REVIEW

On a dissertation for obtaining the educational and scientific degree "Doctor" in the field of higher education: 5. Technical Sciences, professional field: 5.13. General Engineering, scientific specialty: Technology, Mechanisation and Automation in the Woodworking and Furniture Industry

Author of dissertation: Yasmina Georges Khalaf
Part-time doctoral student at the Department of Mechanical Wood Technology, University of Forestry (UF), Sofia, Bulgaria

Dissertation Topic: Utilization of Lignocellulosic Agricultural Residues for Obtaining Multifunctional Composite Materials

Reviewer: Prof. Dr Viktor Petrov Savov, University of Forestry, Sofia
field of higher education: 6. Agricultural Sciences and Veterinary Medicine, professional field: 6.5. Forestry, scientific specialty: Technology, Mechanization and Automation in the Woodworking and Furniture Industry, appointed as a member of the scientific jury by Order No. ЗПС-405/20.06.2025 of the Rector of the UF

1. Brief introduction of the candidate.

Yasmina Georges Khalaf was born on September 17, 1993, in the Republic of Lebanon. She obtained her Bachelor's degree in Chemistry from the Lebanese University in Beirut in 2014, and in 2016, she received a Master's degree in Physical Chemistry of Materials. Her master's thesis, entitled "Miscanthus x giganteus and Recycled Textile Fibres for the Development of Composite Materials," was partially conducted at IMT Mines Alès, France, which demonstrates her adaptability and experience in international scientific environments. She also has experience mentoring undergraduate students and high school learners from specialized science programs.

Since 2020, she has been a part-time doctoral student (self-funded) at the Faculty of Forest Industry, University of Forestry, Sofia, under the supervision of Assoc. Prof. Dr. Yulia Mihaylova, with scientific consultation by Prof. Dr. Ronald El Hage. Her dissertation focuses on the utilization of lignocellulosic agricultural waste to develop multifunctional composite materials.

The doctoral candidate possesses a solid set of technical skills in material characterization, chemical and thermal treatment, and data analysis. She has also participated in research projects across three international laboratories (Lebanon, France, Bulgaria), coordinated laboratory workflows, co-authored scientific publications and a book, and presented at international conferences.

2. Relevance of the problem.

The dissertation topic is closely aligned with the key priorities of modern science and industry related to sustainable development, circular economy, and the environmentally conscious use of resources. Increasing global environmental pressures stemming from overconsumption, waste generation, and reliance on non-renewable materials necessitate the exploration of alternatives to conventional synthetic materials, especially in composite manufacturing.

In this context, the utilization of lignocellulosic agricultural residues such as Miscanthus x giganteus, rice husks, olive pomace, and spent mushroom substrate represents an especially timely and societally relevant research direction. These underutilized or discarded resources can be transformed into biodegradable, renewable composites with wide-ranging applications, from building insulation to interior elements.

A noteworthy contribution of this work is the use of chitosan as a bio-based binder. Compared to better-studied biopolymers such as tannins, lignins, starches, and proteins, chitosan has been less explored in the production of lignocellulosic composites. Of particular interest is the author's decision to apply non-modified chitosan—avoiding chemical crosslinking or functionalization—which streamlines the process, reduces cost, and maintains the green character of the technology.

Furthermore, the use of green pretreatment techniques, such as steam explosion and phosphorus-based flame-retardant treatments, adheres to modern eco-design principles and aligns with the pursuit of fire-safe, mechanically robust, and sustainable composite panels with a minimized environmental footprint.

Overall, the topic holds strong scientific, ecological, and practical relevance and is positioned at the intersection of material science, environmental engineering, and sustainable industrial technology.

3. Degree of knowledge of the state of the problem and creative interpretation of the literature review.

The doctoral candidate demonstrates thorough and systematic knowledge of the current state of research in lignocellulosic bio-residues, bio-based binders, and sustainable composites. The literature review encompasses 285 sources, covering diverse topics including the chemical composition and properties of agricultural residues, processing techniques, and the performance of the resulting composite materials.

Publications from high-impact international journals and recent scientific findings (2018–2024) have been critically analyzed. The comparison of different categories of bio-binders (tannins, lignins, starches, proteins, chitosan) is especially well-structured, clearly justifying the focus on chitosan as a novel and underexplored option.

The literature analysis is not merely descriptive but reflects a critical and analytical perspective. The candidate synthesizes existing knowledge, identifies gaps, and formulates research questions and hypotheses that logically guide the experimental framework. The review builds a solid theoretical foundation and reflects a high level of scholarly maturity and analytical skill, essential for doctoral-level research.

4. Aim, objectives, hypotheses and research methods. Relevance of the chosen research methodology to the stated aim and objectives of the dissertation.

