Institutional echoes: the *Laboratório Químico Municipal do Porto* (1884-1907) as a model for the dynamics of scientific institutionalization

José Ferraz-Caetano
LAQV-REQUIMTE – Department of Chemistry and Biochemistry – Faculty of Sciences, University of Porto, Portugal
jose.caetano@fc.up.pt

Received: May 10, 2024 **Revised**: Oct 07, 2024 **Just Accepted Online**: Oct 14, 2024 **Published**: Xxx

Please cite this article as:
J. Ferraz-Caetano (2024) Institutional echoes: the *Laboratório Químico Municipal do Porto* (1884-1907) as a model for the dynamics of scientific institutionalization. **Substantia**. *Just Accepted*. DOI: 10.36253/Substantia-2753

Abstract

This article explores the institutionalization process of scientific organizations, with a focus on the case-study of the *Laboratório Químico Municipal do Porto* (LQMP). Within the context of Institutionalization Theory (IT) and framed by the history of chemistry, the LQMP's lifecycle is examined to propose a new model for the institutionalization of scientific entities. The article reveals the dynamic interplay between historical developments in chemical science, micro-level scientific practices and macro-level societal changes, offering a comprehensive understanding of how scientific institutions influence public policy and societal norms. Through the lens of IT, the article provides a nuanced exploration of the LQMP's inception, development, and closure, shedding light on the broader implications of scientific institutionalization. This research addresses a gap in LQMP's institutional understanding as a historical peripheral landmark in the emergence of science-based legislation. Its findings

contribute to the theoretical discourse on the institutionalization of scientific practices, with implications for policy formulation on public health and food regulation.

Keywords: Institutionalization Theory; Scientific Institutions; Public Policy; Laboratório Químico Municipal do Porto; Science-based legislation.

Introduction

Institutionalization is a transformative movement that influences human interactions through the dynamics of rules involving both individuals and organizations.[1] The Institutionalization Theory (IT) provides a comprehensive understanding of how societal norms, along with individual and collective actions, shape the institutionalization process. It emphasizes the importance of analyzing both micro and macro-levels of social events to understand the complexities of institutionalization, highlighting the interplay between individuals and societal structures.

Studying institutionalization is crucial for clarifying the emergence of science-based legislation and the dynamics of science communication. IT helps to address how practices, initially developed within scientific communities, shape social values, policies, and legislative frameworks.[2] By analyzing the role played by various stakeholders, IT explores how their interactions affect the public's understanding of scientific advancements. But IT also studies the establishment of scientific standards, regulations, and norms, clarifying their contribution to building public trust in scientific institutions. Naming the challenges encountered during the institutionalization process helps this theory design strategies to enhance the relationship of scientific research with significant policies. It offers a framework to decipher the intricate relationships in the science-society-policy triad, providing insights into how values, norms, and power dynamics influence the embracement of scientific innovations.

While IT offers a robust theoretical framework, it lacks a specific method to incorporate scientific institutions. This is significant when considering the theory's potential to substantiate the implication of laboratories in shaping new science policy. Although IT explains stakeholders' roles and the evolution of practices within scientific communities,[3] it does not provide a simple method to trace how these laboratories, as institutions, transition from sites of knowledge production to influential policymaking entities. A robust theoretical apparatus

can help fill this gap by offering a structured way to laying out the pathways through which scientific practices become embedded within regulatory frameworks. This is especially important for understanding how scientific institutions influence public policy and how, in turn, these institutions are shaped by social and political forces. The model provides a lens to examine how scientific institutions gain legitimacy, influence decision-making, and contribute to broader societal change.

The importance of such model is further amplified when considering scientific institutions located in peripheral or historically marginalized regions. Often, studies on the institutionalization of science focus on central or dominant institutions in major urban or academic hubs, leaving peripheric institutions underexamined. A theoretical model tailored to this process allows for the analysis of case studies from such institutions, offering insights into how they contribute to the broader scientific landscape. As these institutions often face unique barriers in gaining legitimacy, a structured model can highlight how they navigate these challenges and interact with national and international policy. Understanding these dynamics is critical for fostering equitable science policy, as it ensures that contributions from all regions are integrated into broader policy discussions.

This article aims to develop a comprehensive IT model tailored to scientific institutions, using an historic chemistry laboratory as a case study. It hypothesizes that the Portuguese *Laboratório Químico Municipal do Porto* (LQMP), opened in 1884 and closed in 1907, serves as a model to unravel the complex dynamics of institutionalization within scientific practices. This interdisciplinary approach is relevant for a history of chemistry, as it delves into how scientific laboratories shaped legislative frameworks, particularly in areas like public health and food regulation. It posits an essential question: to what extent do the processes and practices cultivated within scientific laboratories influence the development of laws and societal norms? By using the LQMP's historical case study, the article seeks to build a theoretical framework to analyze the broader impact of scientific practices on institutional evolution. This approach not only enriches the understanding of chemistry's role in societal development but also highlights how chemistry laboratories were instrumental in standardizing practices that shaped public policy. This novel exploration is crucial for historians of chemistry, as it provides a detailed account of how laboratory advancements translate into legislative changes.

Institutionalization theory and scientific practice

One can define institutionalization as a transformative movement that aims to influence the dynamics of human interactions. Max Weber[4] defined the logic of institutionalization given three regulatory actions: a phenomenon of regulation; adapting existing rules; and replacement by new rules. It is human activity that installs rules and procedures, involving people (individual and collective) and organizations (social or political), making work a set of norms that establish the social contract.[5] Although it is not this research's goal to analyze the context of institutionalization and its historical development, it highlights the dynamics of how practices become shared rules, formalized around all society's actors.

There are several theories to analyze how institutional movements can occur. Amongst them, there is a confluence of opinions on key three conceptualizations.[6] First, (i) a cultural movement, process of constitutive institutionalization that emerges based on the values and social norms which interconnect people and institutions. Building stakeholders' mutual trust is essential for the effective adoption of regulations, key to understand behavior change. Second, (ii) in a movement of rational choice, institutional momentum comes as a pragmatic urgency of the common good, overlapping actors' individual decisions. Perhaps the most cited explanation for the analysis of society policies, this approach allows a rational observation by assuming that the preferences of the individual are 'stable' and their dynamics of interest manifest in society within pre-established rules. Therefore, it must substantiate certain caution when the model falls into the assumption of more dynamic societies. Finally, (iii) a crisis movement explains that institutions emerge and change because of external shocks that disrupt their normal functioning. The shift in the institutional landscape's *status quo* is a response to these changes, understood as a framework for resolving a generalized crisis. Most times, this type of thinking comes from the understanding of radical changes in social regimes, limiting movement explanations to these moments of tension. Such definition illustrates a sophisticated event, which is comprehensible considering the interdependence between the three referenced movements of community-based norms. Therefore, I intend to highlight the positive aspects that an institutional analysis brings to the compression of historiographical movements. Not in comparison to the advances highlighted by political science, but as a contribution to the integration of actors' actions within society.

The goal of the proposed model is to provide, upon a investigation into different ways of interpreting IT, an overarching potential meta-theory[7] of a scientific organization's institutionalization process. This would be a model that monitors change between levels of

explanation and recognizes practice diversity. To extend IT's connection to the main quandaries of scientific knowledge, namely the link between macro or micro-level social events, the focus is on the sequence by which organizations gain institutional status. In new institutionalism, such as most theories of social systems, individual actors represent the micro-level and structures uphold individuals' actions portrays the macro-level.[8] As social truth rises from many individual-level actions, a simple combination model lacks sufficient detail to describe the practice heading towards social standing.

Coleman emphasizes the necessity for social theory to delimit between the micro and macro-levels of social events,[9] insisting that understanding system segments dynamics is crucial for this clarification. It is vital to avoid merely amalgamating individual system components, as the interplay between levels is a complex phenomenon that may not always be predictable. Addressing the challenge of capturing the nuanced interrelations between these levels is of pivotal concern for theories focused on institutional activities.[10] This typically involves situating the macro narrative within the context of an emerging organizational field. And this will be the backbone of the proposed model: it incorporates three development stages, starting with a macro-level trigger towards micro-level influences,[11] culminating in a new, unified macro-level framework. The process, initiated by a social trigger and mediated through individual and group actions, leads to the adoption of new practices and the establishment of a cohesive scientific field. Several factors are incorporated for a comprehensive understanding of the institutionalization process, as they include identifying the triggers that drive the process and recognizing the role of agency throughout. It is also crucial to identify the mechanisms that embed institutional norms: analyze the factors influencing the spread of the process, the level of uniformity within the organizational field, and pinpoint the conditions that unify various practices and beliefs.

Applying this model to study scientific institutions also provides a structured approach to examining how scientific practices evolve. From individual actions within a laboratory setting to influential factors shaping societal norms, they help understand the institutionalization of scientific practices as a dynamic between micro-level innovations and macro-level structural shifts.[12] It can be thus understood how scientific institutions contribute to the development of science-based policy. This approach aligns with Coleman's suggestion[13] that 'serendipity' in scientific discoveries can catalyze new theoretical understandings, emphasizing the significance of IT in framing the role of scientific institutions.

The *Laboratório Químico Municipal do Porto* (1884-1907) – an institutional case-study

At the end of the 20th century, a clear scientific movement emerged in the social sciences on the study of laboratories as institutions. Perhaps the most impactful studies originate in European sociological schools, as Bruno Latour's works provided a new look at the true extent and influence of activity of scientific laboratories.[14] The new conception on the construction of the scientific argument launched a profound debate on the actual weight of laboratories, as institutional social elements. It did not take long for the historiographical debate focused on this theme, as that influence will be evident in this section.[15]

In the development of scientific policies in historical contexts of laboratories as institutions,[16] most of the research deals especially with the period between wars and post-World War II.[17] In line with a great literature impulse in scientific communication, historiography was concerned with the role of these actors as engines of a scientific agenda, uneasy with society's technological literacy and the adaptation of states' perception to the 20th century scientific revolution.[18] This was later recovered by contemporary science historians interested with the process of science and technology development in the 20th century.

The lifecycle of the Laboratório Químico Municipal do Porto, (1884-1907)

The LQMP was a chemical laboratory established in Porto, Portugal, in the late 19th century.[19] Its creation was part of the city's initiative plan to improve public health, urban sanitation, and food safety standards.[20] The laboratory was set up to conduct chemical analyses, primarily focusing on food and water safety to combat adulteration. Under the leadership of notable chemists such as António Joaquim Ferreira da Silva (1853-1923), the LQMP played a crucial role in the city's scientific advancements, contributing to the establishment of standards and regulations in Portuguese food safety and hygiene.[21] It became a model for integrating scientific practices into governance and public policy, reflecting the broader trend of institutionalizing science towards societal needs.

In discussing the genesis and evolution of the *Laboratório*, it's pivotal to delve into two distinct, yet intertwining contexts: the academic and political realms of late 19th century Porto. The growth of the *Academia Politécnica do Porto* ("Polytechnic Academy of Porto", APP) and

the ambitious "City Improvement Plan" marked key milestones that drove LQMP's establishment. However, the interconnection between these two catalysts – each with its unique origin – raises intriguing questions about academic advancement in nurturing scientific institutions.

António Ferreira da Silva emerges as a key figure in this narrative, bridging the academic pursuits of the *Academia* and the city's development aspirations outlined in the "Improvement Plan". While the former's influence has been explored,[22] the latter warrants a closer examination. The "Improvement Plan"[23] unveiled by the Municipality of Porto in 1881 championed a vision of progress, aiming to transform the city into a desirable destination for tourists and a European commercial hub. Rooted in the aftermath of the 1876 economic and banking crisis, addressing the perceived isolation of the historic city center[24], the plan proposed an integrated approach to urban renewal beyond architectural rejuvenation. The plan's advocates articulated a straightforward vision: "The only remedy now," as stated in the prologue, "was to progress, and improve in order to excite the desire to be visited, and to offer visitors such comforts". Much like historians of science have argued that peripheral European cities played an essential role in shaping scientific modernity,[25] despite often being perceived as "backward" compared to major scientific centers.

Central to this vision was the imperative of public health and sanitation, considered fundamental for revitalizing the city's economic vigor, aligning with the standards of prominent European centers. The plan's scope encompassed citywide hygiene improvements, extended to individual homes' integration into the public sanitation network, reflecting a holistic approach to urban development. Acknowledging the legislative efforts made abroad to inspect health standards of consumable goods (like meat, fish, milk, wine, and olive oil), the plan scrutinized the "pernicious influence on the public health of foodstuffs". Until that time, Portuguese food regulation was largely a legal matter without a robust legislative scientific foundation.[26] The report recognized the emerging need for "special technicians" trained in detecting food adulteration, highlighting an international trend toward establishing specialized laboratories that offer analyses for individuals concerned about the safety of their food. In this context, the proposal suggested that establishing such a laboratory would be a valuable service to Porto's citizens. By providing scientific expertise in the areas of toxicology, food safety, and sanitation, the LQMP would become central to these efforts, much like its counterparts in cities like Paris, Barcelona and Madrid.[27] By exemplifying how peripheral cities could localize

scientific models to address their own urban needs, I argue that LQMP's establishment was not merely a scientific endeavor, but a strategic component of a broader initiative to elevate Porto's stature, blending scientific innovation with urban progress.

