



Properties of Date Palm (*Phoenix dactylifera*), and Its Applications: A Review

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Abstract: Date palm (*Phoenix dactylifera*), that's commonly found within the center east countries inclusive of the Iran, Iraq, Saudi Arabia, and the US (California) that play a large role within the your budget and the environmental situations in the ones regions. The primary motive of planting dates is its fruits, which is ate up as fresh, dried or the processed forms. There are approximately a hundred million date palm bushes within the worldwide that 62 millions of those trees located inside the center east and the North Africa. In Saudi Arabia most effective, 15000 lots of date palm leaves are ready as the waste substances. The leaves of date palm tree are used in the several packages together with making ropes, baskets, and mats in many elements of the world. Unfortunately, the massive amount of the non-meals merchandise from the date palm remains as landfill substances with none particular utilization. Via interest to the date palm properties, the literature definitely confirmed that each part of the date palm has amazing capability for use for a variety of programs which include: making paper, absorption of heavy and poisonous metals, strength production and soil fertilizing. Present review article designed to be a comprehensive source of recent literature and study on date palm. Cultivation and its applications. This article also intended to covers the recent findings in date palm seed with some interest on physical structure and chemical compositions, including their different commercial applications.

Keywords: Date Palm, Properties, The Applications

1. Introduction

The financial importance of the palm circle of relative's vegetation (arecaceae or palmae) is 2nd most effective to the grass circle of relatives (poaceae) among monocotyledons and the third amongst all plant families after legume (leguminosae). Most of the palm crops, the pinnacle three out of the five primary domesticated palm species inside the international are african oil palm (*Elaeis guineensis*), coconut (*Cocos nucifera*) and date palm (*Phoenix dactylifera*)— the other are peach palm (*Bactris gasipaes*) and betel palm (*Areca catechu*) (FAO, <http://www.Fao.Org>). The financial applications of those fingers are multifold, along with staple meals, liquids, ornamentals, building timber, and commercial materials [1]. (*Phoenix dactylifera*) is a strict dioecious evergreen tree able to presiding over a hundred productive years. It isn't always most

effective one of the oldest domesticated bushes but also of socio-monetary significance [2]. The earliest cultivation of (*Phoenix dactylifera*) became recorded in 3,700 BC within the place among the Euphrates and the Nile rivers [3].

Pakistan is the 6th largest producer of Dates in the world, Palm trees are commonly grown in the dry, tropical and sub-tropical areas. The fruit produced with the aid of the palm bushes are known as dates, which are the consumed as fruits and were used inside the food processing enterprise to put together the extensive range of merchandise which include date cookies, syrup and paste [4, 5]. In keeping with latest reports, there is more 100 e 120 millions date palm tree worldwide, with the middle East and north Africa (MENA) international locations estimated to have extra than 70 e 90% of the share [6]. Historically, the date palm tree and its fruit have been grown and the cultivated as a crop within the

MENA area for hundreds of years. Similarly to providing fruits rich in vitamins, the numerous components of the tree have been used in the beyond for the building boats, safe haven and shades for human as well as generating some commodities together with food trays, rope, fish traps, brushes and the furniture. Nowadays, such use is now not practiced, and therefore, the big amounts of waste produced annually throughout the harvesting length are not utilized. Maximum of the waste is both became compost, burned in boilers to the generate steam [7] or sent to land fill. Definitely, the ultimate two options are not environmentally friendly due to the relateds emissions of greenhouse gases. Several researches have checked out the alternatives to deal with the date palm wastes. This includes the use of the palm tree components as precursors for the development of activated adsorbents as carbon or as a feedstock for the biofuel and biochar. The produced cloth by the first technique confirmed no specific structural capabilities as compared to the available commercial adsorbents [8, 9]. For the reason that palm tree waste is understood to be composed of hemicelluloses, lignin, and cellulose, it should represent a great precursor for biofuel production [10, 11]. In the last many years and in the particular these ultimate years, wood and woody products have performed a huge function as an opportunity for the other artificial substances including carbon and glass. The natural fiber can be in lots of sectors and their programs are developing each day [12]. A number of its utility which can be called are in furnishings, production, motors and so forth [3-15]. Wooden as engineering fabric has a crucial function in developing and the advanced countries [16]. Currently, the sources of timber were lowering whilst the needs for raw timber materials are increasing [17, 18]. However, the pressure at the surroundings has been increasing within the ultimate years,

