Journal of Fundamental and Applied Sciences

Research Article

ISSN 1112-9867

Available online at http://www.jfas.info

VALORIZATION OF DATE SEEDS FOR PREPARATION OF BIO ACTIVATED CARBON

F. Z. Benregga[1], A. Maghchiche[*2], R. Nasri[3], A. Jraba[4]

[1]Department of Material Sciences, University of Tebessa, 12000, Algeria

[2]Pharmacy Department, Batna 2 University 5000, Algeria

[3]Department of Chemistry, Constantine University1, 25000, Algeria

[4]Materials Energy and Environment research unit (UR14ES26) University of Gafsa-Tunisia

Received: 21 March 2020 / Accepted: 28 October 2020 / Published online: 01 January 2021

ABSTRACT

The date industry currently produces thousands of millions of metric tons of waste per year. Hence, there is an urgent need to find suitable applications for this waste which are still largely unused. The aim of this research is to value date waste and its potential application for water treatment. Three types of activated charcoal were prepared from the seeds of dates. Different essays were done for each material prepared (moisture rate and ash, pH, concentration, mass, granulometry). The Materials obtained were characterized by different methods like FTIR and BET. The results obtained indicate that the materials prepared from date seeds are low-cost activated carbon with an effective surface similar to commercial activated carbon which has an important economic advantage through the valuation of these wastes.

Keywords: Palm date; Date seeds; Waste valorization; Activated carbon, Adsorption.

Author Correspondence, e-mail: amaghchiche@yahoo.fr

doi: http://dx.doi.org/10.4314/jfas.v13i1.16

1. INTRODUCTION

The date palm (Phoenix dactylifera L.) is considered the most important source of food for both humans in arid and semi-arid regions in the world [1]. The pericarp is an edible part and a seed is considered a by-product and waste [2]. On average, the mass of date seeds varies from 10 to 15% of the total date fruit mass [3]. The date palm is the fundamental element of the oasis ecosystem. It plays a vital role in economic production with the date and by-products (pasta, flour, syrup, vinegar, yeast, alcohol, confectionery, ...). Algeria is the world's second-largest with an annual production of 720 000 tones [4]. Palm dates where most of this production comes from the Arab World (>80%). This fruit has great importance from the nutritional and economic points of view [5]. Dates are one of the main crops in Algeria and represent a major source of income for the majority of the population in the south of Algeria. The fruits of the date palm are commonly consumed in many parts of the world especially in most Arabic countries. Date seeds, by-products of date fruit processing industries, have shown a potential application in the food, fermentation, chemical, and feed industries [6].

Date seeds showed many industrial applications such as a source of edible oil. And could be used in cosmetics, pharmaceuticals and a source of dietary fibers, these are also used for extracting oil for cosmetic and pharmaceutical purposes [7]. Date seeds are generally used as complementary feed materials for animals and poultry [8]. Date seeds are most effective in inhibiting the growth of bacteria as compared to antibiotics. Date seeds have the potential to be used as a supplement for antioxidants in nutraceutical, pharmaceutical, and medicinal products [1]. Date seeds for use as a fertilizer consisting of 70% of date palm wastes and date seeds 30% shrimp and crab shell wastes were reported as good fertilizer containing different elements for the plant growth like potassium, phosphorus and organic matter [9].Replacement of the gas boiler by biomass that uses the date seed [10], as antidiabetic by date seeds drinking [11]. Date seeds as a water filter medium activated carbon are perhaps one of the most widely used adsorbents. It contained distinguished properties to the extensive surface area and internal porosity, as well as their developed surface structure. Date seeds have been recycled into adsorbent for removing of selected heavy metals from artificially contaminated aqueous solutions [12]. Modified date seeds, low cost, minimal pretreatment steps were effectively employed as an adsorbent for remediating Hg^{2+} from aqueous media [13]. The waste utilization could provide economic gain to the farmers, industry, food security, environmental safety, and sustainability.

The objective of the present work was to conduct a preliminary analysis of the date seeds from Phoenix dactylifera L, to develop a low cost, efficient and environment-friendly process by the use of an agro-industrial waste of date palm for the development of value-added products.

2. EXPERIMENTAL

2.1. Materials

Date seeds were used as the raw material, charcoal Merck (Aktivkohle gekörnt etwa 2,5 mm reinst) ultra pur analytical grade, the chemicals used in this study are ortho-phosphoric acid H_3PO_4 (85%), nitic acid HNO_3 (65%), acetic acid CH_3COOH (99%), distilled water.

2.1.1. Preparation of the raw material

The seeds of palm date were collected from the fruits of the Deglet-Nour dates (Phoenix dactylifera L.) from east south of Algeria, shown in (Figure.1), the core represents 7-30% of the weight of the date. After separation of the seeds (Figure.2) from the pulp, they were washed extensively with distilled water and put in an oven at 110 °C for 24 hours, from 10 kg of dates we obtained 1.367 kg of date seeds.