For this purpose, in 1882 the municipality of Porto began installing the LQMP. Eminent chemist António Ferreira da Silva is personally invited by the Mayor to direct this process, later becoming its first (and only) Director.[28] But Ferreira da Silva's choice is not only justified by his scientific curriculum. He had previously taken part as an expert on the city's water distribution assessments. His research on how water from surrounding rivers were supplying the city, proved to be important in the city's determination to pursue sustainable sanitation programmatic lines. On November 9th, 1882, a municipal council session approved LQMP's establishment, installing it near the city's Town Hall on *Rua do Laranjal*, a street that no longer exists today (due to the opening of the current *Avenida dos Aliados*). In January 1883, City Council sworn in Ferreira da Silva as LQMP's director, which opened on June 2nd, 1884.

Figure 1. Photograph of the front of the *Laboratório Químico Municipal do Porto* (c. 1900).[29]

The institution was active until 1907, when it was compulsorily closed by the Municipality of Porto. Alves and Alves' research vividly captures the tension between the Porto City Council and the LQMP's director, amidst discussions on the depletion of competencies and the "consequences of political tactics."[30] While the definitive closure of the LQMP became apparent only a decade later in 1917, the laboratory never resumed its activities. This prompted disappointment within the scientific community, with many lamenting the laboratory's

disappearance as a significant setback for chemical science. One of the most poignant reflections came from chemist Alberto de Aguiar, who mourned the closure of what he coined as a "sanctuary of chemistry."[31]

International Models: a Blueprint for Porto's LQMP

Before LQMP's establishment, Ferreira da Silva would visit the facilities of a model laboratory, selected among those who "around the world tackle the falsification of foodstuffs": the Municipal Chemistry Laboratory of Paris.[32] This laboratory, established in 1878 and following the well-achieved model of the city of Brussels, aimed to enhance public health and hygiene by monitoring adulterated food products. Initially serving only police requests, it became a pivotal institution in the modernization of urban health systems, setting a precedent for municipal laboratories across Europe. But when under pressure from the city's food merchants, it began "hybrid" operations[33] in 1880, catering to both public and private entities.[34] As such, it was the ideal candidate to emulate a new Municipal laboratory in Europe's periphery.

The influence of the Parisian laboratory on LQMP's establishment in 1884 is particularly significant. Founded to address the challenges posed by urbanization, pollution, and the need for public health standards, the laboratory became a trailblazer in chemical analysis. It set new analytical standards, but it also served as a model for other European cities. It inspired the adoption of similar practices in places like Lisbon and Porto in Portugal, as well as major Spanish cities such as Barcelona and Madrid.[35] Unlike Paris', which restricted private service initially, Porto's laboratory was accessible to the city's populace from the beginning, highlighting its commitment to community engagement. This closeness to society is a defining feature of the laboratory's institutionalization, demonstrating how it was essential in shaping its operational framework and contribution to IT.

The Paris Municipal Laboratory's integration into the fabric of municipal governance set it apart as a model of scientific institutionalization. It was not just a research facility. It was embedded within the city's administrative framework, as Parisian chemists played a central role in investigating public health and food safety risks. This model of governance was appealing to other European cities which were eager to modernize a more scientific approach to urban issues.[36] In Porto, the LQMP was similarly integrated into the municipal structure.

This close relationship between the laboratory and municipal governance echoed the Parisian example, showing how science could be institutionalized from a local administration.

The adaptation of the Parisian model involved not only mimicking its structures, but also tailoring the laboratory's functions to the specific Portuguese challenges. Porto was an industrializing city with rising public health challenges, but the local context of wine production, food adulteration, and sanitation standards created unique demands for the LQMP. While the Paris laboratory dealt with a broad spectrum of urban health issues, the LQMP placed particular emphasis on food safety, especially in regulating wine production, central to the regional economy. Wine adulteration posed a significant health risk, and international trade required the enforcement of safety standards to maintain foreign markets' credibility.[37] The Paris laboratory had set a precedent for addressing food adulteration, particularly in detecting harmful compounds, such as sulfur dioxide used in wines. The LQMP adopted similar methods, applying rigorous scientific analysis to ensure that Porto's wine production adhered to local health standards and international trade regulations. This effort to ensure wine safety can be seen in the LQMP's focus in detecting common adulterants like saccharine and sulfites.[38] As noted in the laboratory's activity reports, work on wine adulteration was critical to maintaining public health and the city's economic standing, by following the Paris laboratory's model of chemical analysis.

Beyond Portugal, the Parisian model could also be seen in Spanish laboratories, particularly those in Barcelona and Madrid. Like Porto, these Spanish cities were grappling with the consequences of industrialization and urban growth, which brought about public health crises.[39] Municipal laboratories in Spain developed similar frameworks for food regulation through scientific analysis. For example, the customs laboratory in Madrid and the municipal laboratory in Barcelona took on roles like LQMP in addressing food adulteration and toxic risks in public health. However, the Spanish context differed in that these laboratories often operated under more centralized national frameworks, particularly in customs regulations.[40] The Spanish laboratories focused heavily on the regulation of imported goods, ensuring that food products entering the country met national health standards. This focus on customs was less pronounced in the LQMP, which had a more local emphasis, though the "Lisbon Customs Laboratory" filled this role for Portugal.[41] The LQMP's emphasis on local issues made it distinct from its Spanish counterparts, which were more closely tied to national regulatory frameworks.

Additionally, LQMP was at the forefront of forensic toxicology in Portugal, becoming involved in high-profile legal cases that required scientific expertise in detecting poisons and toxic substances. While this forensic function was already established in Paris and other European cities, it became a hallmark of LQMP's innovative contributions at the local level, ultimately establishing the laboratory as a national reference.

LQMP's institutionalization can thus be traced back to the practices imported from the Municipal Chemistry Laboratory of Paris. This relationship can be categorized though features that were fully (or partially) adopted or not implemented. Concerning adopted features, the LQMP emulated the Paris laboratory's mission of combating commercial fraud and food adulteration, enhancing public health and hygiene. More than just a local scientific entity, the LQMP grew into a recognized national institution, pivotal in the fight against food fraud.[42] Its analyses gained legal credibility, often used as forensic evidence, underscoring its institutional legitimacy.[43] This recognition extended further as the LQMP played a crucial role in standardizing laboratory procedures, illustrating its established institutional stature.[44] This is documented in the amassed reports of the first Portuguese commission to "Standardize Chemical Analysis" for food inspection purposes, where many of the LQMP's procedures are adopted, mainly on wine, olive oils and water analysis.[45]

Under Ferreira da Silva's leadership, the LQMP spearheaded a committee for procedural unification, but also became a beacon of excellence, influencing laboratory practices beyond its walls.[46] This pivotal role, deeply intertwined with the academic community in Porto, signifies the LQMP's impact on the institutionalization of scientific practices, drawing inspiration from, and expanding upon, the foundational model established by the Paris laboratory. However, it is difficult to envision Ferreira da Silva as more than just a brilliant academic without considering the significant contributions he made through his work at the LQMP. There is the possibility that both him and the laboratory have together distilled their legitimacy in the social and academic field. Without this symbiosis, perhaps the conditions for Ferreira da Silva to have chaired the committee for the study and unification of the methods of scientific analysis of wines, olive oils and vinegars in 1895 had not been met.[47]

But LQMP's institutionalization also highlights aspects that were not incorporated. Unlike in the beginning of its Parisian counterpart, as discussed, the LQMP embraced a more inclusive approach, offering its services to both public and private sectors from its inception. Other major difference was the LQMP's initial lack of national legislative certification.[48] This absence is

notable given the laboratory's aim to serve as a scientific institution, but it can be explained because of the lack of a national legal framework defining food regulation standards at the time of LQMP's inception. Indeed, it was the LQMP's director that supervised the scientific effort in designing such regulations. The supervisory role and the need for scientific credibility by other power entities were significant challenges during the laboratory's existence, until the consolidation of Portuguese food regulation and public health act between 1902 and 1905.

LQMP's scientific credibility was bolstered by another pivotal moment for its institutionalization: its involvement in the *Urbino de Freitas Case*, 1890-1893, a high-profile alleged poisoning case in Porto. The laboratory's findings were scrutinized in court, especially when contrasted with diverging results from other institutions and international experts.[49] This case exemplified LQMP's struggle to establish its legitimacy and authority in the forensic domain. The case, often regarded as the first major forensic case in Portugal, brought to the forefront the role of scientific evidence in legal proceedings. Urbino de Freitas, a respected doctor, was accused of poisoning his nephews to claim their inheritance. The case became infamous not only for the crime but also for the public debate it sparked around the legitimacy of scientific evidence versus authority-based arguments in court. At the heart of the trial was the forensic analysis conducted on the LQMP led by Ferreira da Silva, who applied advanced analytical chemistry techniques to detect toxic substances in the victims. The defense, however, questioned Ferreira da Silva's findings, leveraging arguments of authority: that more senior scientists and international experts should be trusted over the younger, local chemists involved. But Ferreira da Silva's interventions were crucial in establishing the credibility of LQMP's scientific analysis as forensic evidence. The trial demonstrated the increasing importance of scientific methodologies in legal decision-making, challenging the traditional reliance on authority figures and subjective judgments, marking a shift towards evidence-based legal practices. Having LQMP's analysis decisively impacted the conviction of Urbino de Freitas, it shaped public opinion on laboratory's status as a credible institution in the development of analytical chemistry and its institutionalization of science in legal frameworks. This blending of science and law was less pronounced in other peripheral city laboratories, where the focus was on broader public health. LQMP's evolution reflects its transition from a purely scientific entity, showing how scientific institutions must secure legitimacy within their broader societal environments.

These efforts were halted with the abrupt closure of the LQMP. Highlighted as a personal crusade against its director and not merely an administrative decision, it was a move that rippled the scientific community, municipal governance, and Porto's society.[50] Especially when the *Laboratório* had garnered international recognition for its scientific contributions.[51] In 1907, the Porto City Council closed the facility influenced by a report[52] suggesting the laboratory had strayed from its core mission of analyzing foodstuffs. The report, coupled with the argument that the laboratory's functions were being absorbed by newer institutions (accompanied from the Portuguese food regulation act) provided the official rationale for its closure. However, this surface reasoning obscured deeper layers of academic rivalry, political maneuvering, and economic considerations.[53] Indeed, the laboratory had broadened its scope of work, which included analyses beyond its original remit, but this expansion enabled the laboratory to tackle an array of public health issues beyond food safety.[54] This was not seen as a scientific advantage from the institution, as critics argued it had diverted from its foundational purpose. Despite several protests, the laboratory was shuttered, a move that some perceived as a dismissal of science's value in societal progress. Although Ferreira da Silva challenged the decision, the laboratory's fate had already been sealed, marking the end of an era in Porto's scientific history.

A case for LQMP's institutional analysis

Introducing IT in the context of the LQMP and its significance involves understanding the interplay between micro-level actions and macro-level social structures.[55] The LQMP serves as a pivotal case study illustrating how scientific practices become institutionalized, influencing broader legislative frameworks, culminating in the emergence of food regulation. Initially, the laboratory's creation was a response to a macro-level social need for improved public health standards, particularly on food safety. This need acted as a trigger, starting a process where micro-level actions (specifically, the scientific analyses and methodologies developed by the LQMP) began to influence and shape social structures.

At the micro-level, individual actors within the LQMP, led by figures like Ferreira da Silva, engaged in scientific practices that laid the groundwork for standardized methods of food regulation. These practices contributed to a shift in how foodstuffs were regulated at a broader societal level. The transition from micro-level actions to macro-level institutionalization occurred as the practices and findings of the LQMP gained recognition and were eventually

incorporated in chemical standards. The laboratory's work helped to establish a mutual trust between the scientific community, the public, and policymakers, demonstrating the effectiveness and necessity of science-based approaches to food regulation. This trust facilitated the adoption of the LQMP's practices, leading to their integration into legislative frameworks.[56] Furthermore, the LQMP's experience aligns with the crisis movement of institutionalization. Societal shocks, such as public health crises related to food safety, prompted a reevaluation of existing practices and the adoption of new validated approaches. The laboratory's success represented a response to these pressures, leading to a transformation in how food safety was regulated.

The institutionalization theory model

In creating the institutionalization process within the context of the LQMP, I propose the following framework based on IT towards scientific laboratories. This model emphasizes the centrality of cognitive and innovation processes in the scientific laboratories' institutional development. It highlights the importance of legitimation, routinization, and the appropriation of these practices in establishing norms to fit new contexts. In parallel, adaptability within the scientific field is compatible with institutional pressures, reflecting the ongoing need for scientific interpretation and public understanding of science. This intends to be a foundation for empirical research aimed at describing the specific causal relationships in the process of institutionalization in scientific laboratories. In this proposal, the original IT model is split into three complementary macro-level phases, as depicted in Figure 2. Each phase has its own micro level environment, which is now introduced.

Figure 2. Macro-level description of the proposed IT model.