which resulted within the wooden components converting. Several products such as medium density fiberboard (MDF), laminated strand lumber (LSL), parallel strand lumber (PSL) and so on were manufactured from uncooked timber substances [19]. The environmental concern about uncooked timber materials results in the find alternative resources in place of timber substances [20]. For the years agricultural wastes and residues together with biogases, wheat straw and so on were used [21-23]. Some others alternative aid, which already allotted a huge amount of agricultural residues, is date palm (*phoenix dactylifera*) which can be observed within the lands around the Persian gulf including Iran, Saudi Arabia [24, 25] and other countries like Iraq. In spite of the shortage of water, date palm bushes develop and the provide a few clean fruit and have their own residues. Further, a few different international locations together with the Arabian Peninsula and North Africa, south the US, Mexico, and Pakistan are brought inside the listing of countries that have and bring date palm's fruit. In the line with the food and agriculture agency (FAO) information, about one hundred and five millions date palm bushes are existing inside the world. Center east countries climate is a super state of affairs for date palm plantation [26]. Every 12 months after date palm harvesting, massive portions of residues (frond and leaves) accumulated in the agricultural lands.

2. Date Palm Seed

The Date palm leaves are the maximum residues, which might be produced by using date palm trees yearly; different components of date palm which includes seeds and trunks are utilizable too. But, a few research investigated the usage of these parts in a few programs. The chemical composition and ultimate evaluation of date seeds are shown in tables 1 and 2.

Table 1. Chemical composition of date palm seeds.

	Carbohydrate	Moisture	Dietary fiber	protein	fat	Ash	Ref
Fresh date seed	2.4-4.7	8.6-12.5	67.6-74.2	4.8-6.9	5.7-8.8	0.8-1.1	[27]
Dry seed	81.0-83.1	-	-	5.2-5.6	10.2-12.7	1.1-1.2	[28]
	81.0-83.1	-	-	5.56-5.17	10.19-12.67	1.15-1.12	
	-	10.50	-	5.56	-	1.35	

Table 2. Ultimate Analysis of date palm seeds.

	C	N	O	S	H	Bulk (Kg/m ³)	Ref
Seed	45.3	1	47.2	0.8	5.6	560	[30]
	44.1	0.9	48.3	0.6	6.1	-	[31]

Those residues also are includes many minerals together with the magnesium, potassium, sodium, calcium, iron, phosphorus, zinc, and the copper, nickel, cobalt, chromium, lead and cadmium [32, 33]. The common mass of date palm seeds is about 8-15 wt% of date palm fruit [34]. Further, its miles envisioned that Saudi Arabia has the produced 550000 heaps of date's culminations in 2011 which contains about 55000 tons of date seeds [35]. However, the date fruit manufacturing turned into almost 1084000 lots in Iran in 2013 which could produce one hundred thousand tons of the

date seeds about. Besides, the seeds occupied a big wide variety, which cannot be amassed again and use as a performance fabric. But, the investigations showed that the date seeds are liable to be used as the gasoline manufacturing material and it may be transformed to fuel, high-value liquid (bio-gasoline), and stable (bio-char).

3. Date Palm Chemical Composition

Its miles believed that the suitability of various materials for the distinctive applications needs understanding their chemical composition; due to the dependency of a number of the characteristics which include fungi assault, recyclability, climate resistance, and degradability of the fiber. Therefore, it is essential to realize the chemical composition of materials to use in the right programs Date palm usually consists of

cellulose embedded inside the lignin matrix [36]. By way of the dividing leaf into the separated elements (leaflet and

rachis) because it has shown in the figure 1, the chemical composition of leaflet and rachis are shown in table 3.

Table 3. Shows the average weight percentage of chemical composition of the date palm fibers from leaf (leaflet and rachis) [37, 38].

Constituents	Cellulose	Lignin	Hemi cellulose	Extractive	Ash
Leaflet	40.21	32.2	12.8	4.25	10.54
	54.75	15.3	20	8.2	1.75
	47.14	36.73	16.13	32.86	
	34.87	14.03	19.84		
Rachis	38.26	22.53	28.17	5.08	5.96
	45.16	26.68	28.16	17.45	
	40.40	12.49	33.08		

[39]



Figure 1. Date palm Rachis and Leaflet.