Fig.1. Palm Dates Fruits

Fig.2. Seeds from palm Dates

2.1.2. Carbonization of the date seeds

The carbonization was done in a preheated electric oven (HERAEUS ELECTRIC furnace) at 600°C with for 3hours. The product obtained was crushed by a (RETSCH electric grinder) then sieved, with 1mm sieve. The obtained ground material was kept safe from air in tightly closed bottles.

2.1.3. Chemical activation of date seeds

Some crushed date seeds samples were chemically activated with 10N HNO_3 (Nitric acid) and other samples was activated with phosphoric acid H_3PO_4 (40%) [14,15]. The collected date seeds were washed with distilled water and dried at 110° C for 24h, the seeds were ground, sieved, activated with HNO_3 (10 N) and calcined in an oven at 450° C for 1hour, then washed with distilled water to remove hydrosoluble impurities, the sample obtained dried at 110° C for 24h to obtain seeds activated charcoal.

2.1.4. Treatment of commercial activated charcoal

About 100 g of commercial charcoal was added to 300ml of distilled water and the suspension was stirred for 30 minutes. After filtration, the charcoal was dried at 110°C for 24hours. Activated charcoal was crushed and sieved to 1mm in diameter.

2.1.5. Characterization of seeds activated carbon and commercial activated charcoal

A comparative study between commercial activated charcoal (Merck) and activated carbon of date seeds was carried out to evaluate the efficiency of activated carbon prepared from date seeds as potential adsorbant, differents characterization method were used (acid-base character, moisture and ash content, IR spectroscopy and BET).

1. Determination acid-base character of activated carbon

About 10 g of each type of activated carbon from date seeds and commercial activated charcoal was added to 100 ml of distilled water, with continuous stirring for 30min after filtration the filtrate was tested by a pH meter. The results of the pH of commercial activated charcoal and date seeds activated carbon was shown in (Table.1).

Table 1. pH of commercial and date seeds Activated carbon

Activate carbon	Commercial carbon	Date seeds carbon
pH	6.43	6.75

2. Determination of moisture content

About 5g of each sample was placed in a crucible at 105°C for 1h in an oven and weighed

The Moisture Content of activated commercial charcoal and date seeds carbon was presented in (Table 2).

Table 2. Moisture Content of commercial and date seeds activated carbon

Adsorbents	Moisture content %
Commercial charcoal	1%
Date seeds	1%

3. Determination of ash content

The determination of the ash content was based on the destruction of all organic matter under the effect of high temperature. About 2g of commercial activated charcoal and seeds Activated carbon was put in a porcelain crucible and incinerated in an oven at 550 ± 5°C for 8 hours, then put in a desiccator for 30minutes. The ash content is expressed as a percentage of the dry matter. The results of ash rates of commercial activated charcoal and date seeds activated carbon are shown in (Table.3).

Table 3. Ash rates of commercial and date seeds activated carbon

Adsorbents	Ash %
Commercial charcoal	3.5%
Date seeds	1.5%

The adsorption procedure was done by acetic acid (CH_3COOH) on commercial activated charcoal and seeds activated carbon, the procedure comprises the following steps:

1-About 1g of activated carbon was put in contact with 50 ml of solution CH_3COOH (0.1M) under stirring for 30min.

2- Filtration.

3- Dosage of 10 ml of the filtrate in the presence of 2drop of phenolphthalein with NaOH (0.1M) until neutralization.

2.6. Optimization of the adsorption conditions

2.6.1. Influence of the contact time

About 50 ml of acetic acid (0.1M) is mixed with 1g of each commercial activated charcoal and date seeds activated carbon each one separately and stirred for different contact times ranging from 10 minutes to 60 minutes at 25°C.

2.6.2. Effect of activated carbon mass

Different masses (1-10g) of activated carbon were put in 50 ml of acetic acid solution (0.1M) with stirring for 30 minutes at 25°C.

2.6.3. IR spectroscopy analysis

The infrared analysis was performed on a spectrometer (SHIMADZU) FTIR-8201PC, the frequency range between 400 and 4000 cm^{-1}. The powder is finely ground, sieved and then mixed with KBr (1/300 by weight).

2.6.4. BET isotherm and surface area

Multiple point nitrogen adsorptions analysis (BET) was used to determine the surface area of Activated carbon from palm seeds. The adsorption and desorption isotherms of N_2 at 77°K consist of determining the volume of liquid nitrogen necessary, to form a monolayer of this gas, on the surface of the carbon, in order to measure the specific surface. The adsorption isotherms were obtained using the ASAP2020 type analyzer according to the classic method of Brunauer Emmet and Teller or BET.

3. RESULTS AND DISCUSSION

3.1. Characteristics acido-basic of commercial charcoal and seeds activated carbon

From (Table.1), the activated commercial charcoal and seeds carbon samples were slightly acidic during the activation. The majority of acid groups formed on the surface of the activated carbon, are mainly carboxylic acid, lactone, phenol, and carbonyl functions, during their manufacture predominate on the surface of the pores.

