agricultural engineering sciences – University of Duhok to study some wood-charcoal quality produced from some local wood species in Kurdistan region Iraq. In market, the quality of wood charcoal produced from tree species is varied due to divers' anatomical structure and carbonizing temperature process. As a consequence, understanding the factors controlling the quality of wood charcoal is an important issue for both producers (sellers) and consumers (buyers). In most charcoal factories, wood charcoal are produced without determining of their quality whereas each quality of wood charcoal has its own properties, price and uses. The quality of charcoal made from some selected local wood species (*Quercus aegilops, Salix alba, Malus domestica, and Populus alba*) were evaluated. The woods species were collected from Zaxo district of Duhok province and were transformed into wood-charcoal using a steel kiln for pyrolysis. The analysis of physical and chemicals such moisture content percentage [MCP] , volatile matter percentage [VMP] , ash content percentage [ACP] and fixed carbon percentage [FCP], of the produced wood-charcoal were proximately resolved using the (ASTM D3176 – 15) method. The results showed, for the first time on all around the Kurdistan region of Iraq, the quality of wood charcoal produced from these wood species. The highest value off moisture content (2.375%) was with *Malus domisteca* as compared with *Populus alba* which was (1.000%), highest volatile matter (21.125%) was with *Quercus aegilpops* compared with *Populus alba* (4.125%), high ash content recorded (4.875%) with *Quercus aegilpops* compared with *Salix alba* (2.250%) and the fixed carbon was greater value in *Populus alba* which was (92.125%) compared with *Quercus aegilpops* (72.875%). In addition, these species present significant divergence in term of good quality of wood charcoal and the (*populous alba)* gave the superior quality of wood charcoal from the rest wood species. Therefore, the results of this study have a high assessment for managers of Kurdistan governmental and private charcoal factories as a suggestion which wood species is suitable in order to achieve better quality of wood charcoal.

KEYWORDS: Wood Characteristic, Charcoal, Physical, Chemical, Quality

1. INTRODUCTION

All over the world, demand for energy has exacerbated human dependence on natural resources (Balatsky *et al*,. 2015). More than 50% of wood-from forests worldwide is used for energy production (Dam J. V. 2019). Recent advances in knowledge about the production and properties of charcoal presage its expanded use as a renewable fuel, reductant, adsorbent, and soil amendment (Antal, & Grønli, 2003).

Charcoal is the residue of solid carbon complying with the pyrolysis (carbonization) of some carbonaceous raw materials. Charcoal is utilized basically as fuel for outdoor cooking and heating. (Moscowitz, 1978). However, wood-charcoal is in high demand as it includes energy that duplicates that of frequent firewood and hence burns much hotter, in addition wood-

dilgash_barzani@uod.ac

charcoal is cheap, easily available and very affordable compared to other energy sources like electricity, cooking gas and kerosene (Ekouevi, & Tuntivate, 2011). Pyrolysis at 400°c the conversion of the wood to wood-charcoal is efficiently complete, the wood-charcoal at this temperature still involves an appreciable sum of tar, conceivably 30% by weight entrapped in the structure, this soft burned woo-charcoal needs distant heating to force off extended of the tar and therefore raise the content of fixed carbon of the wood-charcoal to around 75% which is typical for good quality commercial wood-charcoal (Booth, 1983).

Concerning charcoal quality, superior chemical features of wood-charcoal like high levels content of fixed carbon and lower levels content of volatiles and ash are allied with high lignin levels and low levels of extractives and holocelluloses in wood (Dos Santos *et al*,. 2011)

Oak (*Quercus aegilops*), a genus below the family of Fagaceae, is a group of hardwood trees. Oak *spp.* is found in zones of northern temperate, tropical, subtropical and Southern America (Shrestha 2003). This tree grows in areas with 650-2700 meter above the sea level, at temperature between -31C° to +45C° and rainfall between 250 to 900 mm (Saffarzadeh *et al*. 2000).