4. Mechanical Homes of Date Palm

Mechanical properties can be affected and determined by a few other factors and the variables including chemicals

composition, micro fibrils attitude, structure, cellular dimensions, and the defects [40-43]. The perspective between the micro-fibrils and fiber axis is referred to as micro fibrillar perspective, which is chargeable for the fibrils mechanical residences. The better electricity and stiffness of the fiber may be attributed to the smaller perspective [44]. The natural fibers which proven the higher mechanical strength usually have better longer cell periods, cellulose content, a better diploma of polymerization of cellulose and the lower micro fibrils perspective. Additionally, a number of the important mechanical homes like younger's modulus and the tensile electricity normally improve with the aid of increasing of the cellulose content material and cell wall [45, 46]. An evaluation among date palm cellulose content material and sisal are shown in table 4.

Table 4. Illustrates the contribution of cellulose at the tensile power and young modulus and approve by growing the cellulose content. The two mentioned residences' growth and as a result, the final homes of the composite will pass up.

Constituents	Tensile strength (MPa)	Cellulose (%)	Elongation at break (%) Date	Young's modulus (GPa)
Sisal	530-630	78	3-7	17-22 [47]
Date palm fiber	58-203	40.21-54.75	5-10	2-7.5 [48]

5. Physical Residences of Date Palm

Several research have been performed at the physical residences of the date palm because is crucial within the suitability for the very last programs. Extraordinary business

packages want a few homes which includes density, thermal conductivity, fee, availability, and the fiber's length, diameter and thing ratio [49, 50]. Density, that is one of the maximum vital physical properties, can have an exquisite function in the enforcing herbal fibers. Figure 2 illustrates an assessment among the date palm and other herbal fibers density.

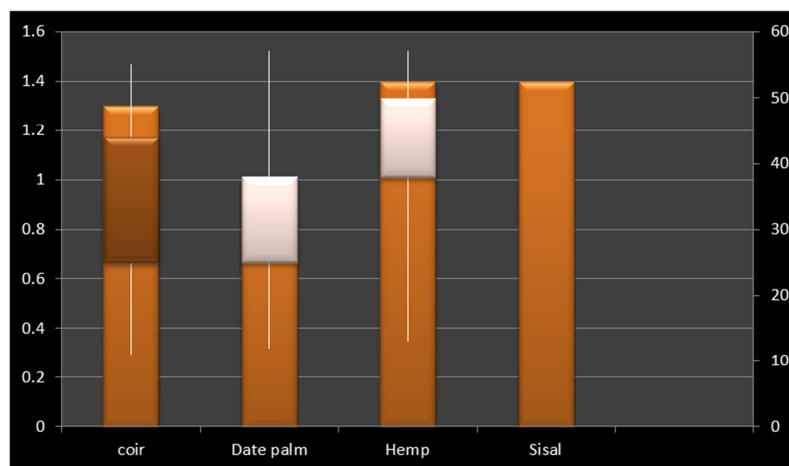


Figure 2. Comparison between date palm and other natural fibers density.

As seen from figure 2, the date palm fiber has the lower density as compared to different herbal fibers, so these assets can lead to having the low-density composites appropriate for car and area application [51]. The opposite physical houses of the date palm in comparison to different natural fibers are indexed in table 5.

Table 5. Comparison between physical properties of date palm and other natural fibers.

Fiber type	Date Palm	Coir	Sisal	Hemp
Length (mm)	20-250	20-150	900	5-55
Density (g/cm ³)	0.9-1.2	1.15-1.46	1.33	1.4-1.5
Diameter (μm)	100-1000	10-460	8-200	25-500
Thermal conductivity (W/m k)	0.083	0.047	0.07	0.115
Specific modulus (approximate)	7	4	17	40

As the visible from table 5, the density of the date palm is lower but the fibers' period is better than the alternative ones. On the other hand, the date palm diameter is larger that can lead the date palm to have an intermediate cost of aspect ratio, which at the stop it is able to be a first-rate assets for the usage of in exclusive packages [52].