3.2. Moisture and Ash Rates

The moisture content of humidity % and ash % of both date seeds and commercial activated carbon was given in (Table.2 & Table.3). The moisture values were less than 5 %, corresponds to the free water of hydration, the determination of ash% content was based on the destruction of any organic material under the effect of high temperature which was (500 ± 25 C°).The ash content was less than 10 %, these values were in the norms and can be indicative of the quality of the new adsorbent phase from the date seeds.

3.3. Effect of contact time on adsorption

The evolution of the adsorption process as a function of time shows that the new phase adsorbent has a capacity adsorption comparable to commercial activated charcoal. According to the results of (Figures 3,4,5 and 6), based on the variation of the pH. It was noted that the pH of the medium increases, as a function of contact time and the pollutant concentration decreases. Indicated the effectiveness of date seeds for acid removal from the water.

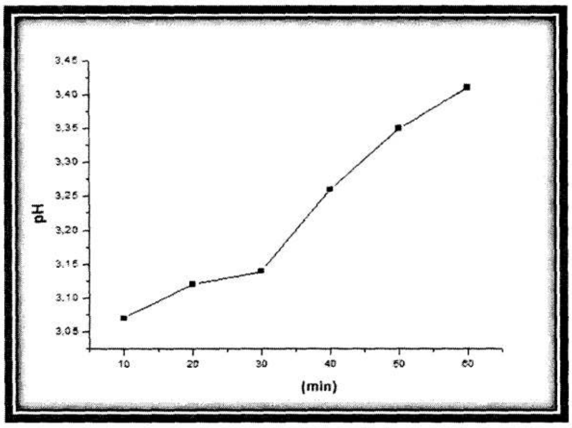

Fig.3. pH versus time variation for date seeds activated carbon

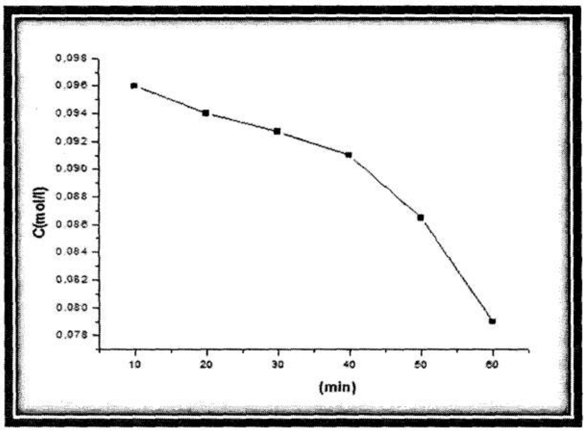

Fig.4. Variation of concentration as a function of time for date seeds Activated carbon

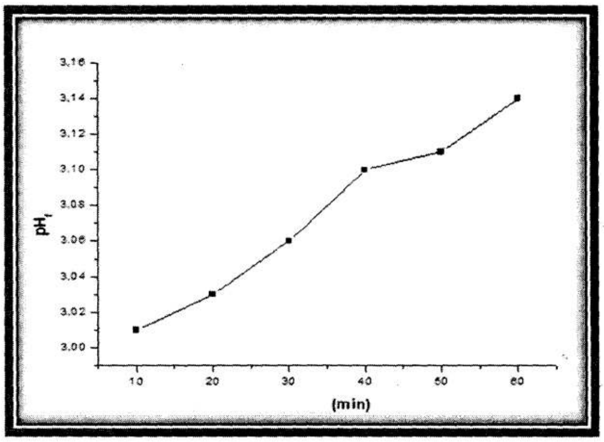

Fig.5. Variation of pH versus time for commercial activated charcoal

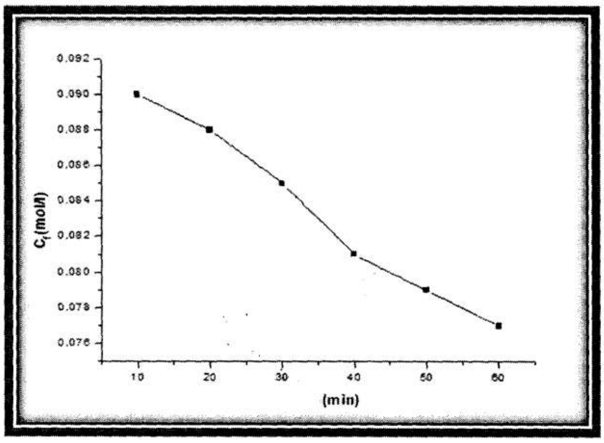

Fig.6. Concentration change as a function of time for commercial activated charcoal

3.4. Effect of activated carbon mass

Based on the Figures (7,8,9, and 10), it was noticed that the pH of the date seeds activated carbon was slightly increased due to the formation of a new functional group contain N, O on the surface of seeds. These functional groups increased the adsorption capacity of the date seeds activated carbon by augmentation of adsorbent mass. The activation of date seeds by phosphoric acid produces activated carbon with larger micro-pores which promote higher molecular mass pollutant adsorption [16]. Many researchers [17-19] used phosphoric acid to increase the activated carbon micro-pores and raise the surface area of adsorbents prepared from different materials. The activated carbon has usually acid functions, which allow a duple reactivity for both anionic and cationic adsorbates [20]. In our study, the samples of date seeds activated by HNO_3 have improved the adsorption rate of acetic acid compared to samples activated by H_3PO_4. Due to the small molecular mass of CH_3COOH adsorbed at date seeds activated with HNO_3, the adsorption was more significant in this phase. We suggest that the activated date seeds with HNO_3 have better adsorption for the low molecular mass pollutants as a result of the increases of the functional groups at the surface of activated date seeds.