Salix alba L. (white willow) is a fast growing hardwood tree. It is one of the largest of the *salix* species and can reach heights of up to 30 meter and a diameter of 1 meter or more (Isebrands & Richardson, 2014). It is usually surviving only 20 to 30 years (Praciak , *et al*. 2013).

Apple tree (*Malus domestica* under family of Rosaceae Juss.) is a global cultivated fruit tree. The originality homeland of this tree is Central Asia, where its antecedent *Malus spp.* is still growing wild. The apple tree could reach 3 to 12 meter in height P. (Judžentienė & Misiūnas, 2017).

Populous alba (White Poplar) is a fast growing, hardwood tree that reaches 60 - 100 feet in height with a 40 - 50 foot spread and build a nice shade, neither it is determined short lived. (Edward & Watson, 1994).

The Aims of this study are to study the rate of fixed carbon, ash and volatile matter is commonly selected species which are responsible for a better burning and calorific value, evaluating the quality of wood charcoal made from selected species, comparison between the selected species and find out the best quality among these species, this would help the factories of charcoal producers to determine the best quality of the species and might encourage them to establish a laboratory for testing wood charcoal quality before sending to market and sellers whereas each quality have its own price, and finally to help the buyers and consumers to select the good quality of wood charcoal easily.

2.MATERIAL AND METHODS

1.1. Wood-charcoal samples collection and preparation

The most common wood species used were: (*Quercus aegilops*L., *Populus alba*, *Salix alba*, and *Malus domestica)* from Zaxo district in Duhok province. The charcoal samples after being carbonized at 350 ºC were collected from the BARY MAZI factory of charcoal production in the Duhok province of the Kurdistan region. All wood-charcoal samples were collected in polyethylene bags and afterward taken to laboratory where the samples were prepared, milled, particles that passed through a No. 20(850-µm) sieve and retained on a No. 100 (150-µm) sieve were taken as showed in fig. (1), and stored in air tight plastic bags before taking for analysis of combustion and fuel-related parameters (ASTM D410-84 1988).

The analysis of wood-charcoal samples

The (BS EN ISO 18134-2:2017) method was used for moisture content, where 1gm of the wood-charcoal sample was placed into a suitable crucible, which was then dried at 105 ºC for 2 hours to constant weight and the total moisture/dry solid contents were calculated from the reduction in weight as showed in fig. (1).

(ASTM D3176 – 15 2015) the standard method was practiced for volatile matter, where a dried wood-charcoal sample was placed in a suitable crucible with a close-fitting lid. The crucible and wood-charcoal samples were weighed and heated in a muffle furnace at a temperature of 900 ºC ±10 ºC for 7 minutes. Cool the crucibles with lids in place in desiccators for 1 hour and reweigh as showed in fig. (1).

(ASTM D1102 – 84. 2013) method was used for Ash—Place the lids and the crucible, and containing the sample in the furnace at 750°C for 6 hours. Cool the wood-charcoal samples in

crucibles with lids in a desiccator for 1 hour and weight as showed in fig. (1).

The percentage of fixed carbon [PFC] contents of the samples were estimated by deducting the sum of (VMP), (ACP) and (MCP) from 100 as presented in equation (1) (ASTM D3180 – 15 2015):

The Fixed carbon content = [100 ─ (VM% + AC% + MC%)]……. (1).