6. Applications

Date palm fiber applications and future potentialities date arms are multipurpose trees due to historic cultivation, processing and utilization. Each part of the date palm may be used for one or extra uses. Table 3 illustrates a few uses of diverse elements of the date

fingers. Date palm fibers provides the several applications together with in the fabric, sports item, baggage, vehicles, shelves, mats. Furthermore, surface modified DPF are being brought for making device components like transmission material, air-bag tying cords, conveyor belt cord and a few cloths for industry makes use of. When the bundles of leaves are dried, they're referred to as barest that is used to make roofs, sunglasses, enclosures and the swall separators. Fishing traps are made from ribs of these leaves [53]. DPF possess similar mechanical and physical properties with recognize to other natural fibers, making it suitable for its broader application as building and creation materials, textiles, furnishings and automotive additives besides as every day existence materials.

Table 6. Diverse applications of various parts of date palms (<http://hubpages.com/living/The-VariousUses-of-Date-Palm-Tree>).

Date Palm Part	Usages
Date seeds	Livestock food and decoration beads
Date fruit	Drugs and medical treatment for sore throat and cold, intestinal problems, fever, edema, cystitis, liver, and abdominal problems.
Date Seed Oil	Soap
trunk and wood	Timber, wood, or fuel
Trunk Fiber and Leaves	Baskets, cords, camel saddles, bags, crates, fans, food covers, twines, mats, trays, ropes, paper, and furniture
Dried leaves	Shades, roofs, separating walls, and enclosures
Leaf Ribs	Fishing boats and traps.
Leaf Base and Fruit Stalks	Fuel
Palm Pith	Date palm flour
Date Palms	Control of desertification and ornamental and landscape purposes

7. Paper from Date Palm Rachis Fiber

The amount of intake of paper has increased from 324 million lots in 2002 to 389 million heaps in 2008 [54]. Softwoods are the primary source of the uncooked substances for paper making and the about 5-10% offer from non-timber lingo cellulosic assets which includes cereal straw, canes, etc. The Using agricultural residues or marine biomass is a manner that some nations have taken into consideration. A few international locations investigated the possibility of paper making from date palm fibers including Malaysia [55], Iran [56], Portugal [57, 58], and Tunisia [59, 60]. In step with the literature, the softwood and hardwood fibers duration are approximately 2-3 mm and 1-2 mm respectively. So, their thing ratio is approximately one hundred and 60 at the same time as the date palm issue ratio is ready 40. This variety shows the capability of date palm rachis for pulping. The primary characteristics of date palm rachis pulp are proven in table 4.

Table 7. The Main Properties of Date Palm Rachis Pulp. Reproduction of [60].

Fiber length ^a (mm)	0.89
Fiber width (μm)	22.3
Fine elements (% in length)	30.8
Shopper Riegler degree (OSR)	14
WRV% (w/w on o.d. pulp)	138

8. Conclusions

Date palm is the conventional crop within the center east which has the ability to apply as opportunity aid rather than timber materials for exclusive applications. Even though palm fruit, that's the primary made from palm bushes, is used as the nutrient supply in low-water and desert regions. The residences of various components of which are in a manner, which may be used in different applications. For making paper consistent with issue ratio and the alternative morphological properties, it has super potential this reason. Producing power is some other application of date palm,

that's a renewable power production cloth, and it guarantees that this supply will now not be depleted. The date palm additionally can be used for abruption of heavy and the poisonous metals, soil fertilizing and the opposite application, that have been established via the researchers. Actually, increasing the beneficial uses of fruits and specifically palm waste will boom human beings' interest in planting this crop and might result in sustainable industrial and economic boom in extraordinary regions. Consequently, there is a need to investigate the capacity of using date palm in exceptional packages for encouraging the industries to make cost-brought merchandise from date palm which can be used in future.

