CHEMICAL AND PHYSICAL CHARACTERIZATION OF DATES PALM (PHOENIX DACTYLIFERA L) PRUNING PRODUCTS FOR THE UTILIZATION AS A RAW MATERIAL FOR MDF MANUFACTURING

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ABSTRACT
This research investigates the potentiality of using date palm pruning products (DPPP), which are midribs, fruit bunches and leaflets for production of medium-density fiberboards (MDF) and

INTRODUCTION
Medium-density fiberboards (MDF) show a growing market demand as an adequate substitute for natural wood and engineered wood products (e.g. particleboards) (De Deus, 2015)[1]. MDF properties qualify the material to be used widely in interior and exterior applications especially in furniture due to its high quality of surface due to its homogeneity and strength of fibers used in the production of the boards (Akhtar et al. 2008, Halvarsson et al. 2008)[2]. With the global awareness of deforestation, more research is being devoted to study the different agricultural residues that can enrich the list of suitable raw materials for MDF manufacturing. Agricultural residues rich in fibers, and harvested with huge amounts, are grabbing attention of researchers (Abdel-Baset et al. 2014)[3]. The industrial exploitation of agricultural residues will lead to the building of scientific and technological capabilities, as well as the emergence of successive waves of innovation from rural areas to urban areas of the country. Egypt has huge amounts of date palms exceeding 15 million palms, distributed among 30 governorates.

Table 1 illustrates the governorates possessing more than 1 million palms. Table 2 gives an estimation of the weights of the products of pruning of Siwi palms. Thus, it could be roughly estimated that the palms in Egypt give an additional crop of 810,000 dry tons of pruning products per year (El-Mously et al. 2016) [11]. DPPP are partially used in making crates and in roofing, while the largest percentage of those pruning products remain unused. Thus, huge amounts of DPPP are open-field burnt, causing environmental problems. It should be taken into consideration that the DPPP are seasonal materials, so they should be collected and stored in adequate quantities to ensure a long term production. MDF's production capacity has increased worldwide - especially in Asia - and has reached 100 million cubic meters in 2017 (Figure 1).
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トルーシフ キミナツウ フィジリウシ ノウワジト クリリム シギウタ キラウタ トウ トスクラス キラウタ ナシマハシ キーケン リヘイ フルシャ キラウタ ナシマハシ

توصيف كيمياء و فيزياء لنوافير تقليم نخيل النمار للاستخدام كمادة خام لتصنيع ألواح ليفية متوسطة الكثافة

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أكاديمية الهندسة جامعة عين شمس - القاهرة - جمهورية مصر العربية

1 مركز البحوث والتطوير شركة نجع حمادي للفيبربورد - قنا - جمهورية مصر العربية

الملخص

هذا البحث يحقق من إمكانية استخدام منتجات تقليم نخيل النمار، والتي هي الجريد والعجوب والخوص لإنتاج الألواح الليفية متوسطة الكثافة واقتراح التطبيقات الممكنة للألواح الليفية من وسطة الكثافة المنتجة وفقا للنتائج المحققة. تم تقييم التوصيف الكيميائي والحراري والفيزيائي لثلاثة أشكال من منتجات تقليم نخيل النمار من المواد: الجريدة والعجوب والخوص، على أساس المكونات الكيميائية للمواد الليفية، وقد تم رسم صورة مجهوئية إلكترونية لكل تناح أشكال المواد الخام، أشكال الخام، الألباب. تمت دراسة المقاطع العرضية الطولية والعرضية للمواد الخام لدراسة تكوين منتجات تقليم نخيل النمار. الكلمات المفتاحية: نخلة النمار، نوافير التقليم، ألواح ليفية متوسطة الكثافة، مجهوئ الكتروني، ماسح

Figure 1 MDF production by continent

Table 1 Top Egyptian governorates in palms plantations

<table>
<thead>
<tr>
<th>Rank</th>
<th>Governorate</th>
<th>Amount of palms (Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Aswan</td>
<td>~ 2.5</td>
</tr>
<tr>
<td>Second</td>
<td>Giza</td>
<td>~ 1.8</td>
</tr>
<tr>
<td>Third</td>
<td>Beheira</td>
<td>~ 1.4</td>
</tr>
<tr>
<td>Fourth</td>
<td>New valley</td>
<td>~ 1.3</td>
</tr>
<tr>
<td>Fifth</td>
<td>Sharqia</td>
<td>~ 1.2</td>
</tr>
</tbody>
</table>
Table 2 Estimated weights of pruning products for each Date palm.