This study was calculated by using complete Randomize Design (CRD), there were four treatments with eight replications for each experimental units of wood-charcoal species were taken for analyzing by SAS program (SAS Institute 2015). And the mean of treatments were analyzed by multiple range test Duncan's (Al-Rawi, K. M., & Khalafalla, A. 2000)

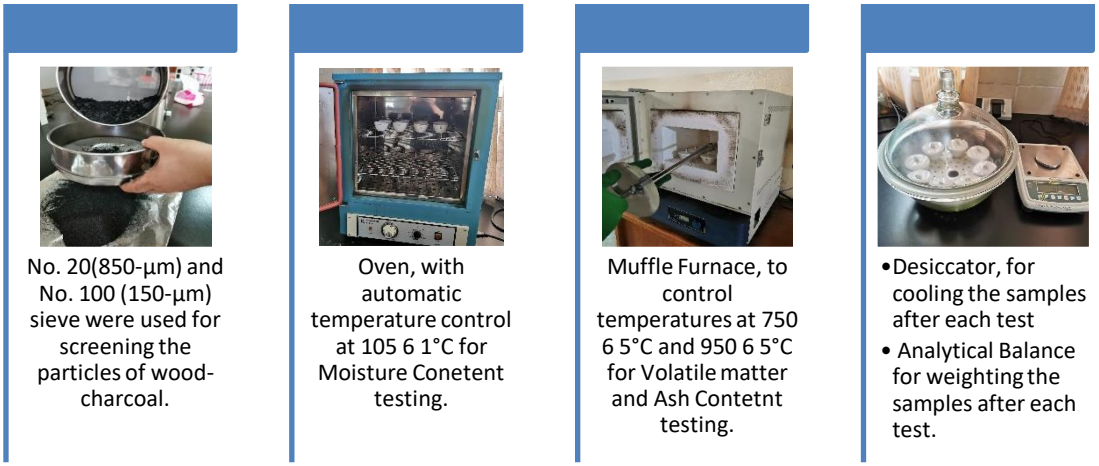

Fig. (1): The equipment that used for analyzing the wood-charcoal samples.

2. RESULTS AND DISCUSSIONS

Table (1): Mean values of charcoal moisture content, volatile matter, ash content and fixed carbon, four species of tree

Tree species	Moisture content (%)	Volatile matter (%)	Ash content (%)	Fixed carbon (%)
Quercus aegilops L.	1.125 b	21.125 a	4.875 a	72.875 d
Salix alba	1.250 b	20.375 b	2.250 c	76.125 c
Malus domestica	2.375 a	13.500 c	3.000 b	81.125 b
Populus alba	1.000 b	4.125 d	2.750 bc	92.125 a

Means of each Species in columns followed with the same letters are not significantly different from each other's according to Duncans multiple range test at 5% level.

2.1. Percentage of Moisture Content

Chemical properties of wood-charcoal revealed significant variance among the different species of wood-charcoal in this analysis. Wood-Charcoal made from *Malus domestica* wood specie significantly had the highest value of moisture content (2.374 %), charcoal from *Salix alba* wood had (1.250 %), charcoal from *Quercus aegilops* wood specie had (1.125%); while wood-charcoal by *Populus alba* wood specie had the lowest value of moisture content (1.000 %) respectively. This is because the high content of moisture make fines and lowers the calorific of wood-charcoal (FAO, 1985). This was because of the nature of water absorbing and low grade of halocelluloses of Oak trees (Stimely & Blankenhorn, 2007). The moisture content values of wood-charcoal manufactured

dilgash_barzani@uod.ac

from various wood species utilized for these analysis reached the acceptable criteria by (FAO, 1985) that the highest limit for moisture content is 7%.