References

- [1] Balick, M. J. & Beck, H. T. Useful Palms of the World: a Synoptic Bibliography (Columbia University Press, 1990).
- [2] Mahmoudi, H., Hosseininia, G., Azadi, H. & Fatemi, M. Enhancing date palm processing, marketing and pest control through organic culture. J. Org. Sys. 3, 29–39 (2008).
- [3] Munier, P. Le palmier-dattier Vol. 24 (G P Maisonneuve and Larose, 1973).
- [4] S. Ghnimi, S. Umer, A. Karimb, A. Kamal-Eldina, Date fruit (*Phoenix dactylifera* L.): an underutilized food seeking industrial valorization, NFS J. 6 (2017) 1e10.
- [5] A. Kamal-Eldin, I. B. Hashim, I. O. Mohamed, Processing and utilization of palm date fruits for edible applications, Recent Pat, Food Nutr. Agric. 4 (2012) 78e86.
- [6] L. I. El-Juhany, Degradation of date palm trees and date production in Arab countries: causes and potential rehabilitation, Aust. J. Basic Appl. Sci. 4 (2010) 3998e4010.
- [7] E. Galiwango, A. H. Al-Marzouqi, M. M. Abu-Omar, A. A. Khaleel, N. S. Abdel Figure 12. (a) Overall product yield and (b) composition of the non-condensable gas from the fast pyrolysis of date palm waste. Y. Makkawi et al. / Renewable Energy 143 (2019) 719e730 729 Rahman, Estimating combustion kinetics of UAE date palm tree biomass using thermogravimetric analysis, J. Nat. Sci. Res. 7 (2017) 106e120.
- [8] M. Shoaib, H. M. Al-Swaidan, Ramp rate influence on synthesis of sliced porous activated carbon from date palm tree by physical activation method, Asian J. Chem. 26 (2014) 5295e5297.
- [9] O. Houache, R. Al-Maamari, B. Al-Rashidi, B. Jibril, Study of date palm stem as raw material in preparation of activated carbon, J. Eng. Res. 6 (2008) 47e51.
- [10] W. H. Barreveld, Date Palm Products; FAO Agricultural Services Bulletin Book (101), Food and Agricultural Organization, Rome, Italy, 1993.
- [11] R. A. Nasser, M. Z. M. Salem, S. Hiziroglu, H. A. Al-Mefarrej, A. S. Mohareb, M. Alam, I. M. Aref, Chemical analysis of different parts of date palm (*Phoenix dactylifera* L.) using ultimate, proximate and thermogravimetric techniques for energy production, Energies 9 (2016) 374e388.
- [12] Elseify, L. A., Midani, M., Shihata, L. A., El-Mously, H. (2019). Review on cellulosic fibers extracted from date palms (*Phoenix Dactylifera* L.) and their applications. Cellulose, 26 (4), 2209-2232.
- [13] Torres, F. G., Cubillas, M. L. (2005). Study of the interfacial properties of natural fibre reinforced polyethylene. Polymer Testing, 24 (6), 694-698.
- [14] Alawar, A., Hamed, A. M., Al-Kaabi, K. (2009). Characterization of treated date palm tree fiber as composite reinforcement. Composites Part B: Engineering, 40 (7), 601-606.
- [15] Rokbi, M., Osmani, H., Imad, A., Benseddiq, N. (2011). Effect of chemical treatment on flexure properties of natural fiber-reinforced polyester composite. procedia Engineering, 10, 2092-2097.
- [16] Hegazy, S., Ahmed, K., Hiziroglu, S. (2015). Oriented strand board production from water-treated date palm fronds. BioResources, 10 (1), 448-456.
- [17] Ghosh, S. K., Nag, D., Nayak, L. K. (2009). Composite particle boards from Date-Palm Leaves-A viable substitute of wood/plywood products. Journal of the Indian Chemical Society, 86 (8), 857-862.
- [18] Alotaibi, M. D., Alshammari, B. A., Saba, N., Alothman, O. Y., Sanjay, M. R. et al. (2019). Characterization of natural fiber obtained from different parts of date palm tree (*Phoenix dactylifera* L.). International Journal of Biological Macromolecules, 135, 69-76.
- [19] Moradpour, P., Behnia, M., Pirayesh, H., Shirmohammadli, Y. (2019). The effect of resin type and strand thickness on applied properties of poplar parallel strand lumber made from underutilized species. European Journal of Wood and Wood Products, 1-9.
- [20] Akgül, M., Tozluoğlu, A. (2008). Utilizing peanut husk (*Arachis hypogaea* L.) in the manufacture of mediumdensity fiberboards. Bioresource Technology, 99 (13), 5590-5594.
- [21] Ghorl, W., Saba, N., Jawaid, M., Asim, M. (2018). A review on date palm (*phoenix dactylifera*) fibers and its polymer composites. IOP Conference Series: Materials Science and Engineering, 368, 012009.
- [22] Ashori, A., Nourbakhsh, A., Karegarfard, A. (2009). Properties of medium density fiberboard based on bagasse fibers. Journal of Composite Materials, 43 (18), 1927-1934.
- [23] Han, G., Kawai, S., Umemura, K., Zhang, M., Honda, T. (2001). Development of high-performance UFbonded reed and wheat straw medium-density fiberboard. Journal of Wood Science, 47 (5), 350-355.
- [24] Sivarajasekar, N., Prakashmaran, J., Naushad, M., ALFarhan, B. Z., Poornima, S. et al. (2019). Recent updates on heavy metal remediation using date stones (*Phoenix dactylifera* L.)-date fruit processing industry waste. Sustainable Agriculture Reviews, 34, 193-206.
- [25] Agoudjil, B., Benhabane, A., Boudenne, A., Ibos, L., Fois, M. (2011). Renewable materials to reduce building heat loss: Characterization of date palm wood. Energy and Buildings, 43 (2-3), 491-497.
- [26] Barreveld, W. H. (1993). Date palm products. FAO Agricultural Services Bulletin, No. 101.