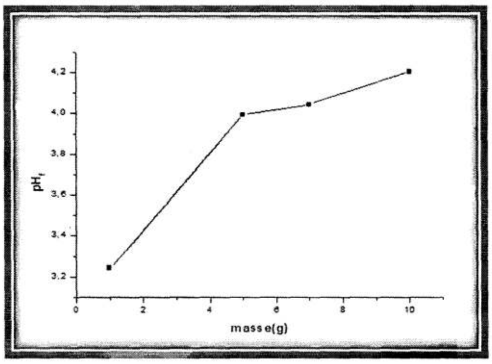

Fig.7. Variation of pH versus masses for date seeds activated carbon with HNO_3

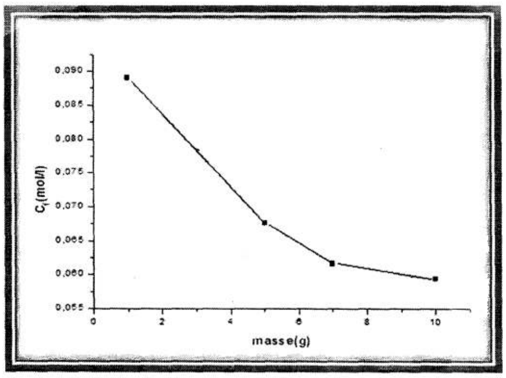

Fig.8. Variation of concentration versus masses of date seeds activated carbon with HNO_3

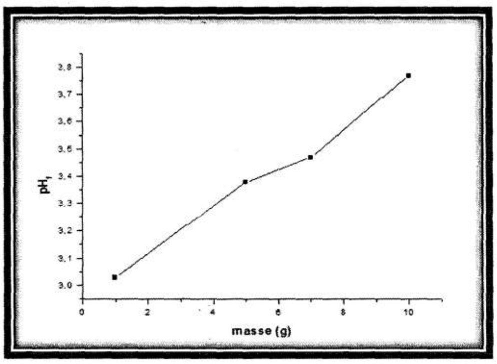

Fig.9. pH variation versus mass of commercial activated charcoal

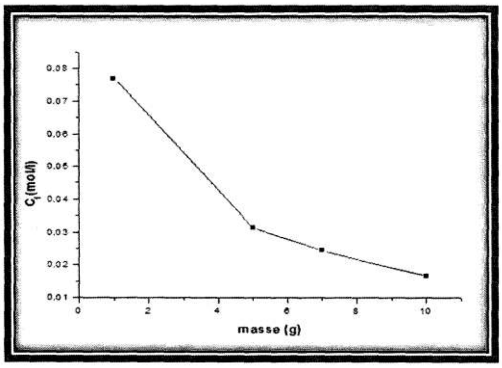

Fig.10. concentration variation versus mass of commercial activated charcoal

3.5. IR spectroscopic analysis

The IR spectroscopy technique is an essential method for the identification of raw and activated carbon constituents. The infrared analysis spectra of the raw material and the prepared activated carbon are shown in the figures below. the analysis was performed over a wavelength range of 400-4000cm^{-1}. The presence of the hydroxyl groups of the phenolic function and the carboxylic function offers an acidic character on the surface adsorbents. While the presence of the carbonyl functions gives basic character to the surface of the adsorbents. We observed that the activated date seeds studied are similar. The only difference lies in the intensity of the peaks, which shows the influence of the treatment on the characteristics of the activated carbon obtained. The main recorded bands are located in the region 3436-3444cm^{-1}, 2922-2927cm^{-1}, 2362cm^{-1}, 1620-1635cm^{-1},1449cm^{-1}. The adsorption bands observed between 3436 and 3444 cm^{-1} are attributed to the presence and vibration of free hydroxyl groups (OH) [21].

The vibration at 3444cm^{-1} (Figure.12) becomes more intense after the adsorption of the CH_3COOH (Figures 13, 14). The bands observed between 2922-2923cm^{-1} (Figure.11 and Figure.12) correspond to the vibration of the symmetrical and symmetrical valence of the C-H bonds present in the alkyl groups [22]. There was also the presence of the peak at 2927 cm^{-1}, this indicated the presence of C-H in the raw date seeds (Figure.12) and the activated date seeds (Figures 13,14). The bands observed in the interval 2362 cm^{-1} (Figure.11) can be attributed to the vibration triple bond of the nitriles C≡N [23]. The bands observed in the interval 1620-1635cm^{-1} can be attributed to the vibration of the C = C bonds of the aromatics [21,22,24]. Other bands also present in the activated date seeds by HNO_3 (1627cm^{-1}) and by H_3PO_4

(1635cm^{-1}). The bands at 1149 cm^{-1} are attributed to the vibration of the C-O bonds.

