

ESSENTIAL OIL EXTRACTION INDUSTRY: EXPLORING THE STRATEGIC TECHNOLOGY DIMENSION

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Abstract: This paper aims at the potential and unexplored improvements imbedded in the essential oil (EO) extraction processes. These processes are worldwide recognized by their low yields and high energy demands, becoming a target to be addressed to improve cost, reliability and quality indicators. A strategic thinking is presented, as a guide, with focus on enabling better business results through the TDC (Total Delivered Cost) optimization and the impact over gross margin in this promising segment. A basic process was evaluated, step by step, to then add technology improvements. The resulting impacts were assessed, improving yield from 1% to 1.2%. Such improvements are discussed in terms of digital technology contribution with the expected positive effects.

Keywords: Essential Oils; technology; cost; strategy.

EXTRAÇÃO DE ÓLEOS ESSENCIAIS: EXPLORANDO A DIMENSÃO TECNOLÓGICO-ESTRATÉGICA DO NEGÓCIO

Resumo: Este artigo aborda as melhorias potenciais e inexploradas cabíveis aos processos de extração de óleos essenciais (OE). Esses processos são globalmente reconhecidos por seus baixos rendimentos e altas demandas de energia, tornando-se uma meta a ser trabalhada para melhorar os indicadores de custo, confiabilidade e qualidade. É apresentado um pensamento estratégico, a título de orientação, com foco em viabilizar resultados promissores de negócios, por meio da otimização do indicador TDC (*Total Delivered Cost*), custo total do produto entregue, e do impacto sobre a margem bruta, neste promissor segmento de negócios. Um processo básico foi avaliado, passo a passo, para então adicionar aprimoramentos de tecnologia. Os impactos resultantes foram avaliados, melhorando o rendimento apenas de 1% para 1,2%. Essas melhorias são discutidas em termos de contribuição da tecnologia digital e seus efeitos positivos esperados.

Palavras-chave: Óleos Essenciais; tecnologia; custo; estratégia

INTRODUCTION

Essential oils (EO) are aromatic liquid and volatile substances obtained through extraction processes from vegetal mass in several forms: flowers, leaves, roots, barks, fruits and seeds. The International Organization for Standardization (ISO 9235: 2013) defines them as "natural products obtained from vegetable raw materials [...] through physical processes". Approximately 3000 thousand types are known and, of these, approximately 300 are used in fragrances, food essences, cosmetics, pharmaceuticals, food and beverages [1], aromatherapy, preservatives and pesticides. The Commission of the European Pharmacopoeia has adopted the following definition: "Odorous product, usually with a complex composition, obtained from a botanically defined plant raw material by steam distillation, dry distillation, or a suitable mechanical process without heating".

1.1. Methods of Extraction: Focus on Steam Distillation

Among the several methods of essential oil extraction [2,3], named below in Table 1, this paper focus on the steam distillation due to the broad utilization worldwide [4], being responsible for 93 % of the produced volume worldwide. The table also mentions the media where the extraction takes place as well as provides a perspective on the advantages and disadvantages for each method.

Table 1. Essential Oils methods of extraction

Extraction Method	Extraction Media	Advantages	Disadvantages
Hydro-distillation; Vapor-hydro-distillation; Steam Distillation; Hydro-diffusion	Boiling water; Steam	Simplicity, relative low investment.	Prolonged process time; possible degradation of components
Organic Solvent Extraction	Maceration in organic solvents	Avoids chemical degradation	Possible residues of solvents; Dangerous waste; Flammability
Cold Pressing	Mechanical pressing	Simplicity, Specificity	Application restrictions (citrus mainly)
Supercritical Fluid Extraction - SCFE (Carbon Dioxide generally applied)	Supercritical Fluid (Carbon Dioxide, generally)	Fluid is inert, non-toxic, non-flammable	High investment; high maintenance costs
Subcritical liquids (Water and Carbon Dioxide)	Subcritical water or CO ₂	Fluid is inert, non-toxic, non-flammable	High investment; high maintenance costs
Ultrasound assisted extraction	In combination with steam or organic solvents	Integrity of EO's; Lower investment (compared to SCFE)	Small scale equipment; Focus on specific ingredients of interest
Microwave assisted extraction	Possibilities: Solvent free; with steam; with water	Short process time; Better sensorial properties	Relatively smaller scale plants; subject of future developments.

As said, the massive part of the global volume is extracted via steam distillation [4], due to simplicity and relatively lower investments, justifying the focus of this paper.

1.2. Essential Oil Market

According to the market research company *marketsandmarkets* [5], the overall plant extract market was US\$ 23.7 billion in 2019 expecting to reach US\$ 59.4 billion by 2025. The essential oils, part of this value, are mentioned by *alliedmarketsearch* [6]: US\$ 8 billion in 2018 reaching approximately US\$ 16-17 billion by 2026.

