A Project Based Oilseed Extraction Research Methodology inspired on IRPM

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Abstract. The proposed work is a project based research methodology inspired by IRPM – Interdisciplinary Research Project Management, and its goal is to support the development of biodiesel from oilseed native *Cerrado*, thus promoting sustainable development of the region *Bico do Papagaio*, state of Tocantins - Brazil. Furthermore, this work intends to be a platform that facilitates future systematic reviews and meta-analyzes, through standardization of procedures and their sequence, because only a well defined and general methodology will provide clarity and allow experimentation reproducibility in a rigorous way. Also, it is shown that IRPM is a strategy that helps produce more publications.

Keywords: Energy Alternatives, IRPM, Oilseed Extraction, Project Management, Sustainable Development.

1. Introduction

A feasible approach to promote a sustainable development of *Bico do Papagaio*, northern region of Tocantins - a Brazilian state, is to induce native oilseed crops for biodiesel production. The regional vegetation is *Cerrado* and its native oilseeds are potential candidates because of soil and climate conditions. For that purpose, we propose a project based oilseed extraction research methodology to support the development of biodiesel of *Cerrado*'s oilseeds, which is inspired on IRPM – Interdisciplinary Research Project Management [1].

The Territory of Bico do Papagaio covers an area of 15,852.60 km ² and comprises 25 municipalities with total population of 180,500 inhabitants [2]. The predominant economic activities are agricultural production, plant and mineral extraction. Plant extraction is the most traditional activity in the region, especially exploitation of timber and babassu oil. This activity, although it presents a great potential to be exploited, given agricultural suitability of soils and existing infrastructure, especially transport, where the train axis Center-North allows the production flow toward the north and south of the country, it still needs to carry out a serious effort to improve sustainability that can be viably developed, encouraging local industrialization [3].

Industrialization of oilseeds is one of the most important activities of Brazilian agribusiness through their use in formulation of: foods, cosmetics, medicines, and, recently, for energy purposes. Consequently, it has increased the interest of government, private companies and research institutions, both in the improvement of oilseed extraction processes, through the use of less toxic solvents, and in search for alternative sources.

The State government of Tocantins has set a goal to transform small farmers and settlers in producers of raw materials for biodiesel from babassu coconut, since babassu oil extracted from almonds has excellent qualities for transesterification due to presence of short chains that more effectively interacts with the agent, either methanol or ethanol, thus obtaining a biodiesel with excellent physical and chemical characteristics. Thus increase in income is expected for family farms, improving their quality of life, and hence regional development [4].

According Parmentier *et al.* [5], in United States of America is no longer allowed to build new plants for extraction of vegetable oils using petroleum solvents. Therefore, the growth of this sector may depend on the use of alternative solvents, which should be less toxic to man and to environment. A well known choice is to

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use ethanol for the extraction of lipid fraction of seeds. That is mainly due to the fact that Brazil has perfected a technology for large scale production of this solvent and it is renewable and non-toxic.

The methods used are IRPM and the extraction experiment methodology used by LAPSDEA – Laboratory for Separation of Biomolecules and Dehydration of Foods, at UFT – Federal University of Tocantins, Brazil. Originally LAPSDEA was a laboratory concerned only with food engineering, though with time it has become a name that also represents a research group. As research evolved and due to its members background and interest, its activities now also include all processes related to biodiesel research, and oilseed extraction plays a key role. Many of these activities are performed in partnership with other laboratories. In particular, this work is a result of an interdisciplinary association with NDS – Software Development Nucleus, also located at UFT.

The authors organized this paper in accordance to the IMRAD structure: introduction, methods, results and discussion; which is adopted as part of the Uniform Requirements for Manuscripts Submitted to Biomedical Journals of the International Committee of Medical Journals Editors, 2008 update. The authors believe that adopting this structure would help search engines in international databases to store and to retrieve information within research papers in order to facilitate meta-analyses and systematic reviews.