The spectra in Figures (12, 13, and 14) also show broadband at 1149.5 cm^{-1} attributed to the C-O elongation [24]. This band was also characteristic of phosphorus and phosphocarbon compounds present in the activated carbon of date seeds [25]. The band at 972cm^{-1} that observed clearly only in the spectrum (Figure.14), that of H_3PO_4 activated carbon could correspond to the vibrations of the elongation of P-O-C (aliphatic), of asymmetric elongation of P-O-C (aromatics), elongation of P- O in P = OOH. The P-O functional group was present due to the use of phosphoric acid in the process of preparing the activated. The bands at 667 cm^{-1} (Figures 12, 14) and 568 cm^{-1} (Figure. 13) are due to the C-H of the aromatic rings.

IR of date seeds activated carbon and Commercial activated charcoal confirms the existence of the following functions: O-H, C=C, C-H, C=O, and, C-O. The comparative study between native date seeds and those activated by HNO_3 and H_3PO_4 shows a shift in the values of the peaks and a change in the intensity, especially the O-H vibrations.

From the FTIR results, it is shown that the appearance of functional groups in the date seeds activated by H_3PO_4 occurred due to the impregnation process. The infrared spectra are marked by several absorption bands, indicating the complexity of the surface chemical structure of the activated carbon studied. The results indicated that the studied activated carbon exhibit different functional groups such as hydroxyl, carboxyl, and carbonyl groups, which may be potential sites of adsorption.

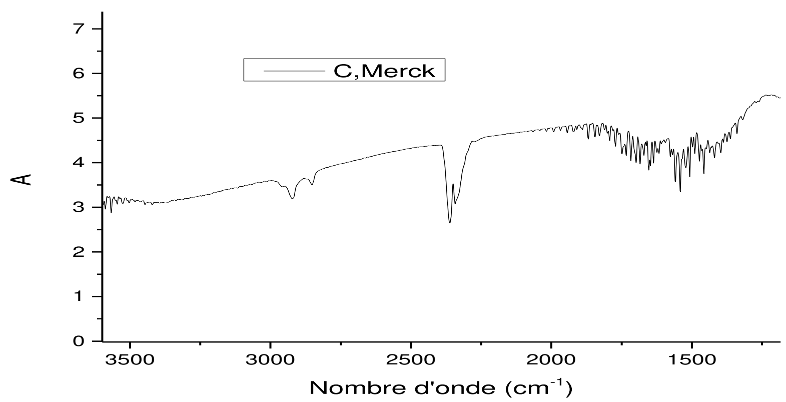

Fig.11. I.R spectrum of Commercial charcoal activated granular (Merck)