3.2. Percentage of Volatile Matter

Volatile matter percentage in wood-charcoal of *Quercus aegilops* specie introduced distinctly the highest proportion (21.125 %) which had close percentage volatile matter to charcoal from *Salix alba* wood was (20.375 %). Charcoal from *Malus domestica* wood, had percentage volatile matter proportions of (13.500 %). Charcoal from *Populus alba* wood revealed the lowest volatile matter value (4.125%). Table 1 shows the variance between different charcoal samples. The volatile matter in wood-charcoal could be differ from a higher value of 40% to a low value of 5% (FAO, 1985). According to (Oliveira, 1990) regarding wood-charcoal quality, low levels of volatile matters in wood-charcoal are allied with higher lignin level and lower extractives levels of wood species. This was liable for *Quercus aegilops* specie that had more extractives between the different wood samples picked for the manufacturing of wood-charcoal and *Populus alba* specie had the lowest. The High value of volatile matter in wood-charcoal is lighting easily but maybe burn with a smoke while charcoal with lower volatility is hard to ignite and burn clean, however higher volatile matter in wood-charcoal is favoured for some uses like barbecue, while for other uses like purification of chemical and metal production need wood-charcoal with lower content of volatile matter, a good commercial wood-charcoal can have a net content of volatile matter (moisture-free) of around 30%. High volatile matter wood-charcoal is nether friable than normal hard burned low volatile wood-charcoal and so makes fewer fines whiling transport and handling. The volatile matter other than water in charcoal comprises all those liquid and tarry residues not fully forced off in the process of carbonization. If the time and temperature of carbonization are increases, then the volatiles matter content is low and vice versa (Vahrman, 1987).

3.3. Percentage of Ash Content

Percentage ash content in different wood-charcoal had a significant difference. Wood-Charcoal of *Quercus aegilops* wood (4.875 %) had the higher value and a close proportion value of ash content with charcoal of *Malus domestica* wood (3.000%), while wood-charcoal of *Populus alba* and *Salix alba* species had low ash content values of (2.750%) and (2.250%) respectively. According to (Tsoumis, 2009), the presence of high rate of mineral matter in woods is not profitable, whereas they are not degrading whilst carbonizing and they prevail in charcoal as an unacceptable residues that also assist to the lowering of charcoal calorific value. The variation in ash content percentage of wood-charcoal samples is showed in Table1. The ash content of wood-charcoal differ from around 0.5 % to 5% or more, which depends on the wood species used to make the wood-charcoal. A good quality wood-charcoal specifically has a value ash content about 3% (FAO 1985). Fine wood-charcoal may have a very high ash content, buyers naturally suspect fine wood-charcoal and it is difficult to sell and use, unfortunately. (Vahrman, 1987).

3.4. Proportion of Fixed Carbon

There is a significant variance in the portion of fixed carbon between charcoal samples used and the highest portion of fixed carbon were in *Populus alba* species (92.125%). Charcoal samples from *Malus domestica* specie had fixed carbon content value (81.125 %). Charcoal samples from *Salix alba* specie had fixed carbon content value (76.125 %). Charcoal from *Quercus aegilops* specie had the lowest fixed carbon content value of (72.875 %). The difference in fixed carbon percentage is shown in Table 1. The content of fixed carbon of wood-charcoal ranges from a low of 50% to a high about 95% (FAO 1985). According to Dos Santos (2011) on charcoal quality, superior chemical properties of charcoal such as high grades of fixed carbon are allied with high grades of lignin and low grades of extractives and holocelluloses in wood. The proportion of fixed carbon could be controlled by increasing temperature and time of the carbonizing process (Hindi, 1994). Increasing content of the fixed carbon of wood-charcoal in this method is allied with a decreasing the yield of charcoal (Vahrman, 1987).

3. CONCLUSIONS

This research was executed to evaluating the physical and chemical features of charcoal produced from some picked local wood species. The quality of charcoal that manufactured from *populous alba* woods was higher than other species, it has the lowest percentage of moisture content, low ash content and highest fixed carbon value. It is followed by charcoal manufactured from *Malus*

domestica specie. There was little variance in the quality of charcoal from other wood species. The manufacturing and uses of charcoal from different wood species should be given wide broadcasting in Kurdistan due to the impending woods shortage and deficiency of other sources of non renewable energy. It was determined that the carbonized process at degree 350 °C is enough to produce a good quality of wood charcoal and if the temperature of carbonizing process raise to 400-450°C the quality of wood charcoal will be at a high level.

4. REFERENCES

Al-Rawi, K. M., & Khalafalla, A. (2000). Analysis of Experimental Agriculture Design. Dar Al-Kutub for Printing and Publishing. Mosul Univ. Iraq (in Arabic). pp, 488.

