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Transferts techniques relatifs à la production du sucre entre l'espace allemand et

la France (1802–1836)

Transfer of sugar processing techniques between the German area and France (1802–1836)

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## **Transfert techniques relatifs à la production du sucre entre l'espace allemand et la France (1802–1836)**

**Résumé :** Ce mémoire porte sur le développement des techniques de production de sucre de canne et leur circulation entre l'espace Allemagne, les pays Tchèques et la France aux XVIII<sup>e</sup> et XIX<sup>e</sup> siècles. À la fin du XVIII<sup>e</sup> siècle et au début du siècle suivant, divers événements politiques incitent plusieurs pays européens à rechercher un substitut approprié au sucre de canne. Après plusieurs tentatives infructueuses portant sur différents fruits, l'érable, dans l'espace allemand, et le raisin, en France, semblent ouvrir des perspectives de production prometteuses.

Mais le faible rendement des deux cultures conduit à leur remplacement par la betterave à sucre, transformée depuis 1800 à petite échelle en Prusse. Les recherches menées dans le cadre de sociétés savantes et les savoirs techniques observés par les troupes françaises amènent Napoléon Bonaparte à s'intéresser de près à la production du sucre de betterave. Bien que l'industrie connaisse un fort développement sous l'Empire, la chute du régime entraîne l'effondrement de la production dans une grande majorité de fabriques sucrières.

Après 1815, les techniques de production conservées dans un petit nombre d'établissements permettent un nouvel essor du sucre de betterave. La France devient alors le deuxième berceau de cette industrie après la Prusse. Le mémoire met en lumière les innovations techniques des années 1820 et 1830 et les transferts techniques entre l'Europe de l'Est et l'Europe de l'Ouest. Il se focalise en particulier sur les techniques adoptées dans les pays tchèques et en France.

**Mots-clés :** sucre, érable, raisin, betterave, Napoléon Bonaparte, transfert des techniques, industrie, XIX<sup>e</sup> siècle

## **Transfer of sugar processing techniques between the German area and France (1802–1836)**

**Abstract:** This Master thesis deals with the cane sugar production techniques and their circulation between the German area, the Czech lands and France in the 18<sup>th</sup> and 19<sup>th</sup> centuries. Due to political events at the end of the 18<sup>th</sup> century and the cessation of sugar supplies in the 19<sup>th</sup> century, the search for a suitable substitute for cane began. After unsuccessful attempts with various types of fruit, the German area found hope in the maple and France in the grapes.

The characteristics and poor yield of both crops led to their replacement by sugar beet, which was processed on a small scale in Prussia since 1800. The research carried out by learned societies and the techniques observed by French troops led Napoleon Bonaparte to take a close interest in beet sugar production. Although the industry developed strongly under the Empire, the fall of the regime led to the collapse of production in the vast majority of sugar factories.

After 1815, the production techniques retained in a small number of establishments allowed beet sugar to develop anew. France then became the second cradle of this industry after Prussia. The work will shed light on what type of innovative techniques were adopted in the 1820s and 1830s, and how the transfer of sugar technology spread between East and West. It focuses in particular on techniques adopted in the Czech lands and in France.

**Keywords:** sugar, maple, grapes, beet, Napoleon Bonaparte, transfer of technology, industry, 19<sup>th</sup> century

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# 1. Introduction

Since the dawn of history, exchange and trade have been the main representatives of interpersonal communication. As individual areas opened up and the movement of people, articles and information rose, commodities started to be exchanged more frequently and prices began to be set in trading from how much was available on the market. Cane sugar, whose history spans several millennia and is associated primarily with wealthy and more privileged populations, follows this example.

As sugar started to be produced as a medicine and sweetener, it became a rare commodity, raising the status of whoever could afford to purchase it. The history of cane itself provides an interesting view that reflects how civilisation evolved in the use of tools and human reason. Even more interesting is the enhancing, accelerated changes and improvements to procedures, originally guided by logic that brought better results. A precise example is sugar crystal technology, which originated in East and South Asia and was refined by the benefits of cultures that adopted and adapted it to their local technical facilities.

The phenomenon of how sugar technology moved between what is now modern France, Germany and the Czech Republic is discussed in this thesis, which demonstrates how ancient methods were adapted to technical conveniences in the times of the nascent industrial revolution. The discovery of sugar in cane, initial methods for extraction and processing it, and how it led to crystallisation and the migration of the technology from the Eastern to the Western Hemisphere are briefly presented in this thesis, while not neglecting to mention how different cultures from Asia, the Arab World and Europe applied their own methods and modifications.

Chapter 3 of the thesis outlines major European discoveries of available sugar sources and showcases in detail the technology for obtaining sugar crystals, which accurately copied the methods derived from processing cane sugar. These have since been widely applied to obtaining sugar from beets, which has played a leading role ever since Andreas Marrgraf presented his discovery to Prussian learned society in 1747. He was followed a few decades later by the contributions of his student, Franz Karl Achard, and his introduction of an affordable, cheap crop for Europe, describing in detail how to plant, harvest and process it.

The timing of the manual's release could not have come at a more prodigious time as cane sugar imports from overseas colonies were dwindling, clearly caused by late 18<sup>th</sup> century political events that were affecting the economies of both the Old and New Worlds. The revolutionary

ideas of 1789 inspired slaves on the island of Hispaniola (today's Haiti) to revolt in 1791 and gain long-awaited freedom redeemed, however, by the blood of their French oppressors and the destruction of cane plantations. Cane sugar shortages were soon felt on the European Continent as it sought to make up for a shortage of a quality commodity.