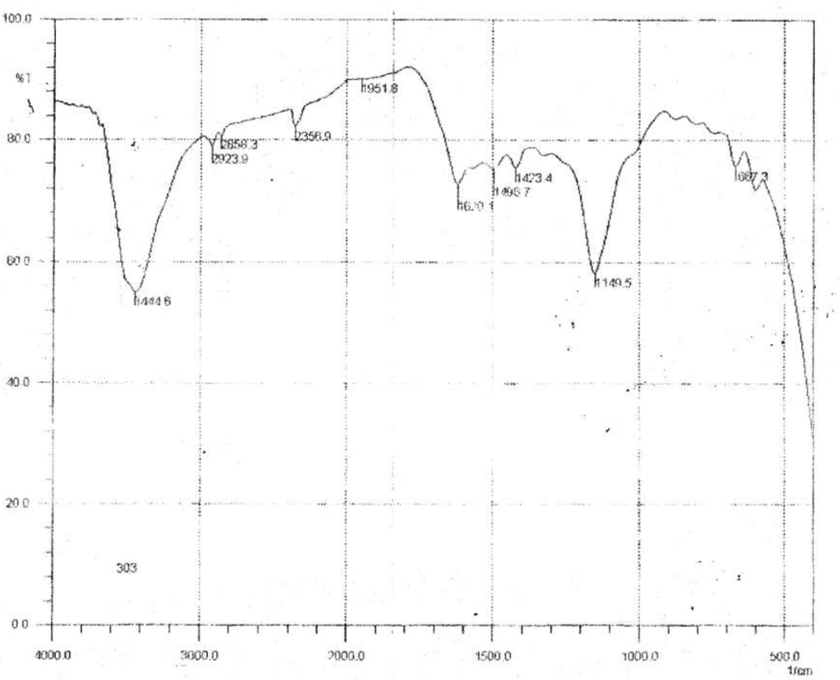

Fig.12. IR spectrum of raw date seeds before activation

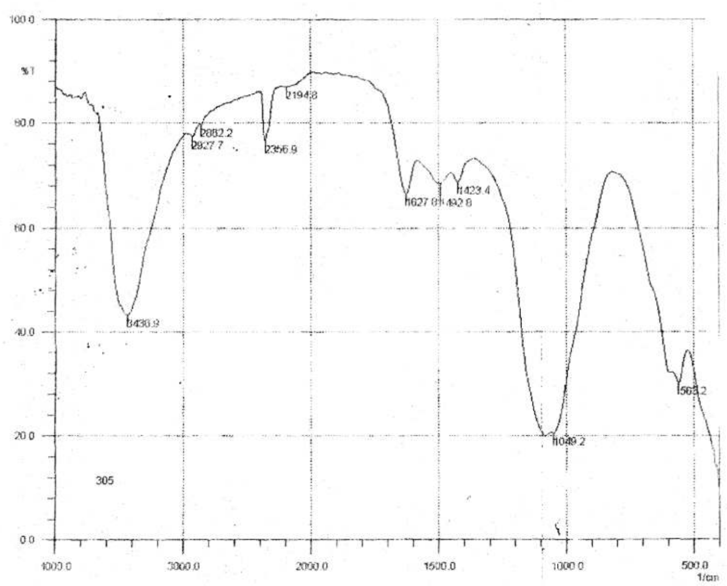

Fig.13. I.R spectrum of seeds dates activated with HNO_3 after adsorption

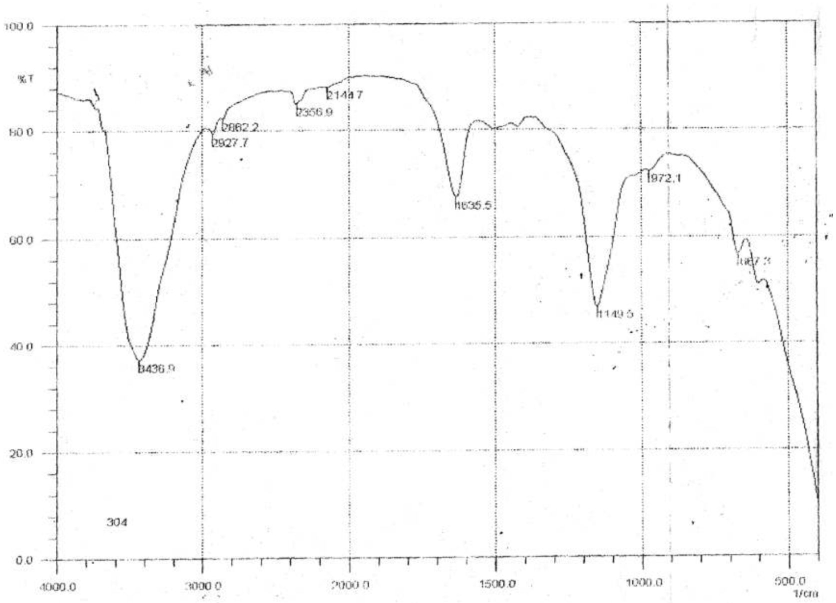

Fig.14. IR spectrum of seeds dates activated with H_3PO_4 after adsorption

3.6. BET isotherm surface area measurement

According to the results of the adsorption and desorption of nitrogen on chemically activated carbon from seeds (Figure.15) and the commercial activated charcoal (Figure.16), the isotherms were of type I isotherm, also known as langmuir isotherm characterized the activated carbon microporous [26,27]. The medium contains only saturated micropores for low values of p/p^0. However, no adsorption occurs at higher values that would fill pores [28]. The isotherm showed that the adsorption was reversible and the amount of gas adsorbed was approaching the limiting value as P/Po → 1. This indicated that the date activated seeds consisted of micropores with a micropores filling mechanism of activated carbon from seeds [29]. The specific surface area of the date's seeds prepared by chemical activation with phosphoric acid was 942,1481m^2/g it was comparable to the specific surface of commercial charcoal which was 1105,1301m^2/g.

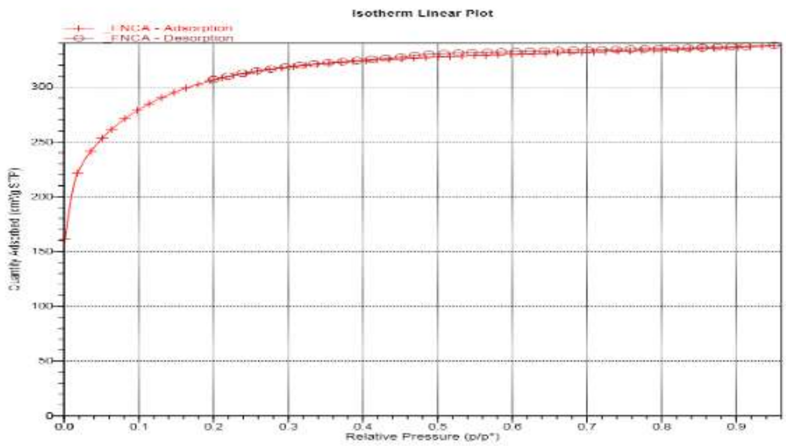

Fig.15. Isotherm of the adsorption and the desorption of N_2 on the activated carbon of the Date seeds activated by H_3PO_4