Phase One – Trigger: launch of scientific laboratories' institutionalization

This phase begins with the recognition of the material and socio-cognitive conditions within laboratories that call for institutionalization – dubbed as "the trigger". These could be, for example, breakthrough discoveries, paradigm shifts, policy changes or crises in scientific credibility. Next, the key agents (or drivers) that influence institutionalization initiation must be identified. Influential scientists at the helm of scientific institutions could play a pivotal role as well as funding bodies or regulatory agencies. There should be an explicit gap recognition that institutionalization drivers aim to address. It might involve advancing scientific knowledge, enhancing scientific credibility, or addressing societal concerns. And finally, initial consensus building aggregates previous findings by establishing a direction for the institutionalization process. Even if not fully detailed, there should be an early agreement on what the institutionalization aims to achieve within the laboratory context. Figure 3 represents the micro-level structure of Phase 1.

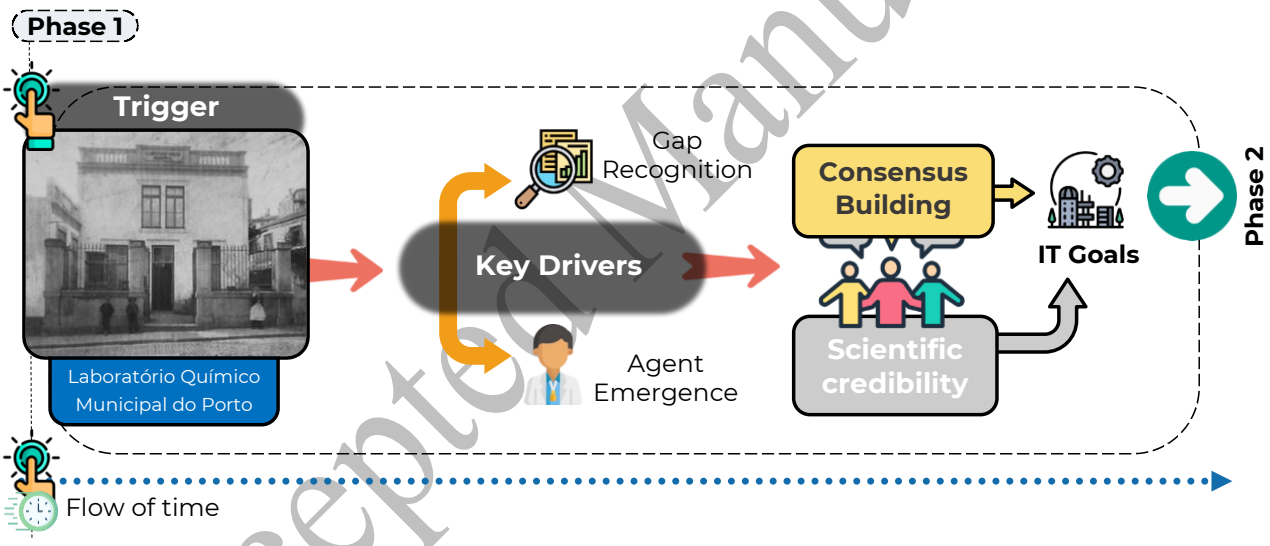

Figure 3. Micro-level description of the proposed Phase One of the IT model.

Phase Two – Legitimation: structuring institutional practices

In the second phase, a novel method, technology, or organizational structure emerges as a response to the "trigger". Various trends can influence the acceptance of new practices within the scientific community, influenced by its structure. Institutionalization occurs when these new methodologies become a central part of the laboratories' *modus operandi*, establishing through habits and incorporating formalities.

This phase is crucial for process materialization, where abstract concepts turn into tangible practices. It starts with the development of new practices, involving the introduction of novel methodologies (technologies or processes) in response to the identified needs. Next, these new practices are integrated into existing laboratory frameworks. Such incorporation requires adaptation, where practices change or become tailored to fit the unique contexts of different laboratories. The concept of agency, where individuals or groups within laboratories take action to implement new practices, often signals the emergence of these innovations. This can result from leadership driving change, collaborative efforts, or institutional mandates.

But the goal of these new practices is also to gain legitimacy within the scientific community. Demonstrating reliability with scientific values can be achieved through successful new practices' routinization and endorsements from influential figures. Through practice consistent monitoring, this feedback is crucial for refining and solidifying the institutionalization process. Thus, Phase Two ensures that new practices are developed, integrated, and legitimized within the scientific laboratories, paving the way for their transition to Phase Three. Figure 4 represents the micro-level structure of Phase Two.

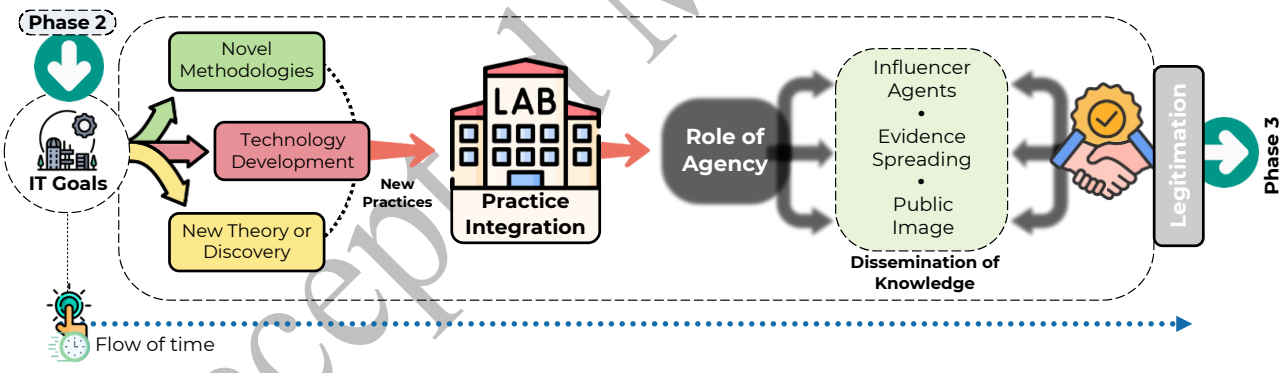

Figure 4. Micro level description of the proposed Phase Two of the IT model.

Phase Three – Memory: diffusion and homogenization of scientific laboratories

The last phase depicts the establishment of new practices. It signifies the maturation of institutionalization, with the eventual appropriation of their norms or standards, adapted to new regulation contexts for policymakers.

Practice adoption is a hallmark of successful institutionalization, showing that they have gained acceptance within the scientific community. Once they become part of a routine, they are no longer seen as new or optional but essential components of scientific work. They are further embedded in the institutional memory of the community, preserved through documentation and transmission of knowledge. In shaping future research beyond cultural integration movements, they now become part of collective knowledge. Evaluating the long-term impact of these institutionalized practices by identifying cultural movements can either expand or restrict their development. This evaluation helps understand the consequences of the institutionalization process. Figure 5 represents the micro-level structure of Phase Three.

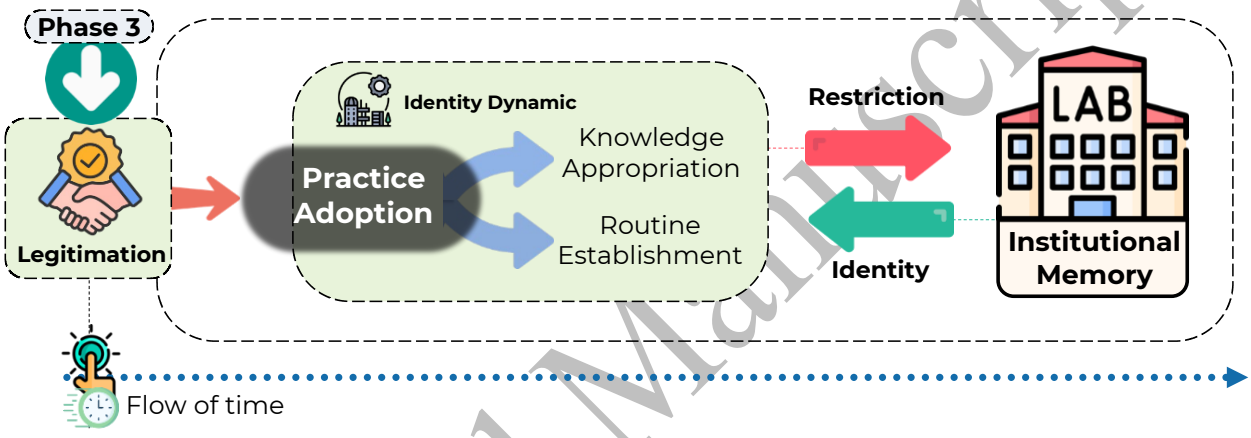

Figure 5. Micro level description of the proposed Phase Three of the IT model.

Institutional analysis of the *Laboratório Químico Municipal do Porto, (1884-1907)*

LQMP's Phase One

By examining the LQMP through the lens of Phase One, its inception aligns with the theoretical framework that emphasizes the importance of socio-cognitive conditions, key drivers and consensus building in the early stages of institutionalization. The laboratory appears in response to Porto's public health concerns, particularly related to food adulteration and water quality.[57] This idea materialized in Porto's urban improvement plan, which highlighted the role of science and technology in advancing the city's welfare, establishing a scientific institution dedicated to addressing these public health issues.

The approval of Porto's urban improvement plan, which included the establishment of the LQMP, was the trigger event in this context. The LQMP was a response to a recognized need

for scientific approaches to address food safety and public health, reflecting a socio-cognitive shift towards trust in science for societal improvement. It's focus on bromatology, public health and chemistry directly addressed the city's concerns, demonstrating a clear link between the institution's needs and objectives.[58] However, the renewal of the APP cannot be ignored in this context. Only through structural reforms in higher education that the critical mass needed to staff this laboratory could be generated.[59]

Porto's challenges with food adulteration, which threatened public health, led to the establishment of the LQMP to address food safety through scientific analysis. This move was also a reflection of a broader trend, aligning Porto with other European cities that had already recognized the importance of scientific laboratories in enhancing urban health standards.[60] The LQMP was envisioned as a pivotal institution that would not only bridge the existing gaps in public health management, but also as a beacon of scientific advancement within the city.

Initial consensus around the creation of the LQMP involved support from various stakeholders, including the city council, the academic community, and the public.[61] By positioning the LQMP at this intersection, stakeholders collectively acknowledged the laboratory's role in fostering a safer urban environment. Such consensus was crucial in ensuring the laboratory's successful integration into the city's public health strategy, solidifying the commitment from various sectors to use the LQMP's services. Also, the laboratory's alignment with the city's improvement plan and its support from prominent figures like Ferreira da Silva would have facilitated this consensus-building process.[62] With his expertise and reputation, Ferreira da Silva played a pivotal role in the laboratory's establishment. His international recognition and scientific acumen provided the credibility and authority to drive the LQMP's creation and its subsequent scientific endeavors.

LQMP's Phase Two

In Phase Two of institutionalization, the focus shifts towards the development, integration, and legitimation of new practices within the institution. This involves the operationalization of its scientific practices within the framework of Porto's public health agenda.

Upon its establishment, the LQMP embarked on developing and refining scientific practices, particularly in analytical chemistry. These practices align with the theoretical aspect of Phase

Two, where an institution operationalizes its foundational objectives. The laboratory pioneered methods for detecting food adulteration, a practice that was not only novel for Porto's context but also set a new standard beyond it. Methodologies were developed in response to relevant societal quarrels, depicted in two major events: the *Salicilagem dos Vinhos do Porto*, (1885-1905) (to be discussed further) and the *Caso Urbino de Freitas*, (1890-1893).[63] Such practice integration into existing laboratory frameworks required a dynamic adaptation process, where traditional methods were reconfigured to accommodate the innovative approaches introduced by the LQMP. Therefore, the municipal laboratory eventually collaborated with other national services to enhance public health.[64] This integration showcases the laboratory's fitness within the broader municipal context, reflecting IT's emphasis on practice integration within the existing framework.

Under the leadership of Ferreira da Silva, the LQMP showed agency in advancing the field of food safety and public health policies.[65] Along with the collective efforts of the laboratory staff, his action ensured that the new practices were not only developed but also effectively adopted and integrated into the laboratory's routine operations. His role in research, analysis, and public engagement illustrates the concept of agency in institutionalization, where his scientific contributions in addressing public health concerns, helped legitimize practices both within the scientific community and the public.[66] The laboratory's international recognition underscore its legitimation, a key aspect of Phase Two where the new practices gain acceptance.