- [27] Demirbas, A. (2017). Utilization of date biomass waste and date seed as bio-fuels source. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 39 (8), 754-760.
- [28] Besbes, S., Blecker, C., Deroanne, C., Drira, N. E., Attia, H. (2004). Date seeds: chemical composition and characteristic profiles of the lipid fraction. *Food Chemistry*, 84 (4), 577-584.
- [29] Azodi, R. A., Hojjatoleslami, M., Shariati, M. A. (2014). Comparison of chemical properties of kabkab and shahani palm kernel. *African Journal of Science and Research*, 3 (6), 23-24.
- [30] Sait, H. H., Hussain, A., Salema, A. A., Ani, F. N. (2012). Pyrolysis and combustion kinetics of date palm biomass using thermogravimetric analysis. *Bioresource Technology*, 118, 382-389.
- [31] Hussain, A., Farooq, A., Bassyouni, M. I., Sait, H. H., El-Wafa, M. A. et al. (2014). Pyrolysis of Saudi Arabian date palm waste: A viable option for converting waste into wealth. *Life Science Journal*, 11 (12), 667-671.
- [32] Ali-Mohamed, A. Y., Khamis, A. S. (2004). Mineral ion content of the seeds of six cultivars of Bahraini date palm (*Phoenix dactylifera*). *Journal of agricultural and food chemistry*, 52 (21), 6522-6525.
- [33] Nehdi, I., Omri, S., Khalil, M. I., Al-Resayes, S. I. (2010). Characteristics and chemical composition of date palm (*Phoenix canariensis*) seeds and seed oil. *Industrial Crops and Products*, 32 (3), 360-365.
- [34] Besbes, S., Ghorbel, R., Salah, R. B., Masmoudi, M., Jedidi, F. et al. (2010). Date fiber concentrate: chemical compositions, functional properties and effect on quality characteristics of beef burgers. *Journal of Food and Drug Analysis*, 18 (1), 8-14.
- [35] Guido, F., Behija, S. E., Manel, I., Nesrine, Z., Ali, F. et al. (2011). Chemical and aroma volatile compositions of date palm (*Phoenix dactylifera* L.) fruits at three maturation stages. *Food Chemistry*, 127 (4), 1744-1754.
- [36] Kaur, J. (2020). Date palm as a potential candidate for environmental remediation. *Green Materials for Wastewater Treatment*, 171-190.
- [37] Mirmehdi, S. M., Zeinaly, F., Dabbagh, F. (2014). Date palm wood flour as filler of linear low-density polyethylene. *Composites Part B: Engineering*, 56, 137-141.
- [38] Sbiai, A., Maazouz, A., Fleury, E., Souterneau, H., Kaddami, H. (2010). Short date palm tree fibers/polypoxy composites prepared using RTM process: effect of tempo mediated oxidation of the fibers. *BioResources*, 5 (2), 672-689.
- [39] Nasser, R., Salem, M., Hiziroglu, S., Al-Mefarrej, H., Mohareb, A. et al. (2016). Chemical analysis of different parts of date palm (*Phoenix dactylifera* L.) using ultimate, proximate and thermo-gravimetric techniques for energy production. *Energies*, 9 (5), 374.
- [40] Azwa, Z. N., Yousif, B. F., Manalo, A. C., Karunasena, W. (2013). A review on the degradability of polymeric composites based on natural fibres. *Materials and Design*, 47, 424-442.
- [41] Dittenber, D. B., GangaRao, H. V. (2012). Critical review of recent publications on use of natural composites in infrastructure. *Composites Part A: Applied Science and Manufacturing*, 43 (8), 1419-1429.
- [42] John, M. J., Anandjiwala, R. D. (2008). Recent developments in chemical modification and characterization of natural fiber-reinforced composites. *Polymer Composites*, 29 (2), 187-207.