Antal, M. J., & Grønli, M. (2003). The art, science, and technology of charcoal production. Industrial & Engineering Chemistry Research, 42(8), 1619-1640.

ASTM D1102 – 84. (2013). Standard Test Method for Ash in Wood.

ASTM D3176 – 15. (2015) Standard Practice for Ultimate Analysis of Coal and Coke

ASTM D3180 – 15 (2015) Standard Practice for Calculating Coal and Coke Analyses from As-Determined to Different Bases

ASTM D410-84 Method of Sieve Analysis of Coal (Withdrawn 1988)

Balatsky, A. V., Balatsky, G. I., & Borysov, S. S. (2015). Resource demand growth and sustainability due to increased world consumption. Sustainability, 7(3), 3430-3440.

Booth, H. E. (1983). Charcoal in the Asia and Pacific Region-problems and possibilities. In FAO/ESCAP Workshop on Charcoal Production and Technology, Bangkok (Thailand), 31 May 1983.

BS EN ISO 18134-2. (2017). Solid biofuels. Determination of moisture content. Oven dry method. Total moisture. Simplified method

Dam, J. V. (2017). The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods. The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods.

Dos Santos, R. C., Carneiro, A. D. C. O., Castro, A. F. M., Castro, R. V. O., Bianche, J. J., de Souza, M. M., & Cardoso, M. T. (2011). Correlation of quality parameters of wood and charcoal of clones of Eucalyptus. Scientia Forestalis, 39(90), 221-230.

Edward F. G. and Watson D. G. (1994). Populus alba White Poplar. Fact Sheet ST-499.

Ekouevi, K., & Tuntivate, V. (2011). Household energy access for cooking and heating: Lessons learned and the way forward. Energy and Mining sector board discussion paper, (23).

Food and Agriculture Organization of the United Nations- FAO (1985). Industrial charcoal making, FAO Forestry Paper No. 63, FAO, Rome.

Hindi, S. S. (1994). Charcoal properties as affected by raw material and charcoaling parameters (Doctoral dissertation, M. Sc. Thesis, Forestry Dept. Faculty of Agriculture, Alexandria University, Egypt).

Isebrands, J. G., & Richardson, J. (Eds.). (2014). Poplars and willows: trees for society and the environment. CABI.

Judžentienė, A., & Misiūnas, A. (2017). Chemical composition of apple-tree (*Malus domestica Borkh.*) leaf essential oils. Chemija, 28(3), 172-176.

Moscowitz, C. M. (1978). Source Assessment: Charcoal Manufacturing: State of the Art (Vol. 1). Environmental Protection Agency, Office of Research and Development, Industrial Environmental Research Laboratory.

Oliveira, E. (1990). Correlations between quality parameters of Eucalyptus grandis (Whill ex-Maiden) wood and charcoal. Technical Bulletin SIF, 2.

Praciak A., *et al*., (2013) The CABI encyclopedia of forest trees. CABI, Oxfordshire, UK.

Saffarzadeh, A., Vincze, L., & Csapó, J. (2000). Determination of some anti-nutritional factors and metabolisable energy in acorn *(Quercus branti), Pistacia atlantica and Pistacia khinjuk* seed as new poultry diets. Acta Agraria Kaposváriensis, 4(1), 41-47.

SAS Institute. (2015). Base SAS 9.4 procedures guide. SAS Institute.SAS Institute.

Shrestha, B. B. (2003). Quercus semecarpifolia Sm. in the Himalayan region: Ecology, exploitation and threats. Himalayan Journal of Sciences, 1(2), 126-128.

Stimely, G. L., & Blankenhorn, P. R. (2007). Effects of species, specimen size, and heating rate on char yield and fuel properties. Wood and Fiber Science, 17(4), 477-489.

Tsoumis, G. (2009). Science and technology of wood: structure, properties and utilization. Science and technology of wood: structure, properties and utilization.