As described in its statutes, the LQMP performed bromatological and food analyses at the service of the population. Its financing, however, came from complementary analytical work outside the LQMP's main area of operation. In this context, attention is drawn to the analysis that Alves and Alves made about LQMP's activity in the period 1884-1906:

According to the Regulation, the analyses requested by individuals or other authorities would be repaid according to an accessible tariff: 500 réis for any qualitative analysis; 2250 réis for quantitative analyses of water, vinegar, sugar, coffee and cheese; 4500 réis of beer, wine, milk, chocolate, flour, butter and bread; According to the objective of its creation, the Laboratory developed its action mainly in the analysis of food substances and their counterfeits, because between 1884-1906, of the 10487 samples counted, 7726 were related to food examinations.[67]

In that period, the LQMP provided society with an analytical inspection service, executed by experienced chemists, on diverse items like wine, bread, milk or butter (and other reports of coffees and vinegars). Simultaneously, the only foodstuffs whose analyses are centrally regulated are wines, olive oils and vinegars. Not only has the Municipality of Porto founded a specific laboratory institution to analyze foodstuffs, but it has also adopted systematic, reproducible methods, making them freely available on the market. Here, its early action fulfilled the city's "Improvement Plan", positioning it as a key player in the emerging food security standards seen across Europe. The laboratory's role as an agent of change, spreading evidence-based practices, helped legitimize its efforts despite the apparent legislative delays from the Portuguese government.[68] To account for this, Figure 6 depicts the sample types analyzed in early years by the LQMP.

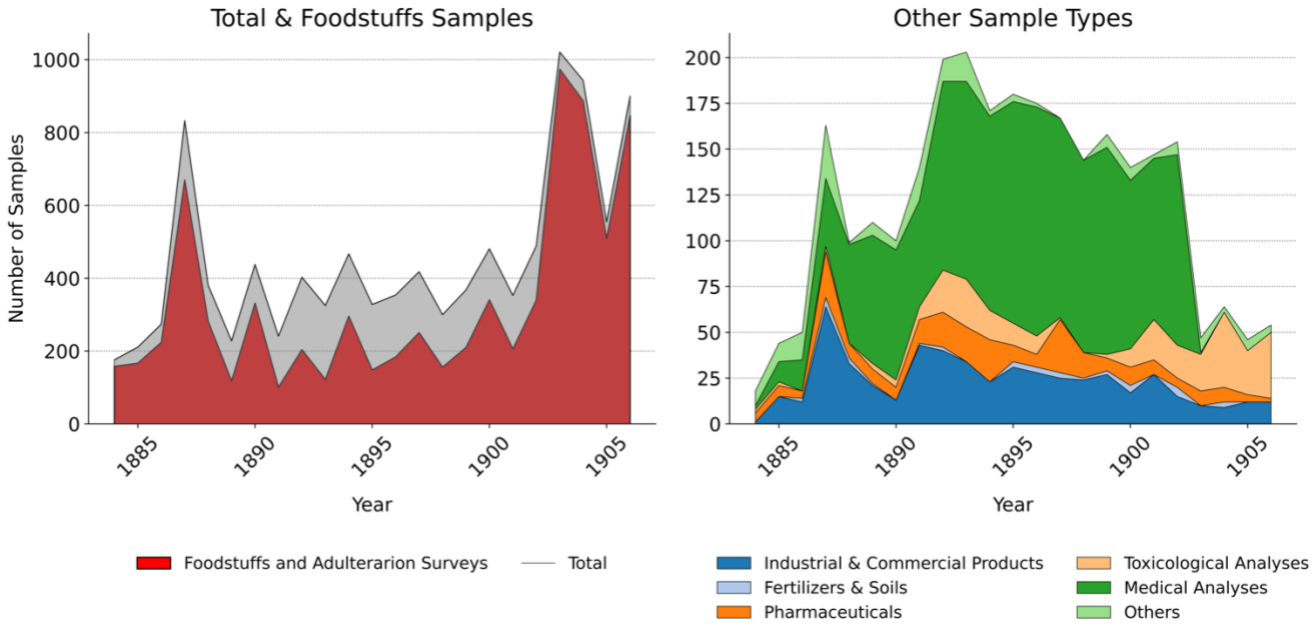

Figure 6. Graph distribution of samples for analysis, submitted to the LQMP from 1884 to 1906, divided by internal category classification.[69]

Figure 6 shows a significant increase in the number of samples analyzed, especially in the early years, followed by sustained high levels of activity. The peak around the late 1880s shows a heightened public concern about food adulteration during this period, leading to more frequent analysis requests. This represents Phase Two's period of consolidation and expansion of the LQMP's role in food safety, marked by the systematic application of analytical chemistry to inspect foodstuffs. Also, Figure 6's right chart shows a diversification of sample types beyond food, especially after 1890. The large green section corresponds to medical analyses, which

became a significant part of the LQMP's work, as this diversification reflects the broader role the laboratory played in municipal health efforts. The increase in non-food-related analyses like medical, industrial and toxicological testing, particularly in the 1890s, shows how the laboratory adapted to additional needs while maintaining its focus on food safety.

On food analysis, the largest part of the LQMP's activities (shown by the dominant red area in the left chart), reflects the core mission of the laboratory during Phase Two: to protect public health by identifying fraudulent practices in food production. The graph demonstrates that the lab responded to the growing awareness and concern regarding food adulteration, a crucial public health issue at the time. As the laboratory's infrastructure and methods matured, more samples were processed, and reproducible methods became standard. This increased testing volume can also be linked to improved institutional practices. According to the regulatory framework, the LQMP offered its services at accessible tariffs, making it easier for individuals to request tests. Reasonable fees likely contributed to the increasing number of samples for analysis as these practices became more established. To achieve this, the LQMP had adequate resources, including a specialized library and state-of-the-art equipment.[70] The increased testing volume can also be linked to these resources, as routinization of successful practices at the LQMP involved transforming experiments to standard procedures.

As elements of consolidation, we can mention the three most relevant. First, the LQMP's role in the legislative sphere in preparing official laboratory documents, in the figure of its director, confers a relevant status for the science carried out in this institution.[71] Second, society recognizes the public image depicting the laboratory's actions. The decisive role in the analysis of high-profile cases conferred a reputation that would lead to the credibility of the science established in the laboratory. Key example of this is the case of *Salicilagem dos Vinhos do Porto* that rose in the late 19th century when Brazilian authorities banned the import of Port wines, citing the presence of salicylic acid, a preservative used to extend shelf life. This threatened a key export market for Port wine, prompting Porto's merchants to ask the LQMP, under Ferreira da Silva, to investigate. Research revealed that the traces of salicylic acid in Porto wine were in fact false positives, not the result of adulteration. By providing scientific evidence, he contested the Brazilian claims and demonstrated that regulatory decisions should account for the quantitative presence of substances, evolving from the binary qualitative system. This scientific intervention not only protected a critical commercial relationship but also underscored the importance of analytical chemistry in distinguishing natural from artificial

substances. The LQMP's work influenced the development of more nuanced food safety standards, moving towards decisions based on empirical evidence, setting a precedent for the use of science in resolving trade disputes and shaping future regulations.

Finally, this consolidation is driven by the promotion of scientific education, by being the editorial sponsor of the first Portuguese chemistry journal: the *Revista de Química Pura e Aplicada* ("Journal of Pure and Applied Chemistry") in 1905.[72] This publication consolidated the laboratory in the academy by bridging science popularization between chemists and laypeople in early 20th century. In fact, this publication was later adopted by the *Sociedade Portuguesa de Química* (the "Portuguese Chemistry Society") as its official bulletin, a tradition that still lives up to this day.[73] It focused on reporting news from European science academies, spreading word on new methods and legislation of interest to chemists. It also engaged in communicating LQMP's findings, as emphasis on food safety analysis in noteworthy in its first years of publication.[74]

Phase Two culminates with LQMP's legitimization, embedding a multilayered phenomenon that stresses the laboratory's establishment as a credible entity. First (i), the LQMP's commitment to scientific rigor played a fundamental role. By adhering to stringent scientific methods and producing reliable, reproducible results, the laboratory established a reputation for trustworthiness. This scientific rigor ensured that the methodologies developed by the LQMP were dependable. The systematic implementation of food safety measures, reflected in the sharp rise in food sample testing between 1885 and 1905, also marked the laboratory's ability to regularly analyze essential foodstuffs, providing reliable, science-based data on food quality. Furthermore, the laboratory expanded its scope to include medical and industrial analyses, contributing to a more holistic public health approach.

Second (ii), the recognition that followed further amplified the LQMP's legitimacy. On public engagement, the laboratory built a strong rapport with the community it served. Examples of this legitimacy are prompted by its repeated reports in contesting incorrect accusations of adulteration from Porto's food merchants. Ferreira da Silva amassed interesting accounts on various analyses made in "his" laboratory, that disputed some specialists' claims of food adulterated products. He goes as far as claiming that "some authorities' analysis and conclusions lacked scientific rigor". This incompatibility amongst reports is the by-product of a bifurcated Portuguese regulatory apparatus, headed by two different institutions, which had

some dissimilarities.[75] Such actions built a reputation for the LQMP's as a "defender" of the "small Porto's merchants", not by partisanship, but by conferring specific foodstuff criteria instead of broad, often blind, ungeneralizable parameters.[76]

Third (iii), collaborations and endorsements from key figures within the scientific community also played a crucial role in legitimizing the LQMP. These not only expanded the laboratory's influence but also served as a testament to its standing in the scientific domain, such as in establishing the Commission for food analysis standards. It showed the practical applicability and relevance of the LQMP's work, as its legitimation is a testament to the multifaceted nature of gaining credibility in the scientific and societal spheres.

LQMP's Phase Three

In Phase Three of the institutionalization process, focus shifts to the embedding of new practices established in Phase Two, leading to their widespread adoption. For the LQMP, this phase would involve the acceptance of its scientific practices to Porto's public health context and beyond.[77] As described previously, practices developed by the LQMP would become standard procedures. Not just within Porto, but in the country, reflecting a broader acceptance, a hallmark of Phase Three, showing that the institution's practices have become embedded.

The *Laboratório's* analytical methods and interventions would become routine components of Porto's public health infrastructure, no longer viewed as novel, but as standard practice. This routinization signifies that the institution's practices became institutionalized, part of the everyday fabric of the city's efforts. Moreover, the LQMP's eventual designation as a photometric post further attests to the confidence placed in the institution's public service. Values, beliefs, and practices promoted by the LQMP would permeate its status, reflecting a deeper integration of the laboratory's scientific ethos into the city's approach to public service,[78] as this cultural integration is a key aspect of Phase Three.

The LQMP played a role in the development of the food regulation act in Portugal, demonstrating a significant incorporation of institutional memory.[79] The laboratory's pioneering work in combating food adulteration laid the groundwork, serving as a crucial repository of knowledge that perceived the legislation. Figure 7 illustrates this amassed

expertise with the broad range of published reports by the LQMP from 1884 to 1907, showcasing laboratory's diverse scientific contributions.

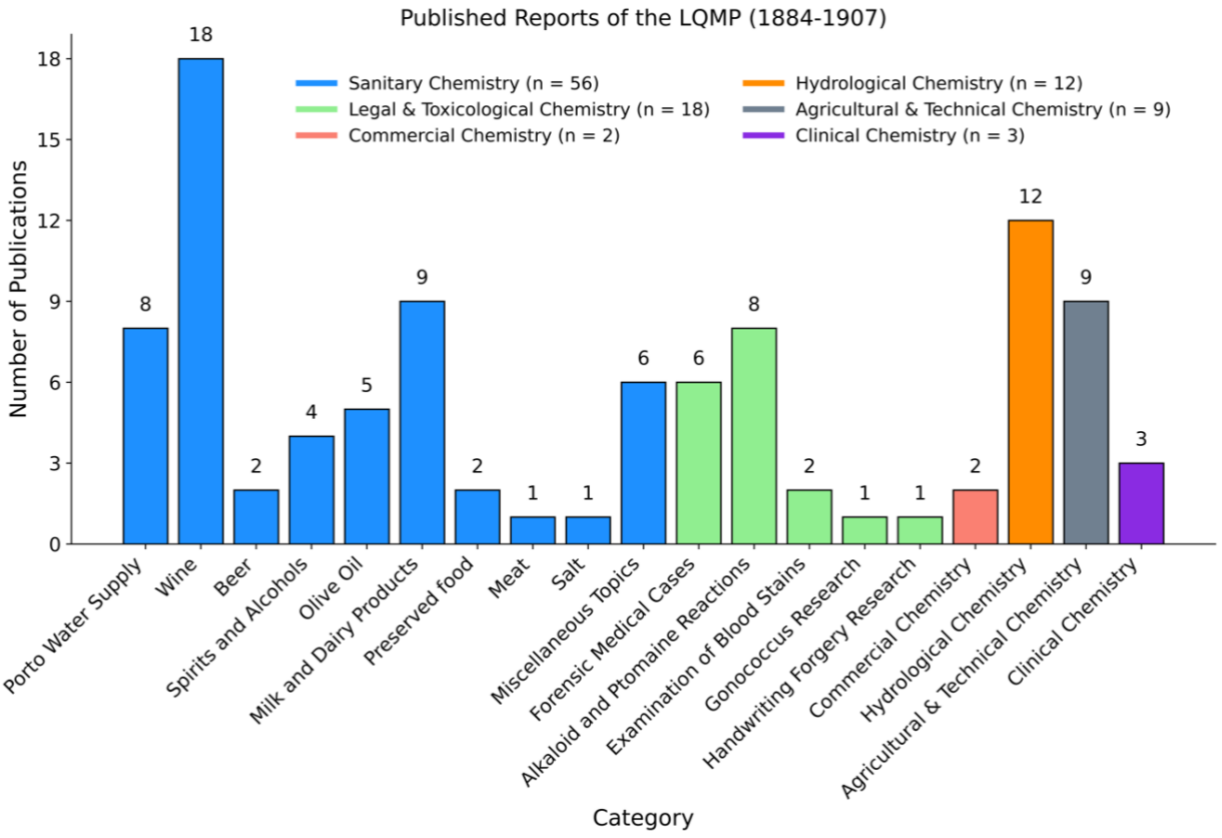

Figure 7. Main works carried out at the LQMP between 1884 and 1907, that were subject to publication, divided by internal category classification.[80]

Figure 7 reflects how the institution's work on sanitary chemistry, particularly in areas such as the analysis of wine, water supply, and preserved food, became integral to shaping public health policy. The overwhelming focus on food-related reports, especially in wine (18 reports) and water supply (8 reports), underscores the laboratory's commitment to addressing key issues to Porto's economic and health landscape. This highlights the LQMP's continuous effort to tackle adulteration in this sector, offering vital data that influenced regulatory measures. It's work on milk and dairy products (5 reports) and spirits and alcohols (4 reports) further illustrates how its expertise extended across various food categories, each of which was prone to adulteration in late 19th and early 20th century Portugal.