1.3. EO Business Environment

The essential oil industry operates in an increasingly prominent market [5]. Consumer's behavior has been motivated by the desire for natural products and a healthier lifestyle [5]. Whenever possible or available users are preferring certified organic agricultural products despite the higher prices and difficulty to find them [7].

Even under these important customer requirements, the essential oil industry operates without significant process updates and lacks the application of updated technology [8]. A considerable part of the producers are small farmers, without frank access to either technologic know-how or financial availability [8].

Even the major manufacturers, those more professionally established, present clear opportunities to improve their operations in a more structured way, in terms of technology, meaning a gap to be filled towards business excellence.

Under the pandemic scenario, the projections for the essential oil market are still positive as reflected in the market research sites [5,6]

1.4. KPI – Proposal of a minimum list for EO operations

It is recommended, as good managerial practices, to set a KPI's list: EO industry is not an exception. KPI management has already been addressed extensively, however, their importance must emphasize the importance as a driver for improvements in essential oil segment, both for establishing objectives as for tracking performance through them [9].

EO operations management, consists ultimately of the quest for efficiency improvements. As a minimum operational KPI list, it is presented the following parameters: yield, OEE* (Overall Equipment Effectiveness), quality (analytic), batch time and energy efficiency [10]. In parallel, the capacity management is a strategic pillar to assure supply chain is capable to respond to sales requirements, on time and in full.

*OEE is defined as the product of 3 factors, according to equation (1):

$$OEE = Availability \times Performance \times Quality \quad (1)$$

1.5. TDC (Total Delivered Cost) and TDC Optimization

The Total Delivered Cost is an important KPI composed by four cost components: Raw Materials (RM); Packaging Materials (PM); Manufacturing Expenses (ME) and Logistics (L), as shown in the equation (2), below:

$$TDC = RM + PM + ME + L \quad (2)$$

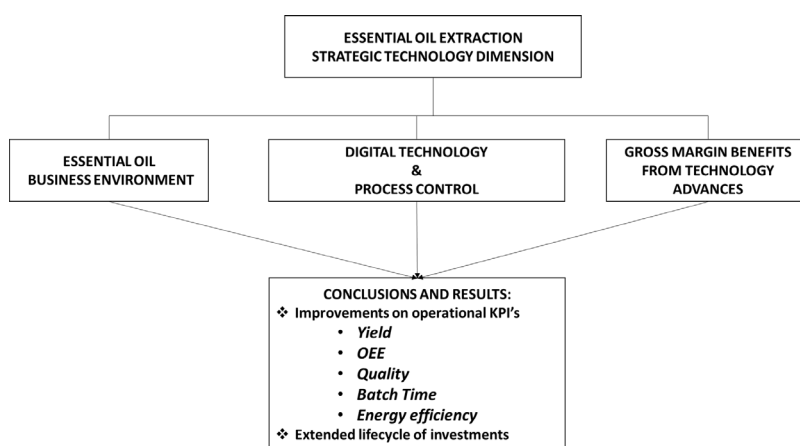
TDC optimization comprises a set of efforts to improve company's gross margin results. The word "optimization" is applied instead of "reduction", which could lead to

the undesired understanding of prioritizing reducing costs in detriment to quality, maintenance practices and customer care requirements [11].

2. METHODOLOGY

As methodologic structure, it is shown in Figure 1 the strategic dimension of technology over EO business, in terms of business environment – already addressed above - digital technology & process control as well as the positive impacts over the gross margin, leading to better KPI's

Figure 1. Technology as Strategic Dimension

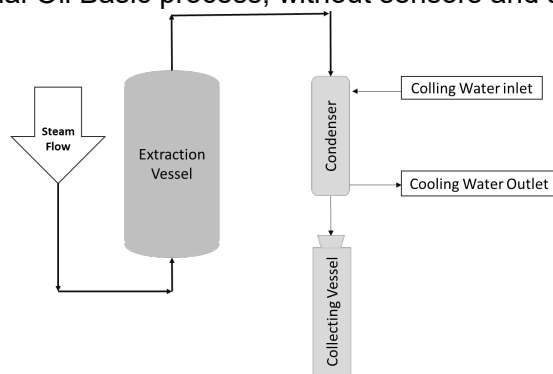


Business owners and managers, when reading the content of this paper, should be compelled to pursue better results through the technology lever. The impacts will be discussed in terms of operational KPI's and their influence on the business overall.

2.1. Implementation of Technology and Process Control

Essential oil extraction industries base their processes parameters essentially in previous historic experiences. The design and installation of sensors and control systems are the basic steps to reach a reasonable level of process understanding and control, beyond the usual parameters established only via practice. The process illustrated in Figure 2 is basic, without sensors, as usually in that industry.