<table>
<thead>
<tr>
<th>Parts</th>
<th>Dry weight (Kg.)</th>
<th>Residues of each palm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midribs</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>Leaflets</td>
<td>14.6</td>
<td>27</td>
</tr>
<tr>
<td>Fruit bunches</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Coir</td>
<td>1.56</td>
<td>3</td>
</tr>
<tr>
<td>Midrib base</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>54.16</td>
<td>100</td>
</tr>
</tbody>
</table>

(El-Mously et al. 2016)[11]

MATERIALS AND METHODS

FIBER PREPARATION AND CHARACTERIZATION

The research focuses on the date palm pruning products specifically for the Siwi species which forms the majority of the date palms in Egypt. The pruning products have been pruned during November and December and collected from Bahariya oases, Giza governorate, Egypt. During the raw materials collection process, products have been sorted into three material groups: whole DPPP mixture (midribs, midrib base, fruit bunches, leaflets and coir), palm midribs only and fruit bunches only. In order to prepare the midribs only materials, leaflets have been removed manually by villagers. Each raw material group has been chopped separately using a drum chopper with a 2 mm sieve as a first processing step before further chopping in Naga Hammadi co. factory site. The fibers were continuously produced by softening the raw materials by pre-heating under pressure using ANDRITZ horizontal digester (Size: 10 m, Diameter: 1 m and pressure: 8-8.5 bar. At this stage, decompression occurred gradually without sudden release of pressure. The fibers were subject to 8 bars steam pressure for 4.8 mins. After fibers preparation, they were left for air drying and moisture content was measured till it approximately reached 8%.

CHEMICAL ANALYSIS

The three raw materials were prepared for chemical composition analysis by grinding samples of the materials. The tests aimed to investigate the contents of cellulose and hemicelluloses, along with the lignin and crude fibers. Samples were tested for each material using ANKOM2000 fiber analyzer. The digested fibers were subjected to a defibrator with 250 µm sieve. The fibers were conditioned in labeled polyethylene bags for 12 hours to be ready for work. The chemical analysis was made to evaluate dry content of the raw materials focusing on total extractives. Extractives were determined in two-step extraction process to remove watersoluble and benzene-ethanol soluble materials, hot water extractive, ethanol-benzene extractive.

SCANNING ELECTRON MICROGRAPHS

The three raw materials were prepared to be examined by cutting thin slices of 10 µm thickness using a microtome, Spencer Lens Co. The cuts were taken in the longitudinal and transverse cross sections and were investigated along with the defibrated fibers using the recording processing tools of JEOL scanning electron microscope (JSM-T3304).
RESULTS AND DISCUSSION

CHARACTERIZATION OF FIBERS

The chemical characteristics of midribs, leaves, fruit bunches and fibers are listed in Table 3. Percentages of holocellulose content ranged from (46.8974%) to (61.3295%), percentages of alpha cellulose content from (31.7014%) to (38.9418%), percentages of lignin content from (18.8831%) to (25.4411%), percentages of pentosan content from (15.1959%) to (24.1949%), percentages of water extractives from (10.0601%) to (20.3246%), percentages of solvent extractives from (2.3347%) to (4.9222%), percentages of total extractives from (12.3948%) to (25.2468%). The solubility of the fibers in hot alkali (1% NaOH solubility %) ranged from (29.1356%) to (55.4843%), and lastly percentages of ash content from (2.8483%) to (5.2654%).

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Extractives (%)</th>
<th>Total</th>
<th>Water</th>
<th>Ethanol-benzene</th>
<th>1NaOH</th>
<th>ASH%</th>
<th>H%</th>
<th>C%</th>
<th>P%</th>
<th>KL%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Std</td>
<td>1.8868</td>
<td>2.0388</td>
<td>1.1284</td>
<td>2.6873</td>
<td>0.5529</td>
<td>2.2306</td>
<td>1.9676</td>
<td>1.1015</td>
<td>0.8936</td>
</tr>
<tr>
<td>Leaflets</td>
<td>Average</td>
<td>25.2468</td>
<td>20.324</td>
<td>4.9222</td>
<td>55.484</td>
<td>5.2654</td>
<td>46.897</td>
<td>31.701</td>
<td>15.195</td>
<td>22.590</td>
</tr>
<tr>
<td></td>
<td>Std</td>
<td>8.7954</td>
<td>7.3552</td>
<td>1.8097</td>
<td>19.077</td>
<td>1.8815</td>
<td>15.831</td>
<td>10.650</td>
<td>5.3078</td>
<td>7.6504</td>
</tr>
<tr>
<td>Fruit bunches</td>
<td>Average</td>
<td>12.3948</td>
<td>10.060</td>
<td>2.3347</td>
<td>34.386</td>
<td>2.8483</td>
<td>58.631</td>
<td>38.941</td>
<td>19.690</td>
<td>25.441</td>
</tr>
<tr>
<td></td>
<td>Std</td>
<td>1.5089</td>
<td>0.7546</td>
<td>1.2540</td>
<td>3.3273</td>
<td>0.5510</td>
<td>1.8413</td>
<td>2.1844</td>
<td>1.0165</td>
<td>0.9227</td>
</tr>
</tbody>
</table>