Vahrman, M. (1987). Charcoal made in the pit-tumulus type of earth-kiln. International journal of energy research, 11(1), 133-143.

dilgash_barzani@uod.ac

خاندنا هندەک ساخلەتێن رەژیيا داری هاتینە بەرهەم ئینان ژ هندەک جورێن دارێن د ناڤ پارێزگەها دهوکێ

پوختە

ئەڤ ڤەکولینە د لابورا کولێژا زانێستێن ئەندازیاریا چاندنێ ل زانکویا دهوک ژبو هەلسەنگاندنا جورییا رەژیيا داری یا هاتیە بەرهەمئینان ژ هندەک جورێن دارا کو ل هەرێما کوردستانا عێراقێ هاتیە کرن. دناڤ بازاریدا, جورییا رەژیيا داری ئەوا دهێتە بەرهەم ئینان ژ جورێن دارا یا جیاوازە ژ بەر هەبوونا جوداهییێ دناڤبەرا تویکاریا داری و پروسا کاربونیکرنا داری. دەر ئەنجام, تێگەهێشتنا ئەوان فەکتەرێن جورییا رەژیيا داری کونترول دکەن بابەتەکێ زورێ گرنگە بو هەردوو بەرهەمهێنەرا (فروشیار) و بکارهێنەرا (بکر). دناڤ پرانییا کارگەهێن رەژیيا, رەژوییا داری دهێتە بەرهەم ئینان بێ کو جوراتییا وان بێتە دیار کرن و ئەڤە ژی د دەمەکێدایە کو هەر جوراتییەکا رەژوییێ خودان سالوخەت و نرخ و بکارئینانێن خو یێن تایبەتە. جورییا رەژیيا داری ئەوێن هاتینە بەرهەم ئینان ژ هندەک جورێن دارێن ژێگرتی د ناوچا کەمەری دا وەک (Quercus aegilops، alba Salix، domisteca Malus ،و alba Populus) هاتینە دیار کرن. جورێن دارا هاتینە کومکرن ل قەزا زاخو ل پارێزگەها دهوکێ و هاتینە گوهارتن ژ بو رەژوییێ ب رێکا بکارئێنانا فرنێن ستیلی. رێژێن کیمیکی وەک: (رێژا سەدی یا شێ ئانکو ئاڤێ [PMC], رێژا سەدی یا ماددەییێن هەلمژی [PVM], رێژا سەدی یا پێکهاتا خوولییێ [PAC], و رێژا سەدی یا کاربونێ نەگور[PFC]) ییێن دناڤ رەژییێن بەرهەم هاتی, نزیک کری هاتنە دیارکرن بکارئینانا رێکا (ASTM D3176 – 15). ئەنجامێن جورییا رەژیيا داری ییێن بەرهەم هاتی ژ هندەک جورێن دارا بو جارا ئێکێ ل سەرتاسەرێ هەرێما کوردستانا عێراقێ هاتنە دیار کرن. بلندترین رێژا شهێ (2.375٪) د جورێ domisteca Malus بەراوردکرن دگەل alba Populus کو (1.000 ٪)، بلندترین رێژا کەرەستێ فیریایی (21.125 ٪) د جورێ Quercus aegilpops بەراوردکرن دگەل alba Populus(4.125 ٪)، بلندبوونا پێکهاتا خولیێ یا تومارکری (4.875 ٪) د Quercus aegilpops بەراوردکرن دگەل alba Salix (2.250٪) کاربونێ نەگوور بلندترین رێژە د alba Populus کو (92.125٪) بەراوردکرن دگەل. Quercus aegilpops (%72.875) زێدەباری هندێ کو وان جورێن دارا جوداهییەکا بەرچاڤ پێشان دا ژ بو جوراتییا رەژیيا داری و جورێ دارا (alba Populus) باشترین جورییا رەژیيا داری دەست خوڤە ئینا ب بەراورد کرن دگەل جورێن دارێن دیتر. لەورا ئەنجامێن مە گرنگییەکا بلند هەنە ژ بو رێڤەبەرێن کارگەهێن رەژیيا ییێن حکومی و تایبەت ییێن کوردستانێ وەک پیشنیار کرنا ڤێ چەندێ کا کیش جورێ داری یێ بکێرهاتییە ژ بو مەرەما بدەستڤە ئینانا جورییا باشتر ییێن رەژیيا داری.