This systematic approach to analyzing foodstuffs provided a solid foundation for the regulatory framework. By contributing its institutional memory to the legislative process, the LQMP

ensured that the food regulation act was not only reflective of the latest scientific understanding[81] but also tailored to the specific challenges identified through the laboratory's research. It is noteworthy how much of the foodstuffs analyzed are related to Porto's economic fabric, essential to both the local economy and the national food supply.[82] This integration of institutional memory into the legislative process exemplifies how the LQMP's accumulated knowledge was not confined within its walls, ensuring that the laboratory's contributions have a lasting impact. Indeed the reports related to legal and toxicological chemistry (18 reports) and hydrological chemistry (12 reports) reveal how the LQMP's expertise contributed not only to food safety but also to forensic regulations, playing a multifaceted role in public policies.

While Phase Three emphasizes practice embedding, it allows room for feedback and evolution. The *Laboratório's* methodologies could be subject to continuous refinement and adaptation in response to new challenges, ensuring their relevance and efficacy. In the third moment of analysis, let us consider the elements of identity and restriction in the addressed timeline (1884-1907). The lack of clear legislation on issues closely tied to laboratory work, such as teaching and practice, reflects weak oversight at the central level. However, the renewal of higher and technical education in Porto supplied scientific resources beyond teaching. Laboratories at the Polytechnic Academy and the Industrial Institute were commonly recognized as "accredited" for food analysis. The decentralization of resources along with other economic factors lead to an "emptying" of LQMP competencies with implementing the new food regulation act.[83] During this period, legislation regarding the analysis of goods at Porto's customs named the "Chemical-Fiscal Laboratories" to empirically assess substances deemed dangerous. With regulatory branches now accredited under the new act, these developments mark moments of restriction for LQMP's operations.[84]

On LQMP's limitations, the installation of new central institutions was a determining factor. It created new entities that ensured, under national scrutiny, tasks within the competence of the LQMP.[85] At the beginning of the 20th century, Portuguese legislation included "first-line" laboratories in charge of performing food and economic analysis. Most of these under the tutelage of the *Ministério do Reino* that, until this time, had been little mentioned in the legislation for official purposes. This dynamic here describe is further highlighted by the data showed by Figure 8.

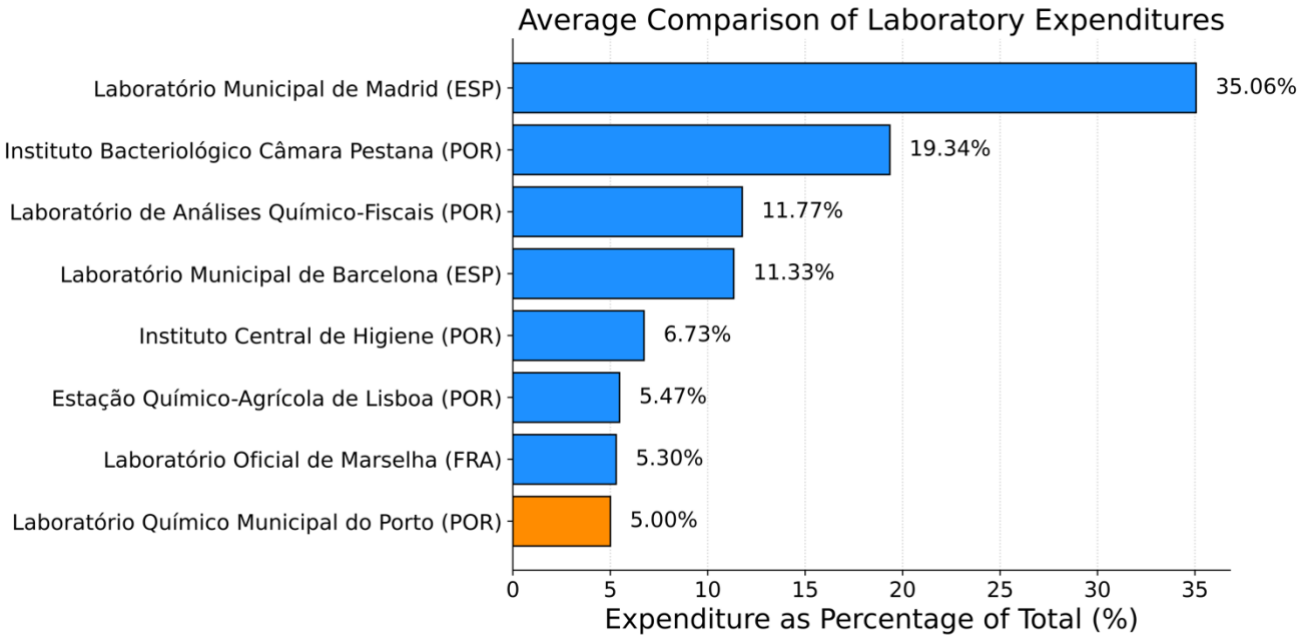

Figure 8. Comparison of estimated yearly expenditure of several Portuguese, Spanish and French laboratories in the period 1899-1907, displayed as percentage of total amassed expenditure.[86]

Figure 8 compares laboratory expenditures across several European institutions that had overlapping directives. In the context of the LQMP, it shows a relatively modest percentage of total expenditures (5.00 %) compared to institutions like the Municipal Laboratory of Madrid (*Laboratório Municipal de Madrid*, 35.06 %) or the *Instituto Bacteriológico Câmara Pestana* (19.34%) could illustrate the shift in resources and centralization of public health responsibilities. The increased expenditures in other Portuguese laboratories may reflect the centralization of laboratory functions under national authority, which diminished the LQMP's prominence and redirected resources to newly centralized entities.

Building on this, Figure 9 further emphasizes the LQMP's moments of restriction by comparing the revenue generated by the LQMP and the *Estação Químico-Agrícola de Lisboa*[87] between 1891 and 1901. The figure visually illustrates the economic decline of the LQMP as new national-sponsored laboratories, like the *Estação*, began to dominate the analytical landscape in Portugal. As shown in the graph, the LQMP's revenue, indicated by the blue line, fluctuated significantly over the years, reflecting its increasingly marginal role in the country's public infrastructure.

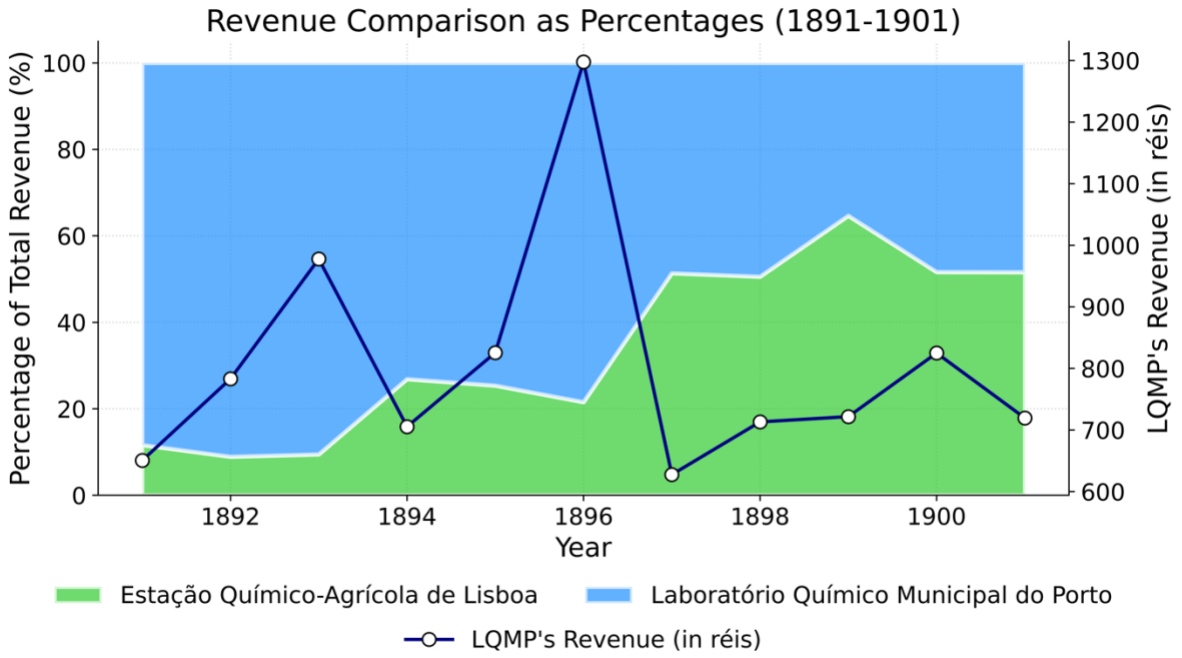

Figure 9. Comparison of percentage of revenue of the LQMP and the *Estação Químico-Agrícola de Lisboa* in the period 1891-1901. The blue line represents LQMP's numeric revenue (secondary yy axis).[88]

Meanwhile, the steady rise of the *Estação's* revenue, particularly after 1895, coincides with the "centralized regulation of analytical methods and the creation of "first-line" laboratories", which were granted priority by the *Ministério do Reino*. This marks a shift where more resources were allocated to central institutions, which were now seen as the authority for conducting chemical analysis. The percentage comparison highlights that Lisbon's laboratory progressively gained a greater share of total revenue, consolidating its role as a player in national regulatory functions. This demonstrates how the decentralization of responsibilities away from the LQMP was accompanied by a corresponding shift in financial resources, leading to a reduction in the LQMP's influence. It complements the vision of restriction and identity loss during Phase Three, where Porto's laboratory increasingly became a peripheral institution as Portugal established more centralized institutions.

Concurringly, a key element of restriction is the unification of analytical methods decreed by Portugal from 1895, to harmonize scientific standards and practices. This element must be regarded not only as a restriction, but also of the identity of the LQMP itself. For example, the fact that its director, Ferreira da Silva, was called to chair the official committee for the elaboration of legislation on scientific practice, should be seen as an element that confers identity and purpose to the Laboratory of Porto.[89] For these reasons, it is clear that these sources

of restriction/identity may have a certain social (and also political) value, which largely depends on their use by public opinion. The ease with which these factors can be generators of a climate of conflict between academic peers, political guardianship, and benefactors, can be strong enough to generate moments of instability. It may be the genesis of a new "trigger" that can initiate a one-way restriction process, whose sources may not be sufficient to address.

Besides the unification of analytical methods, other equally important sources of identity must be considered. The absence of a previous clarifying status on "who" and "how" is authorized to carry out analyses for supervisory purposes, led to the laboratory taking for itself a status of "specialist". With the projection of the research performed by Ferreira da Silva at the LQMP, especially in international scientific journals[90], the scientific contributions emerging from Porto gained significant recognition. And finally, the foundation of the *Revista de Química Pura e Aplicada*, considered by peers as a reference in the scientific Portuguese landscape, can be viewed as a product of the laboratories' identity.

But from all these events, the abrupt closure of the LQMP in 1907 stands as the pivotal incident that highlights the complexities of institutionalization in its Third Phase. The laboratory had firmly established itself as a key player in food regulation, yet political and economic pressures led to its shutdown. Despite its widespread contributions to society, the LQMP's fate illustrates how institutionalized scientific practices can be fragile when confronted with conflicting priorities, resource limitations, and shifting institutional identities.

The decision to close the LQMP was primarily justified by accusations of deviation from its original mission. According to the city council's report, the laboratory had "transformed into a school" and was conducting too many analyses outside its core purpose of food safety.[91] The council noted that, by 1906, the LQMP had conducted 900 analyses, but only 483 were food related. The rest involved substances such as "gasoline, sulfur, and medico-legal analyses like bloodstains and human viscera". This diversification of services was a departure from its original mandate to safeguard public health through food safety analysis. Additionally, the council highlighted the laboratory's "financial inefficiency", stating that it had been running at a loss. With annual expenses exceeding *5600 réis* and minimal revenue from paid analyses, the council argued the LQMP was no longer economically sustainable (as seen in Figure 9's decrease in LQMP's revenue). They also pointed to the availability of other governmental laboratories that could perform similar functions, making the LQMP redundant. Ultimately,

the council asserted that "the laboratory had fulfilled its mission" and that its continued operation was unnecessary in these institutional concerns.