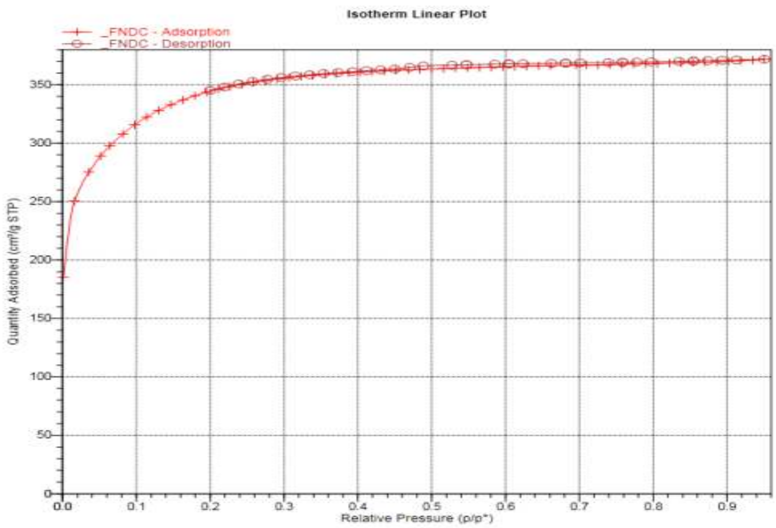

Fig.16. Isotherm of the adsorption and the desorption of N_2 on charcoal activated by H_3PO_4

4. CONCLUSION

Date seeds are waste material from the date palm, show a high potential to be used in the extraction of the bioactive compounds and biomass production. Date palm seeds can be a suitable precursor for the preparation of activated carbon that has been explored. Phosphoric acid and Nitric acid were used as the activating agent, from this study, there are the possible uses of these waste materials as promising green adsorbents, for removing unwanted materials from water and wastewater. Activated carbon prepared from waste palm materials, available locally, efficient and environment-friendly. In order to find an alternative to commercial activated carbon to add considerable economic value, and provide a potentially inexpensive of activated carbon for water treatment.

CONFLICT OF INTEREST STATEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

5. REFERENCES

[1] Al-Farsi M A, Lee C Y. Optimization of phenolics and dietary fibre extraction from date seeds. Food Chemistry, 2008.108 (3), 977-985, doi: 10.1016/j.foodchem.2007.12.009.

[2] Besbes S, Blecker C, Deroanne C, Drira N E, Attia H. Date seeds: chemical composition and characteristic profiles of the lipid fraction. Food Chemistry,2004. 84(4), 577-584.

[3] Hussein A S, Alhadrami G A, Khalil Y H. The use of dates and date pits in broiler starter and finisher diets. Bioresource Technology, 1998.66(3), 219-223, doi10.1016/S0960-8524(98)00054-6.

[4] Manaa S, Younsi M, Moummi N. Study of Methods for Drying Dates; Review the Traditional Drying Methods in the Region of Touat Wilaya of Adrar- Algeria. Energy Procedia, 2013. 36, 521-524, https://doi.org/10.1016/j.egypro.2013.07.060

[5] Al-Mamary M, Al-Habori M, Al-Zubairi A S. The in vitro antioxidant activity of different types of palm dates (Phoenix dactylifera) syrups. Arabian Journal of Chemistry, 2014.7(6), 964-971, https://doi.org/10.1016/j.arabjc.2010.11.014

[6] Hossain M Z, Waly M I, Singh V, Sequeira V, Rahman M S. Chemical composition of date-pits and its potential for developing value-added product-a Review. Polish journal of food and nutrition sciences, 2014.64(4), 215-226, https://doi.org/10.2478/pjfns-2013-0018.

[7] Devshony S, Eteshola E, Shani A. Characteristics and some potential applications of date palm (Phoenix dactylifera L.) seeds and seed oil. Journal of the American Oil Chemists' Society, 1992.69(6), 595-597, https://doi.org/10.1007/BF02636115

[8] Vandepopuliere J M, Al-Yousef Y, Lyons J J. Dates and date pits as ingredients in broiler starting and Coturnix quail breeder diets. Poultry Science, 1995.74(7),1134-1142, DOI: 10.3382/ps.0741134

[9] Khiyami M, Masmali I, Abu-khuraiba M. Composting a mixture of date palm wastes, date palm pits, shrimp, and crab shell wastes in vessel system. Saudi Journal of Biological Sciences, 2008 .15(2), 199-205.

[10] de la Cruz-Lovera C, Manzano-Agugliaro F, Salmerón-Manzano E, de la Cruz-Fernández JL, Perea-Moreno A J. Date Seeds (Phoenix dactylifera L.) valorization for boilers in the Mediterranean Climate. Sustainability, 2019. 11(3), 711.

[11] Saryono S. Date Seeds Drinking as Antidiabetic: A Systematic Review. In IOP Conference Series: Earth and Environmental Science ,2019. Vol.255, No. 1, p.012018. IOP Publishing, doi:10.1088/1755-1315/255/1/012018.1.