2. Methods

2.1. Interdisciplinary Research Project Management

IRPM is a strategy for doing interdisciplinary research proposed in [1]. It applies Project Management concepts [6] and problem-based learning techniques [7], [8]. IRPM's schematic is present in Figure 1, but let us first review briefly PMBOK's (Project Management Body of Knowledge) phases [6]:

- Initiation: to determine project goals, entries and process outputs, to document project constraints and assumptions, to define strategy, to identify performance criteria, to determine resource requirements, to define the budget and to produce a formal documentation.
- Planning: to refine project, to create a work breakdown structure (WBS), to develop the resource management plan, to refine time and cost estimates, to establish project controls, to develop the project plan and to obtain the plan approval.
- Execution: to commit resources, to implement resources, to manage progress, to communicate progress and to implement quality assurance procedures.
- Control: to measure performance, to refine control limits, to take corrective action, to evaluate effectiveness of corrective action, to ensure plan compliance, to reassess control plans, to respond to risk event triggers and to monitor project activity.
- Closing: to obtain acceptance of deliverables, to document lessons learned, to facilitate closure, to preserve product records and tools, and to release resources.

In IRPM – Figure 1, Initiation phase starts from choosing the real problem to solve and identifying at least two fields for an interdisciplinary approach to seek its solution. These fields are necessary to document the real problem constraints and assumptions, to define strategy, to identify performance criteria, to determine resource requirements, to define the budget and to produce a formal documentation.

The Planning phase consists of refining the project and of doing a more profound study of the problem by using the chosen fields. These studies may produce a new fundamental or methodology. Therefore in the Execution phase, even if new concepts are not generated, an educational material may be prepared and applied in a classroom for a Problem-Based Learning (PBL) approach, which is an instructional learner-centred approach to help students in conducting research that integrates theory and practice, to develop a viable solution to a defined problem [6]. Still in the Execution phase, if a new fundamental or methodology was developed, then a new technology may be implemented and used.

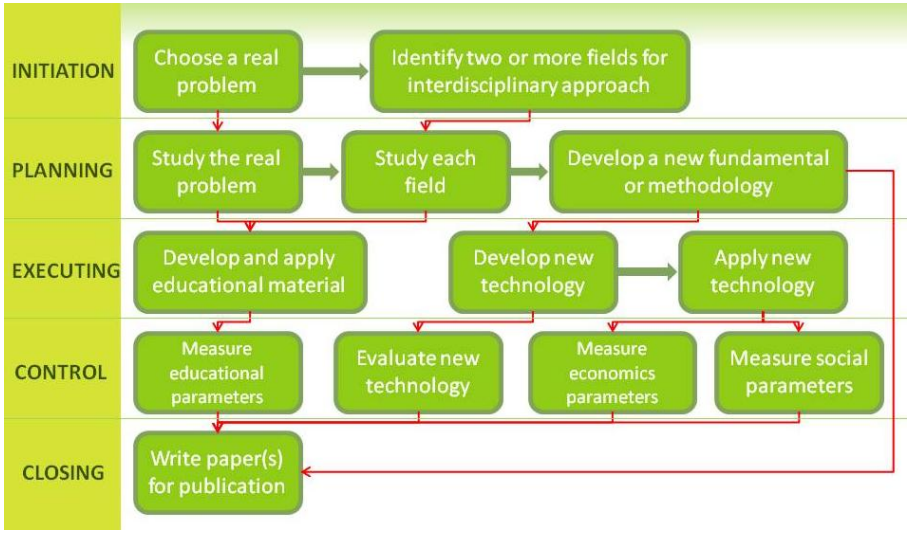

Fig. 1: The Interdisciplinary Research Project Management model.

Moreover, if in the Planning phase controls were established then educational, technological, economics and social parameters may be available for measurement, allowing the Control phase to be performed. Finally, after analyzing the measurements results, papers should be written, and that is the Closing phase.

2.2. LAPSDEA Extraction Experiment Methodology

The extraction experiment methodology used by LAPSDEA is shown in Figure 2. It is applicable to any oilseed. In order to explain it, as an example, it is presented the case of babassu [9], which is a seed native to *Bico do Papagaio*, northern region of Tocantins, Brazil.