دراسة بعض صفات الفحم الخشب المنتوجة من بعض أنواع أشجار في محافظة الدهوك

الخلاصه

تم إجراء هذه الدراسة في مختبرات كلية علوم الهندسة الزراعية في جامعة دهوك وذلك لتقييم جودة الفحم الخشبي المنتج من بعض أنواع الخشب المحلي في إقليم كوردستان العراق. في الاسواق, جودة الفحم الخشبي المنتج من الانوع الاخشاب المحلية تختلف عن بعضها الابعض وذلك بسبب التركيب التشريحي للخشب وعملية الكربنة التي يتم فيها صنع الفحم الخشبي. ونتيجة لذلك، يعد فهم العوامل التي تتحكم في نوعية الفحم الخشبي من المسال الهامة بالنسبة لجميع المنتجين (البائعين) و المستهلكين (المشترين). في معظم مصانع الفحم، يتم إنتاج الفحم الخشبي دون تحديد جودته، في حين أن كل نوع لها خصائصها واسعارها واستخداماتها المختلفة. وتم تقييم نوعية الفحم الخشبي المصنوع من بعض أنواع الاخشاب المحلية المختارة (*Quercus aegilops*، *Salix alba* ، *Malus domisteca* و *Populus alba*). وقد تم جمع هذه الأنواع من الاخشاب في منطقة زاخو من محافظة دهوك، وتم تحويلها إلى الفحم باستخدام فرن فولاذي لغرض التسخين الحراري. وقد تم اخذ التحليل الكيميائي ومن ضمنها النسبة المئوية للمحتوى الرطوبة [PMC] ، ونسبة المئوية للمادة المتطايرة [PVM]، والنسبة المئوية لمحتوى الرماد [PAC]، والنسبة المئوية للكاربون الثابت [PFC]، من الفحم الخشبي المنتج، باستخدام طريقة ASTM D3176 - 15. وأظهرت النتائج، وللمرة الاولى في جميع أنحاء إقليم كوردستان العراق، جودة الفحم الخشبي المنتج من هذه الأنواع الخشبية. أعلى قيمة من محتوى الرطوبة (2.375٪) كان مع domisteca Malusبالمقارنة مع Populus alba الذي كان (1.000 ٪) ، أعلى نسبة مادة متطايرة (21.125 ٪) كان مع Quercus aegilpops مقارنة مع Populu alba (4.125 ٪) ، ارتفاع محتوى الرماد المسجلة (4.875 ٪) مع Quercus aegilpops مقارنة مع Salix alba (2.250٪) وكان الكاربون الثابت أكبر قيمة في alba Populus الذي كان (92.125٪) مقارنة مع Quercus aegilpops (72.875٪). وبالاضافة الى ذلك، فان هذه الأنواع المحلية من الاخشاب تمثل اختلافا كبيرا من حيث النوعية الجيدة للفحم الخشبي وتبين ان *alba Populus* أعطت جودة عالية للفحم الخشبيمن خلال الاختبار عن بقية أنواع الأخشاب المختارة. وبالتالي, فان نتائج هذه الدرسة لها تقيم وتأثير عال لمديري المصانع الفحم الحكومية و كذلك الاهلية على حدا سواء في اقليم كوردستان و العراق كمعيار لاختيار النوع الانسب للاخشاب من اجل تحقيق جودة افضل للفحم الخشبي.

dilgash_barzani@uod.ac