The aim of the dissertation is clearly defined and aligned with the principles of green chemistry and materials engineering: to develop innovative multifunctional panels from agricultural residues using sustainable raw materials and eco-friendly processing. The research objectives are logically derived and include:

1. Processing and characterization of various lignocellulosic wastes—Miscanthus x giganteus, mushroom waste, recycled textiles, rice husks, olive residues;
2. Development of three types of panels: ultra-light thermal insulation panels; panels bonded with chitosan; and binderless panels relying on cohesion forces;
3. Application of steam explosion and phosphorus-based treatment to enhance fire resistance and adhesion;
4. Comprehensive evaluation using analytical, mechanical, thermal, and microscopic techniques.

The experimental methodology is well-structured, technically sound, and includes advanced analytical tools such as SEM, contact angle, PCFC, optical microscopy, cone calorimetry, mechanical strength tests, and thermal conductivity measurements. Data analysis was supported by appropriate software (e.g., OriginLab, Excel, PowerPoint, Mendeley).

The doctoral student successfully integrates classical and novel methods, enabling her to address a wide range of scientific questions, from fiber morphology to panel performance. The methods are reproducible, appropriate, and effectively implemented. The research objectives have been fully met, and the results offer real solutions to relevant scientific and industrial problems.

5. Visualization and presentation of the results.

The experimental findings are presented in a logically structured and highly readable manner. The dissertation includes 67 figures, 16 tables, and 15 equations that effectively illustrate the obtained results.

The data cover a wide spectrum of studies: morphological analysis (SEM, optical microscopy), thermal behavior (contact angle, PCFC, cone calorimetry), and mechanical and insulating performance. The results are presented with statistical rigor—mean values, deviations, comparisons with control samples and relevant standards (e.g., EN 312 and EN 13171).

Scientific integrity is maintained throughout, with all tests conducted using validated and ethical procedures. Selected results have been corroborated by tests conducted in international laboratories, enhancing their credibility.

Overall, the experimental section demonstrates high quality, precision, and scientific completeness, meeting contemporary standards for doctoral research.

6. Discussion of results and literature used.

The conclusions and generalizations presented in the dissertation are clearly formulated, logically structured, and fully consistent with the aims and tasks of the research. They are based on a systematic analysis of the experimental results and serve as a

natural continuation of the analytical thinking shown throughout the dissertation.

Each conclusion is well-supported by empirical data and is reinforced by both the candidate's own results and comparative analysis with relevant scientific literature. The author does not merely report findings, but rather presents insightful scientific and applied interpretations, identifying cause-effect relationships between raw material characteristics, processing methods, and final composite properties.

For instance, the influence of fiber structure and chemical composition on fire resistance and mechanical strength is convincingly demonstrated. The roles of steam explosion, phosphorus treatment, and the bio-based binder (chitosan) are evaluated critically and without overgeneralization.

The dissertation ends with summarised findings of a contributory nature, alongside recommendations for future research. This reflects the candidate's ability to engage in reflective scientific reasoning and her vision for continued academic development.

The conclusions are thematically organized, numbered, and address the key technological, functional, ecological, and economic aspects of the study. Their clarity and substantiation increase the credibility and scientific value of the dissertation.

7. Contributions of the thesis.

The dissertation presents original scientific contributions as well as scientifically applied and practically relevant results, which have high potential for real-world implementation.

Scientific contribution:

- The dissertation proposes a novel approach involving the use of unmodified chitosan as a natural binder in the production of bio-composite panels made from agricultural residues. This is a significant innovation, as most prior studies employ chemically modified chitosan or combine it with other adhesives.

Applied scientific contributions:

- Three distinct types of composite panels were developed (insulating, chitosan-bonded, and binderless), each demonstrating favorable mechanical, thermal, and fire-resistant properties.
- A phosphorus-based fire-retardant treatment was introduced using phytic acid and urea, offering an environmentally friendly alternative to conventional fire-protection chemicals.
- A wide range of agricultural residues with different chemical profiles (Miscanthus, rice husks, spent mushroom substrate, olive waste, recycled textiles) were examined, broadening the applicability of the method.

Applied contributions:

- A reproducible laboratory methodology was developed involving steam explosion and hot pressing, with potential for industrial scaling.
- The feasibility of producing panels without synthetic resins was demonstrated, aligning with the current trend to reduce formaldehyde emissions in construction materials.
- The final composite panels show strong potential for use as internal insulation materials with enhanced environmental performance and reduced carbon footprint.

In conclusion, the contributions are clearly defined, well-justified, and reflect both the

innovative character and practical utility of the dissertation.

8. Assessment of the extent of the dissertator's personal involvement in the contributions.

The dissertation is the result of substantial and independent research work conducted by the doctoral candidate within the framework of international collaboration involving laboratories in Bulgaria, France, and Lebanon. Yasmina Khalaf has taken active part in all stages of the research process—from formulating the objectives and hypotheses, through the design and execution of experiments, to the interpretation of results and derivation of conclusions.