**Table 3 Chemical characteristics of the tested DPPP fibers**

Avg: Average, Std: Standard deviation

According the data in Table 3, the main components of lignocellulosic material (α-cellulose, hemicellulose, pentosane and lignin), while holocellulose content can be arranged from the high to the low value as midribs, fruit bunches and leaflets respectively, alpha cellulose content can be arranged from the high to the low value as fruit bunches, midribs and leaflets respectively, pentosane content can be arranged from the high to the low value as midribs, fruit bunches and leaflets respectively and lignin content can be arranged from the high to the low value as fruit bunches, leaflets and midribs respectively. The percentages of the fiber extractives included the water extractives, solvent extractives and the total extractives. The percentages of solvent extractives can be arranged from the high to the low value as leaflets, midribs, and fruit bunches respectively.

SEM OBSERVATION OF THE TREATED FIBERS

By using JEOL - JSM-5500 LV scanning electronic microscope, the following SEM microphotographs were taken to explain the surface features of treated fibers. The sample was scanned without any chemical treating and it was also pretreated with sodium hydroxide 1%, the best result was obtained when the sample was pretreated with sodium hydroxide 1% before observation. The surface features of midrib fibers are displayed in Figure 3; M-A (500 X) explains a cross-section of midrib vessel element; M-B (2,000 X) explains a magnified view of longitudinal ray cells. The surface features of bunches fibers are displayed in Figure 4; B-A (500 X) explains a cross-section of bunches vessel element; B-B (1,000 X) explains a magnified view of longitudinal ray cells. The surface features of leaflets fibers are displayed in Figure 5; L-A (1,000 X) is showing a cross section of one fibril which is formed from bundles of micro fibrils; L-B (1,000 X) explains a part of ray cells.
EFFECT OF HOLOCELLULOSE CONTENT
Holocellulose can be defined as the total polysaccharide fraction of the fibers or the lignocellulosic composite. It is made up of cellulose (α-cellulose portion) and all of the hemicelluloses. It can be determined by removing the extractives and the lignin content from the fibers or lignocellulosic composite. The cellulose portion is a large and well-organized polysaccharide polymer. It is located in the primary cell wall, while hemicelluloses are branched polysaccharides polymer that are less rigid than cellulose. It is made up of two monomers (pentose & hexose) and able to wrap around the cellulose. One can guess that good mechanical properties of the manufactured panels are related to high holocelluloses content of their composite, but the previous statement is not always right where there are many other factors that can affect the mechanical properties of the manufactured panels. From the chemical properties data in Table 3 and according to the fibers holocellulose content only, one can guess that midribs (61.329%) and fruit bunch fibers (58.631%) have good suitability for manufacturing than leaflets fibers (46.897%), i.e. they can be ordered from high to low value as midribs, fruit bunches and leaflets.
CONCLUSIONS
In the end and based on the results of this study, it can be concluded that DPPP, which are available in huge amounts all over Egypt, can be a potential materials for MDF manufacturing. Using both of midribs fibers and fruit bunches fibers for MDF manufacturing are good solution to face the raw materials shortage in wood based panels industry. MDF manufacturing: not only contributes to reduce the shortage of raw materials but also it solves the environmental problems, which result from burning these pruning products. Leaflets are a lignocellulosic material that contains mild content of holocellulose & α-cellulose. These low contents decrease the mechanical strength properties of the boards. Although leaflets fibers don't comply with the requirements of European Standards, they can be used as co-material in the composite to form the core layer of the particleboards or they could be used for interior purposes.

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REFERENCES