In response, the LQMP's director launched a powerful defense, positioning the laboratory as a key contributor to scientific knowledge in Portugal.[92] Ferreira da Silva argued that the laboratory's role extended far beyond mere food analysis. He emphasized that "the laboratory studied old and new water supplies," helping to secure drinking water purity. He stressed the LQMP had contributed to national and international scientific developments. One notable example was the laboratory's work on the salicylation of Port wines, which averted a major trade dispute with Brazil. This defense shows that, while the laboratory may have expanded beyond its original purpose, it had done so in ways that enhanced its scientific reputation, aligning with the Third Phase of institutionalization where institutions adapt and expand to remain relevant.

The closure of the LQMP illustrates the restrictions that institutions often face during the third stage of institutionalization. As scientific institutions expand their influence, they often encounter financial and political constraints that limit their ability to sustain operations. The laboratory's growing influence and expansion into other scientific realms, such as toxicology and industrial analyses, ran counter to the council's more restricted view of the LQMP's mandate. This tension between institutional growth and political restriction is a common feature of the third phase of institutionalization. While the LQMP had developed a broader identity, its expanding role came at a cost that the local government was unwilling to support. The political decision showcases the limitations that institutions often face in balancing their growing scope with the political realities of the environment in which they operate.

The debates over the LQMP's closure also highlight the shifting identity of the laboratory. Initially established as a municipal institution focused on public health, the LQMP had evolved into a multifaceted scientific organization conducting a wide range of analyses. This expansion was partly driven by the laboratory's growing increasing demands placed upon it by both the local government and the scientific community. However, this evolving institutional identity also contributed to its downfall. The city council's argument that the LQMP had strayed too far from its original purpose reflects the challenges that institutions face in the Third Phase of institutionalization. As the LQMP expanded its functions, it began to occupy a more ambiguous space between its original mandate and its new role as a scientific research institution. The

council's decision to close the laboratory can be seen as an attempt to rein in this expanding identity and return the focus of municipal resources to more clearly defined public functions.

One of the key elements of the Third Phase of institutionalization is the preservation of institutional memory. In defending the laboratory, Ferreira da Silva underscored the LQMP's longstanding contributions to Porto's public health infrastructure and its role in shaping national food safety standards. He pointed out that the laboratory had been officially recognized by the Portuguese government in 1904 as an "official establishment for the analysis of foodstuffs" to assist in regulating food safety. This acknowledgment by the national government reinforced the LQMP's institutional memory as a critical player in safeguarding public health. The decision to close the LQMP, despite these historical contributions, reflects a break in the institutional memory of scientific practices. Its closure signaled the loss of this accumulated knowledge and expertise, a key aspect of de-institutionalization where institutions lose their historical continuity. Ensuing legal battles highlight how deeply the LQMP had become embedded in the social fabric of Porto and how its loss was felt as a blow to both the city and the scientific community. This serves as a case study of how scientific institutions, despite their contributions, must continually navigate the tensions between their expanding roles and the restrictive forces of politics to maintain their institutional legacy.

Influence of institutionalization in adopted legislation

The institutionalization dynamic exemplified by the LQMP plays a pivotal role in the emergence of food regulation. As the first Portuguese laboratory critically specialized in analyzing foodstuffs, the LQMP not only set a precedent for scientific intervention in Portugal's public health, but also laid the foundational framework for integrating scientific expertise into regulatory practices. By developing methodologies for detecting adulteration and contamination, the laboratory provided a scientific basis for establishing standards into legislation. This transition from *ad hoc* inspection to standardized, scientifically validated procedures is crucial for effective food regulation. Its work showed how scientific insights could directly influence policy, ensuring that regulations were not just descriptive but also based on demonstrable risks and interventions.

The *Laboratório's* integration into Porto's public health system highlighted the importance of institutional collaboration for effective food safety governance. By linking scientific research

with its role in ensuring food safety, it helped build public trust in both the scientific community and the government's regulatory efforts.[93] It also served an educational role, raising awareness among producers, consumers, and regulators about the importance of food safety and the scientific principles underlying it.

The LQMP's contributions to the food regulation legislation in Portugal are further exemplified by the data on published reports and revenue trends from the laboratory during the institutionalization period. Figure 7, which categorizes the LQMP's reports between 1884 and 1907, underscores the institution's extensive research output in critical areas of food safety, instrumental in providing scientific data that directly influenced legislative frameworks. The focus on sanitary chemistry (56 reports) and legal and toxicological chemistry (18 reports) shows that the LQMP was not only addressing immediate public health concerns but also shaping the scientific basis for broader regulatory policies in Portugal.

Moreover, Figure 9, which compares revenue between the LQMP and the *Estação Químico-Agrícola de Lisboa*, reflects how the economic landscape shifted as regulatory responsibilities became centralized. The LQMP's fluctuating revenue throughout the 1890s and early 1900s can be interpreted because of this centralization, which gradually transferred authority to Lisbon's institutions. The combination of these elements – the LQMP's scientific output and the shifts in its financial stability – reinforces the argument that the laboratory's institutionalization was not only foundational to the development of food regulation but also reflective of broader political dynamics that shaped public governance. As the LQMP laid the groundwork for legislative action, its eventual decline and closure illustrate the complex relationship between scientific institutions, policy-making, and economic centralization, all of which played crucial roles in shaping Portugal's food regulation landscape.

The LQMP's closure and its interaction with the broader themes of institutionalization provide a nuanced understanding of the challenges in embedding scientific practice within public policy. Its establishment in 1884 under Ferreira da Silva's leadership was an embodiment of institutionalization in its early phase, where an identified need (food adulteration), was addressed by a new institution. However, the controversial decision to close the LMQP in 1907, illustrates the challenges inherent in the third phase of institutionalization – diffusion and homogenization. The laboratory's closure amidst political, economic, and institutional pressures showcases the fragile nature of institutional permanence and the influence of external

factors on the sustainability of institutionalized practices. The legal battles and public outcry following the decision highlight the societal recognition of the LMQP's value.[94] This resistance against the laboratory's closure can be seen as a societal pushback against de-institutionalization, emphasizing the laboratory's integration within the local and the scientific community.

Final remarks

This article intended a comprehensive analysis of the LQMP within the framework of IT, providing a nuanced understanding of how scientific institutions undergo the process of institutionalization. Impacting public policy and societal norms, the LQMP's inception, operations, and eventual discontinuation encapsulate a spectrum of institutionalization dynamics.

The emergence of the LQMP was not an isolated event. It was a response to the burgeoning needs of a rapidly industrializing Porto, grappling with the challenges of public health and food safety. This response was emblematic of the First Phase of institutionalization, where a societal need catalyzes the formation of an institution. The laboratory's establishment under the guidance of Ferreira da Silva was a pivotal moment, marking the city's commitment to leveraging scientific expertise to address pressing public health issues. The LQMP was envisioned as a bridge between scientific inquiry and public welfare, tasked with the critical mission of ensuring food safety and public health through rigorous chemical analysis, as highlighted in its second phase.

But the institutionalization journey of the LQMP was not linear. The laboratory's closure in 1907, prompted by a combination of political, economic, and institutional factors, underscores the challenges inherent in the diffusion and homogenization phase of institutionalization. As hallmarks of its third phase of institutionalization, along with the public and scientific community's reaction, the LQMP's closure reflects the deep-rooted impact of the laboratory on Porto's societal and scientific landscape.

The detailed examination of the LQMP through a proposed multi-layered model of institutionalization – initiation, structuring, and homogenization – provides a rich narrative that encapsulates the role of scientific institutions in societal advancement. The model helps

tracking LQMP's journey throughout its lifecycle, offering insights into the dynamics of institutionalization and on how scientific practices are influenced by societal and policy frameworks. This detailed analysis not only contributes to the understanding of the LQMP's historical significance, but also offers a broader replicable model to understand other laboratories on their intricate institutional interplay between science, society, and institutionalization.

List of Bibliography

Ana Simões, "From Capital City to Scientific Capital: Science, Technology, and Medicine in Lisbon as Seen through the Press, 1900–1910," in *Urban Histories of Science*, eds. Oliver Hochadel and Agustí Nieto-Galan (New York: Routledge, 2018), pp. 141-163.

Andreas W. Daum, "Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections," *Isis* 100 (2009): 319-332.

António M. Basto, *Memória Histórica da Academia Politécnica do Porto* (Porto: Universidade do Porto, 1987).

Bruno Latour, *Laboratory Life: The Construction of Scientific Facts* (Princeton University Press, 1979).

Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Open University Press, 1987).

Christine Oliver, "Strategic Responses to Institutional Processes," *The Academy of Management Review* 16, no. 1 (1991): 145-179

Christoph Stadtfeld, "The Micro–Macro Link in Social Networks," *Emerging Trends in the Social and Behavioral Sciences* (2018): 1-15,

Graeme Gooday, "Placing or Replacing the Laboratory in The History of Science?" *Isis* 9 (2008): 783-795.

I. Suay-Matallana, "Customs laboratories, chemistry and excise: An historical introduction," *World Customs Organization News* 77 (2015): 34-37.

I. Suay-Matallana, "The material culture of the customs laboratory of Lisbon," *Conservar Património* 30 (2019): 131–139.

I. Suay-Matallana and X. Guillem-Llobat, "Poisoned Wine: Regulation, Chemical Analyses, and Spanish-French Trade in the 1930s," *Ambix* 65, no. 2 (2018): 99-121.

I. Suay-Matallana, "The Customs Laboratory of Lisbon from the 1880s to the 1930s: Chemistry, trade and scientific spaces," in *Science, Technology and Medicine in the Making of Lisbon 1840–1940*, eds. Ana Simões and Maria Paula Diogo (Leiden: Brill, 2022), pp. 179–202.

J. R. Bertomeu-Sánchez, "Chemistry, microscopy and smell: bloodstains and nineteenth-century legal medicine," *Annals of Science* 72, no. 4 (2015): 490-516.

James A. Secord, "Knowledge in Transit," *Isis* 94 (2004): 654-672.

James Coleman, *Foundations of Social Theory* (Cambridge: Harvard University Press, 1990), namely in the interconnection between micro and macro levels.

Jorge Alves and Rita Alves, "Ferreira da Silva e o Laboratório Químico Municipal do Porto (1884-1917)," *Estudos do Século XX* 12 (2012): 14-30.

Jorge Alves and Rita Alves, *Nos Caminhos da Química, A. J. Ferreira da Silva* (U. Porto Edições, 2013).

José Ferraz-Caetano and Bruno D. A. Pinheiro, "Legislators' Plague: How History of Science Can Explain the Struggles of Universal Pandemic Responses," in *Handbook of Research on Historical Pandemic Analysis and the Social Implications of COVID-19,* eds. Antonio Cortijo Ocaña and Vicent Martines (Hershey, PA (USA): IGI Global, 2021), pp. 47-59.

José Ferraz-Caetano, "As raízes da regulação alimentar em Portugal: leis e práticas baseadas em ciência, 1875-1905," *Ler História* 82 (2023): 171-194.

José Ferraz-Caetano, "The Case of the 'Salycilation of Port Wines': Echoes of the Social, Economic and Scientific Vision of Portugal-Brazil Relations (1885-1905)," *Revista Brasileira de História da Ciência* 15, no. 1 (2022): 108-119.

José Ferraz-Caetano, *As Artes Químicas na Academia do Porto e o Surgimento da Regulação Alimentar em Portugal (1875-1905).* (Coimbra: University of Coimbra, Master's thesis, 2021).

José Ferraz-Caetano, João Paiva, and Francisco M. Romeiras, "António Ferreira da Silva and the Teaching of Chemistry at the Academia Politécnica do Porto (1877-1910)," *História da Ciência e Ensino: construindo interfaces* 20 (2019): 213-221.

M.W. Bauer, "The Evolution of Public Understanding of Science - Discourse and Comparative Evidence," *Science, Technology and Society* 14, no. 2 (2009): 221-240.

Maria Fernanda Rollo, Tiago Brandão, and Maria Inês Queiroz, "Revising the Institutionalization of Science Policies: Historical Contexts and Competing Models," *Portuguese Journal of Social Science* 17, no. 1 (Mar 2018): 37-61.

Max Weber, *Economy and Society: An Outline of Interpretive Sociology* (University of California Press, 1978).

Oliver Hochadel and Agustí Nieto-Galan, "How to Tell the Tale," in *Urban Histories of Science,* eds. Oliver Hochadel and Agustí Nieto-Galan (New York: Routledge, 2018), p. 1-15.

P.S. Tolbert and L.G. Zucker, "The Institutionalization of Institutional Theory," in S. Clegg, C. Hardy, and W. Nord (Eds.), *Handbook of Organization Studies* (London: SAGE, 1996).

Paulo Augusto, "Teoria Institucional: Qual o Lugar da Agência," presented at the 30º Encontro da Associação Nacional dos Programas de Pós-graduação em Administração, Rio de Janeiro, 2007 (ANPAD, 2007).