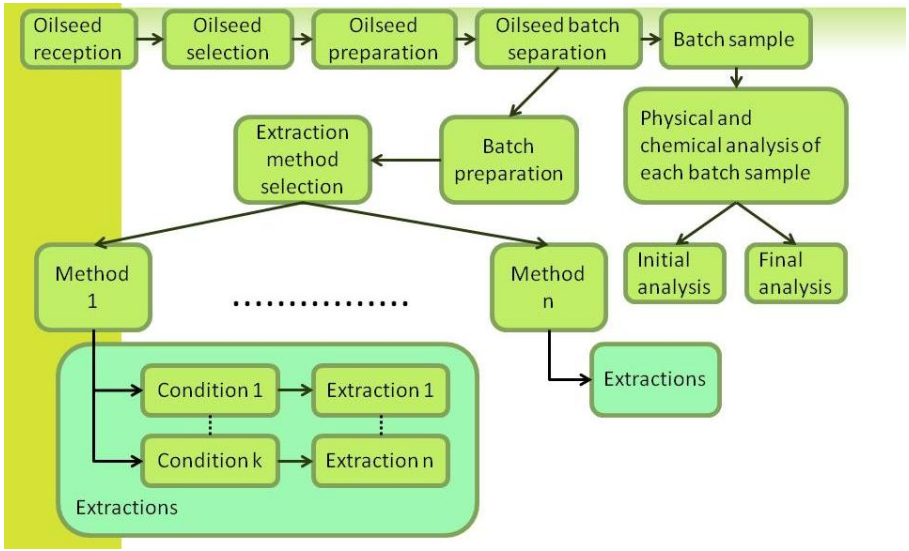

Fig. 2: LAPSDEA's Extraction Experiment Methodology.

The first step is reception of raw material that is babassu, which comes from *Bico do Papagaio*. Then oilseed selection is performed, that is, separation of seeds (part of interest) from the rest (bark, dirt, etc.). Once separated, seeds are washed with chlorinated water, and dried at 70 ° C to remove excess water, which corresponds to oilseed preparation. Afterwards, seeds are separated in batches of 200 g, a sufficient quantity for each analysis, which was established in the planning stage of the process. Before being vacuum packed, it is important to remove from each batch, shares in sufficient quantity for physical and chemical analysis, which must be carried out in triplicate before and after extraction. The batches must be kept under humidity, light and lower temperature than environment. The physical and chemical analyzes of moisture, oil content, ash content and peroxide are performed before extractions were started and at the end of them all, to ensure that no changes were observed in batches during the period in which they were stored. The step batch preparation in the case of babassu only consists of crushing seeds. The breaking of seeds' tissue facilitates oil extraction, because it increases contact surface for solvent action. But disintegration of grains also activates

cellular enzymes as lipase and peroxidase, thus grinding process must be as fast as possible, that is, each batch must be prepared only at extraction day.

There are different methods for vegetable oil extraction such as cold pressing, hydro or turbo distillation, hypercritical CO_2 or solvents, and after method selection, there may have different conditions for the process. In this example, babassu's case, the solvent used for extraction was ethanol. In order to optimize the efficiency of extraction of babassu oil, during experimental design were evaluated various parameters associated with the pre-treatment of samples and incubation step. The temperature ranged and the rate solvent per sample was defined on basis of solubility data for vegetable oils in ethanol [8].

The ground samples were incubated with ethanol (99.2%) in thermostatic bath at atmospheric pressure with slow and constant stirring, enough to maintain solids in suspension. For this type of extraction, solvent penetration within ground grain is facilitated by exposing a larger surface, the oil in the crushed material may be on the surface, which is removed by simple dissolution, and the oil present within the intact cells are removed by diffusion. The oil solution in the solvent is called a "micelle" and the balance in the system oil-solvent-micelle is the factor that determines speed of extraction. After extraction, the mixture was filtered and ethanol removed by evaporation in a stove at 80 ° C. The concentration of solute (oil) obtained varies depending upon oil content and physical characteristics of the sample obtained in the pre-treatment of seeds.