Figure 2. Essential Oil Basic process, without sensors and automatic controls



Source: The authors

Figure 3 shows an example of Process and Instrumentation Diagram (P&ID) (symbology according to ISA) with a simple design proposal for instrumentation. Of course, the complexity level of the improved installation will depend on the expected return on investment and the availability of funds, respecting the principles of economic engineering.

When sensors are designed to cover process needs, the effective control of parameters leverages optimized results. Other important features for control and process management architecture complete that scenario: programmable logic controller (PLC), Supervisory, Control and data Acquisition system (SCADA) and, eventually, other levels of manufacturing management, the Manufacturing Execution System (MES).

When a culture of operation and process control takes place within a company, other levels of process development are considered. For instance, models allow process simulation and optimization of operational parameters. Just as illustrative element, Figure 4 shows a view of Digital Twin, which is the most advanced model for a real process digital representation, delivering optimized parameters, setpoints, times and self-configuration for next batches, from machine learning principles.

The diagram illustrates the process of creating a digital representation of a real product. It features two main components: a **REAL PRODUCT** (represented by a dark blue circle with a robotic arm icon) and a **DIGITAL REPRESENTATION** (represented by a light blue circle with a cloud and server icon). A **LINK** (represented by a cloud and server icon) connects the two. The process is divided into 10 steps, arranged in a circular flow around the central link:

0. Transport Product
1. Gather Data
2. Save Data
3. Transfer Data
4. Evaluate/Analyze Data
5. Vary Parameters
6. Simulate Characteristics
7. Evaluate Simulation
8. Save Results
9. Transfer Parameters
10. Make Adjustments

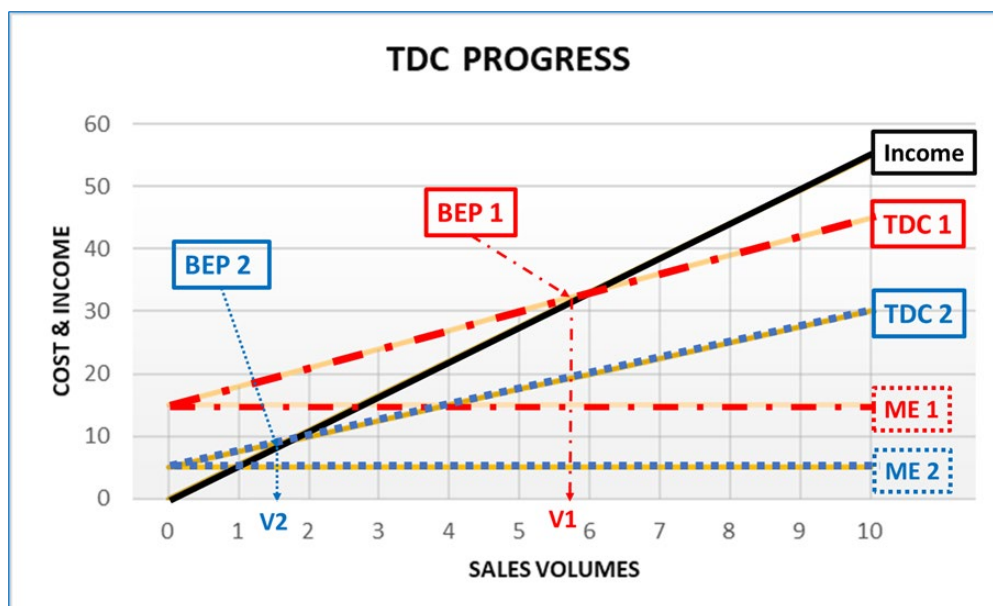
Investments in technology within EO industry will generate increasingly positive results, reflected in the KPI's (see minimum list in item 1.4.).

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margin; OEE: Technology will deliver better effectiveness: increasing availability, performance and reducing losses due to low quality; Quality: Processes will prevent the undesired degradation of EO elements when technology is in place; Batch Time: This KPI is linked to availability and performance (OEE) and closely related to capacity planning and management; Energy efficiency: Optimizes energy per unit produced; TDC: The main indicator in terms of operation management reflecting the bottom line of the overall performance improvements.

Given the importance of TDC, a graphic (Figure 4) demonstrates how TDC optimization improves margin and reduces exposures.

Figure 4. TDC Evolution due to technology enhancement



Source: The authors

Income: Total value (cash; revenue) from sales and invoices to customers; TDC: Total Delivered Cost; ME: Manufacturing Expenses; BEP: Break Even Point; V: Volume of sales; Index 1: Before technology updates; Index 2: After technology updates

The indexes 1 reflect the figures before the technology implementation, meaning higher ME and TDC costs. When technology is in place, the indexes 2 show improved ME and TDC, delivering more competitive BEP. $BEP2 < BEP1$ ($V2 < V1$), which means a smaller business exposure.