Peter J. Atkins and A. Stanziani, "From Laboratory Expertise to Litigation: The Municipal Laboratory of Paris and the Inland Revenue Laboratory in London, 1870-1914: A Comparative Analysis," in *Fields of Expertise: A Comparative History of Expert Procedures in Paris and London, 1600 to Present,* (Cambridge Scholars Press, 2008), pp. 317-338.

R. J. Dinis-Oliveira, "Portugal's First Major Forensic Case and the Genesis of Forensic Toxicology: 10 Years of Research to Reconstruct the Event," *Forensic Sciences Research* 4, no. 1 (2019): 69-81.

Richard Harvey Brown, "Modern Science: Institutionalization of Knowledge and Rationalization of Power," *The Sociological Quarterly* 34, no. 1 (1993): 153-168.

Richard Whittington, "Putting Giddens into Action: Social Systems and Managerial Agency," *Journal of Management Studies* 29, no. 6 (1992).

Stephen Barley and Pamela Tolbert, "Institutionalization and Structuration: Studying the Links between Action and Institution," Organization Studies 18, no. 1 (1997).

T. Felin and N. Foss, "Microfoundations for Institutional Theory?" in P. Haack, J. Sieweke, and L. Wessel (Eds.), *Microfoundations of Institutions*, Research in the Sociology of Organizations, Vol. 65B (Emerald Publishing Limited, Leeds, 2019), pp. 393-408

Tanja Kuchenmüller, Laura Boeira, Sandy Oliver, Kaelan Moat, Fadi El-Jardali, Jorge Barreto, and John Lavis, "Domains and Processes for Institutionalizing Evidence-Informed Health Policy-Making: A Critical Interpretive Synthesis," *Health Res Policy Sys* 20, 27 (2022).

Walter W. Powell and Patricia Bromley, "New Institutionalism in the Analysis of Complex Organizations," in *International Encyclopedia of the Social & Behavioral Sciences*, Second Edition, ed. J.D. Wright (Elsevier, 2015), pp. 764-769.

Zuoyue Wang and Naomi Oreskes, "History of Science and American Science Policy," *Focus - Isis* 99 (2008): 365-373.

List of Sources

António Ferreira da Silva, *A Fiscalisação Dos Generos Alimenticios No Porto: (Vinhos)*, Papelaria La Bécarre, Porto, 1903.

António Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto, (1907-1908)*, s.n., Porto, 1909.

António Ferreira da Silva, *Documentos sobre os trabalhos de química aplicada à higiene do Laboratório Municipal de Química do Porto*, Imprensa Portugueza, Porto, 1904.

António Ferreira da Silva, *Os Vinhos Portuguezes Genuínos Condenados como Falsificados: Notas Sobre os Trabalhos a Que Deu Origem a Questão dos Vinhos Suppostos Salicylados no Brasil com a Apreciação do Snr. H. Pellet e Vários Documentos*, Off. do Comércio do Porto, Porto, 1902.

António Ferreira da Silva, *Recursos e Peritos na Fiscalisação Sanitaria no Porto em 1903: (O Reverso da Medalha)*, Imprensa Portugueza, Porto, 1905.

António Ferreira da Silva, *Relatórios do Laboratório Municipal de Chimica do Porto no período de 1884 a 1896*, Typ. A. da Fonseca Vasconcellos, 1897.

António Ferreira da Silva, *Documentos sobre os trabalhos de química aplicada à higiene do Laboratório Municipal de Química do Porto: 1884-1906*, s.n., 1910.

António La-Grange, *Audiências de julgamento do Dr. Urbino de Freitas*, A.J. de Sousa, Porto, 1893.

Amando Seabra *et al*., *Documentos Scientificos da Commissão Technica dos Methodos Chimico-Analyticos* (Coimbra: Imprensa da Universidade, 1910).

Arquivo Digital da Universidade do Porto, Fundo APP, 1837-1911, Livros de cópia dos relatórios químico-legais do Laboratório Químico Municipal do Porto (1900-1907), available at https://repositorio-tematico.up.pt/handle/10405/47964, last accessed on [20/03/2024].

Augusto de Aguiar, "Dr. António Joaquim Ferreira da Silva," *Revista de Química Pura e Aplicada*, 1924, 16, 7-11. 11-16. Diário do Governo, nos. 284, 24, 268, 50, 99, 90 (dates: 14 de dezembro de 1895, 7 de outubro de 1901, 26 de novembro de 1902, 4 de março de 1902, 6 de maio de 1903, 25 de abril 1904).

Diário do Governo, no. 284 (14 de dezembro de 1895).

Diário do Governo, no. 24 (7 de outubro de 1901).

Diário do Governo, no. 268 (26 de novembro de 1902).

Diário do Governo, no. 50 (4 de março de 1902).

Diário do Governo, no. 99, (06 maio de 1903).

Diário do Governo, no. 90 (25 de abril 1904).

Direção Geral dos Serviços Agrícolas, *Methodos Officiaes para as Analyses dos Vinhos, Vinagres e Azeites: Seguidos da Indicção Summaria dos Processos Empregados nos Documents sur les falsifications des matières alimentaires et sur les travaux du Laboratoire municipal: Deuxième rapport*, République Française, Préfecture de Police (Paris: G. Masson, Librairie de l'Académie de Médecine, 1885).

Laboratorios do Estado para o Exame do Leite e Lacticinios; Alcooes e Aguardentes, Typ. da Encyclopedia Portugueza, Lisboa, 1910.

Henri Pellet, *O Ácido Salicylico e a Questão dos Vinhos Portuguezes no Brazil em 1900*, Imprensa da Universidade de Coimbra, 1906.

O Laboratório Chimico Municipal do Porto: Relatório da Commissão de Inquérito, Aprovado em Sessão de 31-XII-1907, Typ. Emp. Guedes, Porto, 1909.

Plano de Melhoramentos da Cidade do Porto apresentado à Câmara Municipal em sessão extraordinária de 26 de setembro de 1881, Typ. José da Silva Teixeira, Porto, 1881.

Notes

[1] A broad introduction to institutionalization theory is given by P.S. Tolbert and L.G. Zucker, "The Institutionalization of Institutional Theory," in S. Clegg, C. Hardy, and W. Nord (Eds.), *Handbook of Organization Studies* (London: SAGE, 1996), pp. 175-190.

[2] In the same framework where Kuchenmüller argued for the case of health-related policies: Tanja Kuchenmüller, Laura Boeira, Sandy Oliver, Kaelan Moat, Fadi El-Jardali, Jorge Barreto, and John Lavis, "Domains and Processes for Institutionalizing Evidence-Informed Health Policy-Making: A Critical Interpretive Synthesis," *Health Res Policy Sys* 20, 27 (2022).

[3] As in the seminal example of institutionalization of knowledge in Richard Harvey Brown, "Modern Science: Institutionalization of Knowledge and Rationalization of Power," *The Sociological Quarterly* 34, no. 1 (1993): 153-168.

[4] Namely in the sections on "legitimate domination" in Max Weber, *Economy and Society: An Outline of Interpretive Sociology* (University of California Press, 1978).

[5] The exploration of Weber's initial theory is expanded in Christine Oliver, "Strategic Responses to Institutional Processes," *The Academy of Management Review* 16, no. 1 (1991): 145-179 and Stephen Barley and Pamela Tolbert, "Institutionalization and Structuration: Studying the Links between Action and Institution," Organization Studies 18, no. 1 (1997). We will use these references in framing the concept of IT into scientific institutions.

[6] The basis for the threefold conceptual vison is first introduced in Richard Whittington, "Putting Giddens into Action: Social Systems and Managerial Agency," *Journal of Management Studies* 29, no. 6 (1992) and it is later operationalized with an example in Paulo Augusto, "Teoria Institucional: Qual o Lugar da Agência," presented at the 30º Encontro da Associação Nacional dos Programas de Pós-graduação em Administração, Rio de Janeiro, 2007 (ANPAD, 2007).

[7] The proposed model will follow closely the article by James Coleman, *Foundations of Social Theory* (Cambridge: Harvard University Press, 1990), namely in the interconnection between micro and macro levels.

[8] As defined in Walter W. Powell and Patricia Bromley, "New Institutionalism in the Analysis of Complex Organizations," in *International Encyclopedia of the Social & Behavioral Sciences*, Second Edition, ed. J.D. Wright (Elsevier, 2015), pp. 764-769.

[9] Coleman, *Foundations of Social Theory*.

[10] The book chapter T. Felin and N. Foss, "Microfoundations for Institutional Theory?" in P. Haack, J. Sieweke, and L. Wessel (Eds.), *Microfoundations of Institutions*, Research in the Sociology of Organizations, Vol. 65B (Emerald Publishing Limited, Leeds, 2019), pp. 393-408 gives a detailed description on how level dynamics can change how institutionalization is perceived for a particular organization.

[11] In Christoph Stadtfeld, "The Micro–Macro Link in Social Networks," *Emerging Trends in the Social and Behavioral Sciences* (2018): 1-15, this is explored between agents in institutionalization.

[12] One similar example in the Portuguese context that poses a similar proposition was presented by Maria Fernanda Rollo, Tiago Brandão, and Maria Inês Queiroz, "Revising the Institutionalization of Science Policies: Historical Contexts and Competing Models," *Portuguese Journal of Social Science* 17, no. 1 (Mar 2018): 37-61.

[13] Coleman, *Foundations of Social Theory*.

[14] For a general understanding of Bruno Latour's works: Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Open University Press, 1987); and Bruno Latour, *Laboratory Life: The Construction of Scientific Facts* (Princeton University Press, 1979).

[15] In historiographic debate upon this subject see especially Graeme Gooday, "Placing or Replacing The Laboratory in The History of Science?" *Isis* 9 (2008): 783-795.

[16] On the circulation of scientific knowledge, James A. Secord, "Knowledge in Transit," *Isis* 94 (2004): 654-672; Andreas W. Daum, "Varieties of Popular Science and the Transformations of Public Knowledge: Some Historical Reflections," *Isis* 100 (2009): 319-332.

[17] In the field of science communication, M.W. Bauer, "The Evolution of Public Understanding of Science - Discourse and Comparative Evidence," *Science, Technology and Society* 14, no. 2 (2009): 221-240.

[18] Zuoyue Wang and Naomi Oreskes, "History of Science and American Science Policy," *Focus - Isis* 99 (2008): 365-373.

[19] For a descriptive history of the laboratory, see Jorge Alves and Rita Alves, "Ferreira da Silva e o Laboratório Químico Municipal do Porto (1884-1917)," *Estudos do Século XX* 12 (2012): 14-30.

[20] The Porto City Council, recognizing the central value of chemistry in the city's development, highlights its importance in the *Plano de Melhoramentos da Cidade do Porto apresentado à Câmara Municipal em sessão extraordinária de 26 de setembro de 1881* (Porto: Typ. José da Silva Teixeira, 1881).

[21] The LQMP's food safety contributions are documented in José Ferraz-Caetano, "As raízes da regulação alimentar em Portugal: leis e práticas baseadas em ciência, 1875-1905," *Ler História* 82 (2023): 171-194.

[22] Ferreira da Silva's role in the consolidation of Portuguese chemistry teaching and in the emergence of a new discipline, Analytical Chemistry, is explored in José Ferraz-Caetano, João Paiva, and Francisco M. Romeiras, "António Ferreira da Silva and the Teaching of Chemistry at the Academia Politécnica do Porto (1877-1910)," *História da Ciência e Ensino: construindo interfaces* 20 (2019): 213-221. For a wider view on the APP's educational context, see António M. Basto, *Memória Histórica da Academia Politécnica do Porto* (Porto: Universidade do Porto, 1987).

[23] *Plano de Melhoramentos da Cidade do Porto*, (1881).

[24] A description of Porto's social and economic landscape at the end of the 19th century can be found in Alves and Alves, "Ferreira da Silva e o Laboratório Químico."

[25] This is argued by depicting Lisbon as a case study in Ana Simões, "From Capital City to Scientific Capital: Science, Technology, and Medicine in Lisbon as Seen through the Press, 1900–1910," in *Urban Histories of Science*, eds. Oliver Hochadel and Agustí Nieto-Galan (New York: Routledge, 1st ed., 2018), pp. 141-163.

[26] The early inception of Portuguese food regulation is described in detail in the section "Origens da regulação alimentar portuguesa" in Ferraz-Caetano, "As raízes da regulação alimentar em Portugal."

[27] The dichotomy with the Iberian cases beyond food safety is reported by J. R. Bertomeu-Sánchez, "Chemistry, microscopy and smell: bloodstains and nineteenth-century legal medicine," *Annals of Science* 72, no. 4 (2015): 490-516.

[28] Jorge Alves and Rita Alves, *Nos Caminhos da Química, A. J. Ferreira da Silva* (U. Porto Edições, 2013), pp. 177-214.

[29] Unknown author, *A entrada do Laboratório Químico Municipal, no n.º 41 da Rua do Laranjal*, c. 1900, MHNC-UP Archive.

[30] The ensuing political tensions were personalized in Ferreira da Silva, whose "fervent catholic faith" clashed with the rising republican movements in early 20th century Portugal. Alves and Alves, "Ferreira da Silva e o Laboratório Químico".