[12] Al-Saad K, El-Azazy M, Issa A, Al-Yafei A, El-Shafie A S, Al-Sulaiti M, Shomar B. Recycling of date pits into a green adsorbent for removal of heavy metals: A fractional factorial design-based approach. Frontiers in chemistry, 2019. 7,552, https://doi.org/10.3389/fchem.2019.00552

[13] Al-Ghouti M A, Da'ana D, Abu-Dieyeh M, Khraisheh M. Adsorptive removal of mercury from water by adsorbents derived from date pits. Scientific Reports, 2019. 9(1), 1-15. https://doi.org/10.1038/s41598-019-51594-y

[14] Baccar R, Sarrà M, Bouzid J, Feki M, Blánquez P. Removal of pharmaceutical compounds by activated carbon prepared from agricultural by- Product. Chemical engineering journal, 2012. 211, 310-317, DO -10.1016/j.cej.2012.09.099

[15] Sun Y, Yue Q, Gao B, Huang L, Xu X, Li Q. Comparative study on Characterization and adsorption properties of activated carbons with H_3PO_4 and $H_4P_2O_7$ Activation employing Cyperus alternifolius as precursor. Chemical Engineering Journal, 2012.181, 790-797.

[16] Achaerandio I, Güell C, López F. Continuous vinegar decolorization with exchange resins. Journal of Food Engineering, 2002. 51(4), 311-317.

[17] Kuppireddy SKR, Rashid K, Al-Shoaibi A, Srinivasakannan C. Production and characterization of porous carbon from date palm seeds by chemical activation with H_3PO_4:

Process optimization for maximizing adsorption of methylene blue. Chemical Engineering Communications, 2014.201(8), 1021-1040.

[18] Canales-Flores R A, Prieto-García F. Taguchi optimization for production of activated carbon from phosphoric acid impregnated agricultural waste by microwave heating for the removal of methylene blue. Diamond and Related Materials, 2020. 109, 108027.

[19] Zubir MHM, Zaini MAA. Twigs-derived activated carbons via $H_3PO_4/ZnCl_2$ composite activation for methylene blue and congo red dyes removal. Scientific reports, 2020.10(1), 1-17.

[20] Kra DO, Atheba GP, Drogui P, Trokourey A. Degre d'activation, surface spécifique et fonctions de surfaces de charbons actifs d'Acacia auriculaeformis et d'Acacia mangium/Degree of activation, specific surface area and surface chemistry fonction of activated carbons from Acacia auriculaeformis and Acacia mangium. International Journal of Innovation and Applied Studies, 2017. 20(2), 568.

[21] Sakr F, Sennaoui A, Elouardi M, Tamimi M, Assabbane A. Étude de l'adsorption du Bleu de Méthylène sur un biomatériau à base de Cactus (Adsorption study of Methylene Blue on biomaterial using cactus). Journal of materials and Environmental Science, 2015. 6(2), 397-406.

[22] Minceva M, Fajgar R, Markovska L, Meshko V. Comparative study of Zn^{2+}, Cd^{2+}, and Pb^{2+} removal from water solution using natural clinoptilolitic zeolite and commercial granulated activated carbon. Equilibrium of adsorption. Separation Science and Technology, 2008. 43(8), 2117-2143.

[23] Badr N, Al-Qahtani KM. Treatment of wastewater containing arsenic using Rhazya stricta as a new adsorbent. Environmental monitoring and assessment, 2013.185(12), 9669-9681.

[24] Coates J. Interpretation of infrared spectra a practical approach. Encyclopedia of Analytical chemistry: John Wiley & Sons Ltd, Chichester, 2000. pp. 10815-10837

[25] Puziy A M, Poddubnaya O I, Martınez-Alonso A, Suárez-García F, Tascón J M D. Synthetic carbons activated with phosphoric acid: I. Surface chemistry and ion binding properties. Carbon, 2002. 40(9), 1493-1505, https://doi.org/10.1016/S0008-6223(01)00317-7

[26] Lynch J. Analyse physico-chimique des catalyseurs industriels : manuel Pratique de caractérisation. Editions Technip, 2001,1-313.

[27] Al-Othman, Z. A. A review: fundamental aspects of silicate mesoporous materials. Materials 2012, 5: 2874–2902.

[28] Jraba, A., Anna, Z., & Elaloui, E. Effects of Sr^{2+}, Fe^{3+} and Al^{3+} doping on the properties of TiO_2 prepared using the sol-gel method. Comptes Rendus Chimie 2019., 22(9-10), 648-658.

[29] Ghazali S A, Sapari J M. PREPARATION OF DATE SEED ACTIVATION FOR SURFACTANT RECOVERY. Malaysian Journal of Analytical Sciences, 2017,21(5), 1045-1053, DOI: https://doi.org/10.17576/mjas-2017-2105-06.

How to cite this article:
Benregga FZ, Maghchiche A, Nasri R, Jraba R. Valorization of Date Seeds for Preparation of Bioactivated Carbon. J. Fundam. Appl. Sci., 2021, *13(1), 292-309.*