3. Results

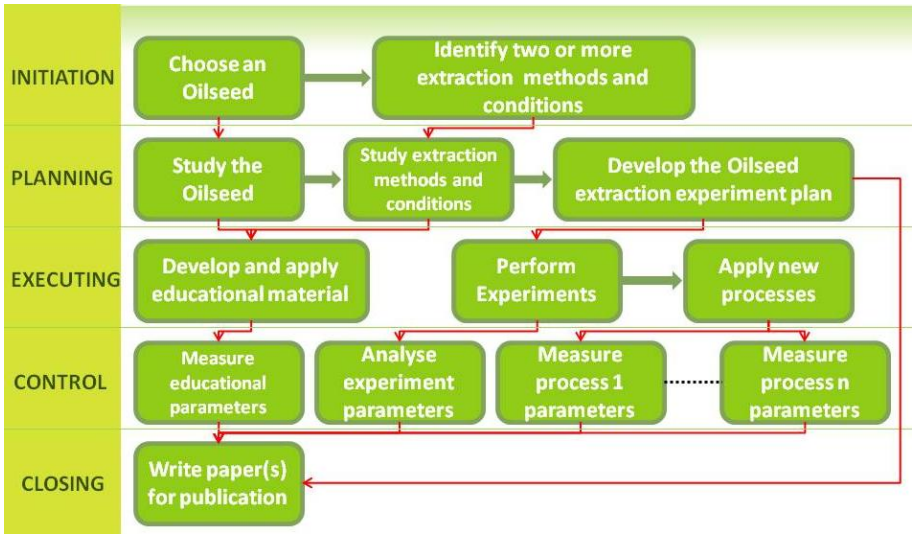

Fig. 3: LAPSDEA IRPM.

Applying the LAPSDEA methodology to IRPM established a strategy for managing this project, shown in Figure 3. The Initiation phase begins with the selection of an oilseed and in the sequence two or more extraction methods must be identified, where preliminary extraction conditions such as kind of solvent, temperature and reason solvent / sample must be determined. Then in Planning phase, the oilseed has to be studied, *i.e.*, a literature review must be performed. When it comes to oilseed native to *Cerrado*, we expect a certain lack of literature, therefore the review should consider previous studies of similar oil. Based on knowledge acquired from literature, the extraction methods identified should be studied to select the most appropriate plan to prepare the extraction experiment, where extraction conditions should be detailed and arguments written about the choice. Then we have to choose the method and its conditions, experimental extractions are done to confirm and guarantee its effectiveness. That done, Execution phase begins, where all analyzes are performed in triplicate to confirm results and to have a better process control. After extractions completion and obtained the results, these are analyzed and documented. Lastly, the work can be written. If the results are satisfactory then these works consist of scientific papers. Additionally, teaching materials can be prepared and applied in the classroom for a Problem-Based Learning approach with instruction to help students conduct research, define problems and develop workable solutions.

4. Discussion

The proposed methodology intends to be a platform that facilitates future systematic reviews and meta-analyses. When data types, procedures and their sequence are standardized, different oilseeds extraction methods may be compared lessening experimentation discrepancies in execution, or highlighting how sequencing may affect results. Additionally, a general and well defined methodology promotes clarity and allows repetitions of an experiment.

If procedures are not properly sorted comparisons can be misleading. Taking as an example steps six and seven of LAPSDEA methodology described in section 2.2, we observe that babassu almonds are first stored whole, being broken only on the day of each extraction, which promotes surface increase for solvent extractors. However, the disintegration of grains also activates cellular enzymes as lipase and peroxidase, therefore the grinding process must be as fast as possible. That is, if the results obtained with the method LAPSDEA are compared with other methods where the sequence of these procedures is inverted and the almonds are first crushed and then stored until the day of extraction, probably the data will be distorted, even if the raw material used is the same. This is due to the fact that it isn't sufficient that the process steps are the same, it is necessary that they follow the same sequence for considering the methods equal. Only a clear and well defined methodology allows reproducibility of an experiment, and to use IRPM helps to accomplish that. However, to develop a research following all the steps laid down by IRPM requires a longer time for planning activities, a greater amount of data is gathered, and more documents are stored, not to mention the need for training beginners.

Finally, documents stored throughout the development of the LAPSDEA methodology based on IRPM may be used to generate classroom material for educational purposes. Hence, to elaborate such material is a future activity that applied in a classroom using a problem-based learning approach might also generate a paper for submission. Furthermore, data obtained with the extraction of babassu oil using the methodology LAPSDEA were documented, and by presenting satisfactory results through statistical analysis, will also be submitted for publication [10]. All this proves that the use of the IRPM methodology provides more opportunities for publication of the work done.

5. References

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