[31] Augusto de Aguiar, "Dr. António Joaquim Ferreira da Silva," *Revista de Química Pura e Aplicada* 16 (1924): 7-11.

[32] Alves and Alves, *Nos Caminhos da Química*, pp. 131-176.

[33] As a basis for the description of the Laboratory, see P.J. Atkins and A. Stanziani, "From Laboratory Expertise to Litigation: The Municipal Laboratory of Paris and the Inland Revenue Laboratory in London, 1870-1914: A Comparative Analysis," in *Fields of Expertise: A Comparative History of Expert Procedures in Paris and London, 1600 to Present*, (Cambridge Scholars Press, 2008), pp. 317-338.

[34] A practice that the LQMP would adopt more extensively.

[35] Suay-Matallana has extensively written on this impact on Spanish institutions, namely customs laboratories in I. Suay-Matallana, "Customs laboratories, chemistry and excise: An historical introduction," *World Customs Organization News* 77 (2015): 34-37.

[36] Oliver Hochadel and Agustí Nieto-Galan, "How to Tell the Tale," in *Urban Histories of Science*, eds. Oliver Hochadel and Agustí Nieto-Galan (New York: Routledge, 1st ed., 2018), p. 1-15.

[37] Reports on the Paris Laboratory activities are depicted in *Documents sur les falsifications des matières alimentaires et sur les travaux du Laboratoire municipal: Deuxième rapport*, République Française, Préfecture de Police (Paris: G. Masson, Librairie de l'Académie de Médecine, 1885).

[38] Trade relationships with countries like Brazil, which had stricter regulations on sulfites and preservatives in imported wines.

[39] I. Suay-Matallana and X. Guillem-Llobat, "Poisoned Wine: Regulation, Chemical Analyses, and Spanish-French Trade in the 1930s," *Ambix* 65, no. 2 (2018): 99-121.

[40] A piece on customs laboratories can be found on I. Suay-Matallana, "Customs Laboratories, Chemistry and Excise: An Historical Introduction," *World Customs Organization News*, 77 (2015): 34-37.

[41] I. Suay-Matallana, "The Customs Laboratory of Lisbon from the 1880s to the 1930s: Chemistry, Trade and Scientific Spaces," in *Science, Technology and Medicine in the Making of Lisbon 1840–1940*, eds. Ana Simões and Maria Paula Diogo (Leiden: Brill, 2022), pp. 179–202.

[42] Both following contributions are well documented in the article of Alves and Alves, "Ferreira da Silva e o Laboratório Químico."

[43] The key official legislative recognition of the laboratory's expertise is shown in *Diário do Governo*, no. 90 (25 de abril 1904), pp. 163.

[44] There are three sources that document this. Mainly, both cited works of Ferreira da Silva are extremely detailed on the LQMP's activities, including technical details and collaboration reports. A. Ferreira da Silva, *Relatórios do Laboratório Municipal de Chimica do Porto no período de 1884 a 1896* (Typ. A. da Fonseca Vasconcellos, 1897) and A. Ferreira da Silva, *Documentos sobre os trabalhos de química aplicada à higiene do Laboratório Municipal de Química do Porto: 1884-1906* ([S.l.: s.n.], 1910).

[45] On Seabra's book, that lists the Commission's activities, we find multiple citations of Ferreira da Silva's collaborators that devise these methods. Moreover, there are reports of a chemist, Hugo Mastbaum, who quotes

practices imported from the Paris Municipal Laboratory, later changed (or partially changed) by the LQMP. Amando Seabra et al., *Documentos Scientificos da Commissão Technica dos Methodos Chimico-Analyticos* (Coimbra: Imprensa da Universidade, 1910). A key example is shown in the technical notes for cheese analysis.

[46] The laboratory's influence in Portuguese food regulation implementation is seen in Ferraz-Caetano, "As raízes da regulação alimentar em Portugal."

[47] This is strongly supported by the composition of the committee, where many of Ferreira da Silva's collaborators (and students) in the LQMP are nominated. See *Diário do Governo*, no. 284 (14 de dezembro de 1895).

[48] An argument for the reasons behind this can be found in section 2 of the article Ferraz-Caetano, "As raízes da regulação alimentar em Portugal.", while a formal certification of LQMP's works is found in *Diário do Governo*, no. 90 (25 de abril 1904), pp. 163.

[49] To understand the impact of Ferreira da Silva and the LQMP in resolving this case, it is essential to read the article by R.J. Dinis-Oliveira, "Portugal's First Major Forensic Case and the Genesis of Forensic Toxicology: 10 Years of Research to Reconstruct the Event," *Forensic Sciences Research* 4, no. 1 (2019): 69-81 and consultation of the court hearings of the trial in the compilation of António La-Grange, *Audiências de julgamento do Dr. Urbino de Freitas* (Porto: A.J. de Sousa, 1893).

[50] Based on the City Council's report that sustained shutting down the LQMP in *O Laboratório Chimico Municipal do Porto: Relatório da Commissão de Inquerito, Aprovado em Sessão de 31-XII-1907* (Porto: Typ. Emp. Guedes, 1909) and its aftermath on Section 6 of Alves and Alves, "Ferreira da Silva e o Laboratório Químico."

[51] Mostly due to Ferreira da Silva's work on the famous cases of the "'Salycilation" (see José Ferraz-Caetano, "The Case of the 'Salycilation of Port Wines': Echoes of the Social, Economic and Scientific Vision of Portugal-Brazil Relations (1885-1905)," *Revista Brasileira de História da Ciência* 15, no. 1 (2022): 108-119) and "Urbino de Freitas" (Dinis-Oliveira, "Portugal's First Major Forensic Case").

[52] *O Laboratório Chimico Municipal do Porto: Relatório da Commissão de Inquerito, Aprovado em Sessão de 31-XII-1907* (Porto: Typ. Emp. Guedes, 1909).

[53] Section 6 of Alves and Alves, "Ferreira da Silva e o Laboratório Químico".

[54] Ferreira da Silva's public defense is amassed in his book A. J. Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto, (1907-1908)* (Porto: [s.n.], 1909). It also includes echoes from peers and external scientific institutions.

[55] Following the example of Stadtfeld, "The Micro–Macro Link in Social Networks".

[56] The legislative directives that marked this integration are in *Diário do Governo*, no. 268 (26 de novembro de 1902) and *Diário do Governo*, no. 50 (4 de março de 1902).

[57] As explained within the *Plano de Melhoramentos da Cidade do Porto* and Alves and Alves, "Ferreira da Silva e o Laboratório Químico".

[58] Beyond the historical description in the previous section, the record of the laboratory's analysis found in the recent online repository, cross-reference these assertions with LQMP's activities. Arquivo Digital da Universidade do Porto, Fundo Academia Politécnica do Porto, 1837-1911, Livros de cópia dos relatórios químico-legais do Laboratório Químico Municipal do Porto (1900-1907), available at https://repositorio-tematico.up.pt/handle/10405/47964.

[59] The impact is described in detail on Chapter 3 of the following dissertation: José Ferraz-Caetano, *As Artes Químicas na Academia do Porto e o Surgimento da Regulação Alimentar em Portugal (1875-1905).* (Coimbra: University of Coimbra, Master's thesis, 2021).

[60] Porto's alignment with other major European city on Public Health was significantly increased with the outbreak of Bubonic Plague in early 20th century: José Ferraz-Caetano and Bruno D. A. Pinheiro, "Legislators' Plague: How History of Science Can Explain the Struggles of Universal Pandemic Responses," in *Handbook of Research on Historical Pandemic Analysis and the Social Implications of COVID-19*, eds. Antonio Cortijo Ocaña and Vicent Martines (Hershey, PA (USA): IGI Global, 2021), pp. 47-59.

[61] As introduced in note 34, where the laboratory's works are cited amongst peers for official deliberation of food analysis procedures.

[62] More on Ferreira da Silva's biography: Alves and Alves, *Nos Caminhos da Química*, pp. 177-214.

[63] See note 50.

[64] See note 44.

[65] Ferraz-Caetano, *As Artes Químicas na Academia do Porto*, Chapter 3.

[66] As discussed in Alves and Alves, "Ferreira da Silva e o Laboratório Químico".

[67] Alves and Alves, "Ferreira da Silva e o Laboratório Químico", pp. 7.

[68] As described in note 26.

[69] Data extracted from Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*, pp. 66 & 68.

[70] The LQMP's specialized library was considered by Portuguese chemist's to be the most up-to-date compendium of chemistry books. Most of its equipment was based on the apparatus' used in the Paris Municipal Laboratory.

[71] As the Laboratory's expertise was previously discussed in notes 31 and 32, including the official legislative remarks.

[72] The aims and vision for the *Revista* are written by Ferreira da Silva himself in its debut edition A. Ferreira da Silva, "O Nosso Programa," *Revista de Química Pura e Aplicada* 1, no. 1 (1905): 1-3.
[73] The journal is now published under the name *Química* (https://b-quimica.spq.pt/).
[74] Specially in its first five years of publication. The complete historic archive of the journal is freely available at: https://www.spq.pt/magazines/rcpapplicada.
[75] Experimental guidelines were not clear about the methodology on analytical procedures by the competent laboratories, as per Section 2 of Ferraz-Caetano, "As raízes da regulação alimentar em Portugal."
[76] Ferreira da Silva makes a strong argument about this by citing several works of other scientists of the LQMP, on his book A. Ferreira da Silva, *Recursos e Peritos na Fiscalisação Sanitaria no Porto em 1903: (O Reverso da Medalha)* (Porto: Imprensa Portugueza, 1905). For example, he quotes a situation where a detection of "wine fortification", a traditional and common practice for producing certain organoleptic qualities, was argued by certain hygiene inspection as adulteration. However, a LQMP scientist's report was ignored in this decision.
[77] See notes 44 to 46.
[78] This is documented in the "unofficial" report of the LQMP's work, regarding public health, on a book published by its director, A. Ferreira da Silva, *Documentos sobre os trabalhos de química aplicada à higiene do Laboratório Municipal de Química do Porto* (Porto: Imprensa Portugueza, 1904).
[79] As reported by the shared expertise and circulation of actors cited in the previous section.
[80] Information extracted from Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*, Section 1: "Main Works Carried out at the Laboratório Chimico Municipal do Porto", pp. 1-34.
[81] The full disclosure of these regulations is compiled in Direção Geral dos Serviços Agrícolas, *Methodos Officiaes para as Analyses dos Vinhos, Vinagres e Azeites: Seguidos da Indicção Summaria dos Processos Empregados nos Laboratorios do Estado para o Exame do Leite e Lacticinios; Alcooes e Aguardentes* (Lisboa: Typ. da Encyclopedia Portugueza, 1910).
[82] As reported by Ferreira da Silva himself about the impact on Port Wine analysis in A. Ferreira da Silva, *Os Vinhos Portuguezes Genuínos Condenados como Falsificados: Notas Sobre os Trabalhos a Que Deu Origem a Questão dos Vinhos Suppostos Salicylados no Brasil com a Apreciação do Snr. H. Pellet e Vários Documentos* (Porto: Off. do Comércio do Porto, 1902) and its generalization in A. Ferreira da Silva, *A Fiscalisação Dos Generos Alimenticios No Porto: (Vinhos)* (Porto: Papelaria La Bécarre, 1903).
[83] Specially in the period 1902 to 1905.
[84] According to *Diário do Governo*, no. 99, (06 maio de 1903), pp. 3.
[85] These entities were under the orientation from two ministries: the *Ministério do Reino* and *Ministério das Obras Públicas*, as revealed in Ferraz-Caetano, "As raízes da regulação alimentar em Portugal".
[86] Data extracted from Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*, pp. 100-101. The data for the LQMP and the *Estação Químico-Agrícola de Lisboa* report to the median average expenditure between 1899 and 1901. The remaining figures account for the years 1906 and 1907.
[87] The *Estação Químico-Agrícola de Lisboa* (Lisbon Chemical-Agricultural Station) was a scientific institution founded in late 19th century Portugal. Its main objective was to support agricultural development by providing chemical analyses of soils, fertilizers, water, and agricultural products.
[88] Data extracted from Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*, pp. 72.
[89] According to *Diário do Governo*, no. 24 (7 de outubro de 1901).
[90] A key example is the recognition of famous scientist Henri Pellet, who invited Ferreira da Silva to present an updated version of his method to quantify salicylic acid in wines, at the French Academy of Sciences. A good account on this is on Ferreira da Silva's biography and in a publication by Pellet himself: H. Pellet, *O Ácido Salicylico e a Questão dos Vinhos Portuguezes no Brazil em 1900* (Coimbra: Imprensa da Universidade de Coimbra, 1906).
[91] The full report can be found on Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*, sction "Relatório do Vereador do Pelouro sobre a Extincção do Laboratório Chimico Municipal do Porto", pp. 35-63.
[92] Ferreira da Silva condensed the outcomes (and his defense) on this quarrel in Ferreira da Silva, *A Questão do Laboratório Municipal de Chimica do Porto*. His formal statements are found on pp. 63 onwards.
[93] See notes 44 to 46.
[94] As in Alves and Alves, *Nos Caminhos da Química*, pp. 177-214.