Note: ME (Manufacturing Expenses) was considered fixed by simplification, without impact on the methodology.

3. RESULTS AND DISCUSSION

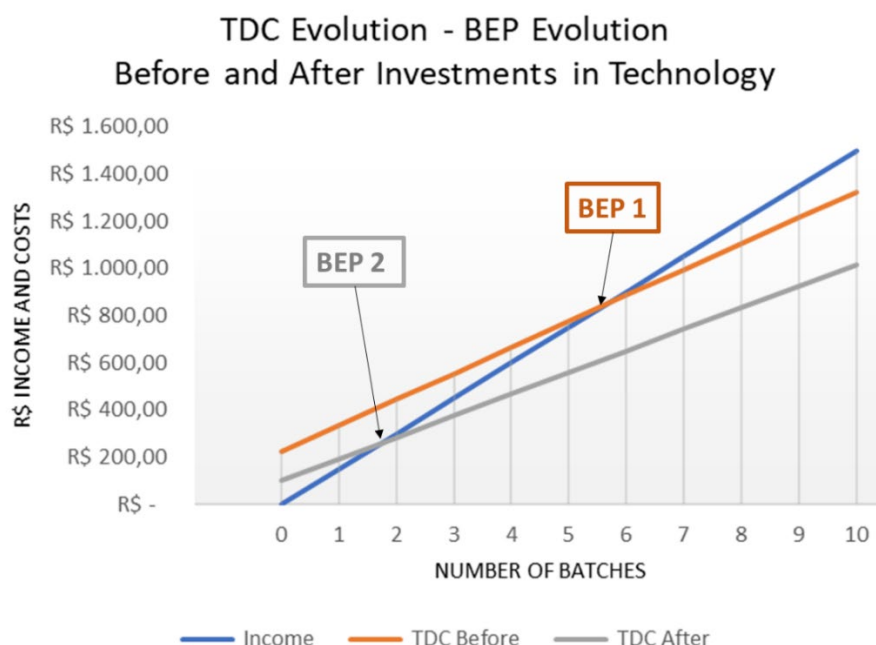
A hypothetical case was assessed showing a hypothetical case where a company with only one extraction vessel of, for example, 1000 kg capacity (dry raw material), experiences yield evolution from 1% to 1.2% due to technology improvements. For simplification, manufacturing expenses were estimated at R\$ 4.000,00 per employee, all included as well as energy consumption. Table 2 demonstrates figures from the estimates. Reduced manpower requirements and batch time are responsible for an interesting new scenario, called below as "after".

Table 2. Hypothetical Assumptions – Business Case

OPERATION CONDITIONS			TDC (R\$/kg of extracted essential oil)		
Raw Material (RM)	kg	1000	TDC Factors	BEFORE	AFTER
Cost of RM	R\$/kg	R\$ 1,00	RM	R\$ 100,00	R\$ 83,33
Sale Price of EO	R\$/kg	R\$ 150,00	PM	R\$ -	R\$ -
Comparison Before - After			ME	R\$ 225,00	R\$ 100,00
Yield	% (kg)	1% (10)	L	R\$ 10,00	R\$ 8,33
Manpower	people	3	TDC	R\$ 335,00	R\$ 191,67
Batch Time	h	4			
		2			

Figure 5 demonstrates technology update impacts over business breakeven point, reducing the company exposure to volume sold and bringing the overall business performance to a more convenient steering and control.

Figure 5. TDC and BEP evolution: comparison between before and after investments



In this hypothetical scenario, a short improvement from 1% to 1,2 %, was evaluated with its beneficial effects on gross margin and overall business performance. The quest for better results will mean the reason to pursue technology enhancements as basis for business perpetuity.

As far as process effectiveness is concerned, this paper was targeted to bring up the discussion over the technology update positive effects on the EO business, arising the motivation to validate this strategic value. It remains, as subject for future works, the application of these propositions to real cases. Such proposals – even though straightforward – are a case for studies and experiments i

4. CONCLUSION

A comprehensive program of investments on technology updating is a key factor for business success. When Essential oil industry aims at improving competitiveness, these strategic projects are necessary to assure business perpetuity as well as operational effectiveness, with effects on gross margin, environmental impact and image to customers.

Several scenarios can be established in function of capital availability, geographic demands and, importantly, competitive requirements. Consuming behaviors are changing dramatically towards green products, services and corporations, indicating a direction for top management and owners to pursue efficiency. Overall business results will no longer stand on only on financial aspects.

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