- [43] Wong, K. J., Yousif, B. F., Low, K. O. (2010). The effects of alkali treatment on the interfacial adhesion of bamboo fibres. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, 224 (3), 139-148.
- [44] Al-Oqla, F. M., Sapuan, S. M. (2014). Natural fiber reinforced polymer composites in industrial applications: feasibility of date palm fibers for sustainable automotive industry. *Journal of Cleaner Production*, 66, 347-354.
- [45] John, M. J., Thomas, S. (2008). Biofibres and biocomposites. *Carbohydrate Polymers*, 71 (3), 343-364.
- [46] Methacanon, P., Weerawatsophon, U., Sumransin, N., Prahsarn, C., Bergado, D. T. (2010). Properties and potential application of the selected natural fibers as limited life geotextiles. *Carbohydrate Polymers*, 82 (4), 1090-1096.
- [47] Jacob, M., Thomas, S., Varughese, K. T. (2004). Mechanical properties of sisal/oil palm hybrid fiber reinforced natural rubber composites. *Composites Science and Technology*, 64 (7-8), 955-965.
- [48] Al-Khanbashi, A., Al-Kaabi, K., Hammami, A. (2005). Date palm fibers as polymeric matrix reinforcement: fiber characterization. *Polymer Composites*, 26 (4), 486-497.
- [49] Alves, C., Silva, A. J., Reis, L. G., Freitas, M., Rodrigues, L. B. et al. (2010). Ecodesign of automotive components making use of natural jute fiber composites. *Journal of Cleaner Production*, 18 (4), 313-327.
- [50] AL-Oqla, F. M., Alothman, O. Y., Jawaid, M., Sapuan, S. M., Es-Saheb, M. H. (2014). Processing and properties of date palm fibers and its composites. *Biomass and Bioenergy*, 1-25.
- [51] Faruk, O., Bledzki, A. K., Fink, H. P., Sain, M. (2012). Biocomposites reinforced with natural fibers. *Progress in Polymer Science*, 37 (11), 1552-1596.
- [52] Chao CT and Krueger R R 2007 The date palm (*Phoenix dactylifera* L.): overview of biology, uses, and cultivation *HortScience* 42 1077-1082.
- [53] FAO. Forests. Food and Agriculture Organization of the United Nations, Rome. 2011.
- [54] Rosli, W. W., Leh, C. P., Zainuddin, Z., Tanaka, R. (2003). Optimisation of soda pulping variables for preparation of dissolving pulps from oil palm fibre. *Holzforschung*, 57 (1), 106-113.
- [55] Hedjazi, S., Kordsachia, O., Patt, R., Latibari, A. J., Tschirner, U. (2009). Alkaline sulfite-anthraquinone (AS/AQ) pulping of wheat straw and totally chlorine free (TCF) bleaching of pulps. *Industrial Crops and Products*, 29 (1), 27-36.
- [56] Antunes, A., Amaral, E., Belgacem, M. N. (2000). *Cynara cardunculus* L.: chemical composition and sodaanthraquinone cooking. *Industrial Crops and Products*, 12 (2), 85-91.
- [57] Cordeiro, N., Belgacem, M. N., Torres, I. C., Moura, J. C. V. P. (2004). Chemical composition and pulping of banana pseudo-stems. *Industrial Crops and Products*, 19 (2), 147-154.

- [58] Aguir, C., M'Henni, M. F. (2006). Experimental study on carboxymethylation of cellulose extracted from *Posidonia oceanica*. *Journal of Applied Polymer Science*, 99 (4), 1808-1816.
- [59] Guezguez, I., Dridi-Dhaouadi, S., Mhenni, F. (2009). Sorption of yellow 59 on *posidonia oceanica*, a nonconventional biosorbent: comparison with activated carbons. *Industrial Crops and Products*, 29 (1), 197-204.
- [60] Khiari, R., Mhenni, M. F., Belgacem, M. N., Mauret, E. (2010). Chemical composition and pulping of date palm rachis and *Posidonia oceanica*-A comparison with other wood and non-wood fibre sources. *Bioresource Technology*, 101 (2), 775-780.