She has demonstrated high professional competence in organizing and performing complex laboratory work, preparing samples, conducting advanced material testing, and applying appropriate data processing and scientific documentation tools. The doctoral candidate is the first or co-author of peer-reviewed publications and a scientific monograph chapter, and has presented her work at international conferences.

The candidate's methodological decisions, including the choice of materials, processing techniques, and binder systems, reflect originality, independent judgment, and a strong grasp of interdisciplinary research. Her active involvement in writing and analyzing scientific outputs confirms the authenticity and significance of her individual contribution to the presented dissertation.

The level of scientific maturity and analytical thinking demonstrated throughout the research is fully aligned with the expectations for the doctoral degree.

9. Critical comments and questions.

The dissertation is well-structured and scientifically sound. However, one terminological clarification is warranted in relation to the classification of the developed materials. In some parts of the dissertation, the term *particleboards* is used to describe the composite panels obtained. Given the predominant fibrous nature and morphology of the raw lignocellulosic materials used—especially Miscanthus, mushroom substrate, and textile waste—the designation *fiberboards*, *bio-based fiber panels*, or *hybrid lignocellulosic panels* would be more appropriate and scientifically precise.

In addition, the following recommendations may enhance the scope and impact of future research:

- Incorporating a more detailed techno-economic analysis (TEA) of the developed materials could provide valuable insight into their industrial feasibility and cost-competitiveness relative to conventional insulation and construction products.
- Conducting a life cycle assessment (LCA) of the panels would strengthen the environmental validation of the proposed solutions and contribute to their credibility as sustainable alternatives.

These remarks are intended as constructive suggestions and do not detract from the overall positive assessment of the work. Rather, they highlight opportunities for further development and refinement of the research in future studies.

10. Published articles and citations.

During the doctoral study period (2020–2025), Yasmina Khalaf has co-authored four scientific publications, including three peer-reviewed articles published in international journals indexed in Scopus and Web of Science with high impact factors (Q1), and one article indexed in CABI. In addition, she is a co-author of a book chapter published by CABI, a reputable international scientific publisher. These works directly reflect the subject and results of the dissertation and confirm the scientific quality and originality of the research.

11. Assessment of the publications on the dissertation: number, nature of the publications in which they are printed. Reflections in science - use and citation by other authors.

The dissertation's key findings have received international recognition, as evidenced by **47 citations** in peer-reviewed journals, books, and doctoral theses. Citations come from reputable sources, such as *Polymers*, *Construction and Building Materials*, *Gels*, *Biomass Conversion and Biorefinery*, *Journal of the Science of Food and Agriculture*, *Applied Acoustics*, *Frontiers in Nutrition*, *Foods*, *Forests*, *Applied Sciences*, and others.

Notable publications include:

1. Khalaf, Y. et al. (2025). "An extensive study of an eco-friendly fireproofing process of lignocellulosic Miscanthus x Giganteus particles and their application in flame retardant panels," *Polymers*, IF: 5.0, Q1 – cited once.
2. Khalaf, Y. et al. (2024). "Eco-Friendly Chitosan Composites: Transforming Miscanthus, Mushroom, Textile and Olive Waste into Sustainable Materials," *AppliedChem* – cited 3 times.
3. Khalaf, Y. et al. (2021). "Influence of agricultural fibres size on mechanical and insulating properties of innovative chitosan-based insulators," *Construction and Building Materials*, IF: 7.4, Q1 – cited 29 times.
4. Khalaf, Y. et al. (2021). "Innovative fireproof insulating panels from agricultural waste," *Innovations in Woodworking and Engineering Design* – indexed in CABI.
5. Book chapter (2021): "Harvest and postharvest technologies. Mushrooms: Agaricus bisporus," published by CABI – cited 13 times.

These publications and citations clearly demonstrate the originality, relevance, and international recognition of the research conducted within the framework of the doctoral dissertation.

Presented abstract reflects objectively the structure and content of the dissertation.

CONCLUSION:

Based on the presented research methodology, the sound experimental work, the reliability of the data, and the scientific and practical contributions of the dissertation, I conclude that the dissertation of Yasmina Georges Khalaf fully meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria and the regulations of the University of Forestry, which gives me the reason to evaluate it as **POSITIVE**.

The dissertation demonstrates originality, depth of analysis, technical rigor, and international visibility through peer-reviewed publications and citations. The doctoral candidate has clearly shown her ability to conduct independent research and contribute meaningfully to the field of sustainable composite materials.

I confidently recommend that the esteemed Scientific Jury award Yasmina Georges Khalaf the educational and scientific degree "Doctor" in the scientific specialty "Technology, Mechanization and Automation in the Woodworking and Furniture Industry.

Date: July 8, 2025
Sofia

REVIEWER: .....
(Prof. Dr. Viktor Petrov Savov)