Prussia, the cradle of the modern sugar beet industry, became the model for all future sugar factories built during Napoleonic rule on the Old Continent. Exploiting their knowledge, Achard's successors followed in his footsteps to process not only beets but other crops such as corn, chestnuts, and potatoes using the same methods, whose roots had in turn come from cane processing techniques. Prussia's advantageous location between the German and French speaking areas of Europe enabled the new ideas to spread and led to the opening of the first experimental refineries and sugar factories, especially in what is today the Czech Republic, while France, through an expert commission, resorted to modifying the original methods.

The following chapter presents in greater detail the three main sources of sugar that replaced cane sugar after the imposition of the Continental System in November 1806 and the resulting shortage from overseas. The tradition of diverse crop cultivation forced farmers in the Kingdom of Bohemia to obtain more sugar from maple sap, while French farmers used grapes in great numbers which would have otherwise deteriorated. The chapter compares the two areas and demonstrates how interest in both crops gradually grew and subsequently fell as both poor-quality sugar and bad harvest encouraged Bohemia and France to focus on beets.

An entire subchapter highlights the beet sugar industry and directly follows up on the effects of the Continental System's embargo and renewed interest in beet growing, which initially received mainly French civic support from scholars and the first private large producers who shared their achievements in thematic magazines such as *Annales de chimie*. An interesting phenomenon that took place at this period was professional magazines becoming an available medium that connected domestic and foreign technological knowledge with the common man motivated to repeat the attempts of his fellow citizens and to jointly develop the emerging industry.

For obvious reasons, German-speaking Central Europe was hostile toward beets, and private entrepreneurs took the initiative not in the newly built sugar factories, but on farms near aristocratic estates. Nonetheless, the more or less successful producers listed here sought a cheap substitute for cane sugar to cope with times of economic recession, although their efforts mainly failed. State support was rather passive; only the actions of enlightened men and

the *Patriotic Economic Society* made it possible to gain at least a few tonnes of beet sugar crystals.

By contrast, the French *Society for the Encouragement of National Industry* was much more active, organising exhibitions and awarding both medals and generous financial rewards to motivate future large producers. Two significant decrees promulgated by Emperor Napoleon I in 1811 and 1812 strove to do the same by establishing experimental schools, setting aside land to plant beets and offering other, largely positive and encouraging mechanisms that marked the pinnacle of the industry in the period shortly after their enactment.

The culmination of the Napoleonic Wars and the demise of the French Empire foretold the collapse of the beet sugar industry, which had already become directly dependent on government support and could not compete with the return of cane sugar to the European market. The veil of secrecy during the fifteen-year period between the disintegration of the First French Empire and its client states and the new impulse of the beet sugar industry in the 1830s is underscored in Chapter 5, which also points out the changes in the price and the state of beet sugar factories. Even though most of them succumbed after the fall of Napoleon, those that did survive became a model for a new wave and exchange of technological processes and innovations that had emerged over the last twenty years.

Questions this thesis seeks to answer include how the technology of sugar processing developed, taking into account determining factors, namely the availability of local crops; how the technology spread at national (or regional) and transnational levels; and how major a role European countries of the time played in supporting the emerging industry. In doing so, light will be shed on whether sugar technology spread for the benefit of the state or for the benefit of individuals, by what means such results were achieved and what role the political, economic and social background played.

In examining both government by decree and the derivation of processing methods for entrepreneurs running their own businesses, the main methodological procedures will be the use of induction together with deduction. The richness of preserved sources allows the direct method to be used in France, while in the German-speaking areas the indirect method will have to be used because of the limited nature of private actions. At the same time, the diachronic method will be used to explain the locally defined development of maple sugar in Bohemia and grapes in France, and the synchronous method when comparing the circumstances of beet sugar factories which will naturally lead to a comparison of how they were supported by the rulers.

The thesis focuses on the history of science, technology, business, technology transfer and microeconomic analysis to show how the resulting sugar factories contributed to sugar production and the development of national economies, while forestalling cane sugar shortages. Biographical analysis will uncover the social origins of important representatives of (not only the beet) sugar industry.

### Heuristics and source criticism

The thesis presupposes, or even requires a basic overview of the origin, description and dissemination of the first technological procedures for sugar cane processing,<sup>1</sup> from its origin in the Pacific<sup>2</sup> through changes in the Arab world,<sup>3</sup> Europeanisation of methods in the modern age<sup>4</sup> to rediscovery of beets in experiments in the laboratories of Prussian chemists and pharmacists.<sup>5</sup> Manuals produced by two representatives of the early beet sugar industry had been translated for Occident readers and introduce the first comprehensive methods that had been discovered in sugar beets by Marrgraf,<sup>6</sup> and processed by Achard.<sup>7</sup> Several versions of the latter manual appeared, some of them condensed,<sup>8</sup> and so it lost the authentic style and illustrations. The original German-language version<sup>9</sup> appears in the thesis, the content of which inspired the similarity and equipment of future beet sugar factories.

A major force in Bohemia was Karel Cyril Neumann,<sup>10</sup> a former director of sugar factories, who used his experience in his detailed work on the state of the sugar industry in the kingdom with an overlap to the other members of the German Confederation and France. The book

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<sup>1</sup> MACINNIS, Peter, *Bittersweet. The Story of Sugar*, Crows Nest, Allen & Unwin, 2002.

<sup>2</sup> COOKE, D. A., *The Sugar Beet Crop. Science into practice*, Wallington, Chapman & Hall, 1993.

<sup>3</sup> OUERFELLI, Mohamed, *Le sucre. Production, commercialisation et usages dans la Méditerranée médiévale*, Leiden, Koninklijke Brill NV, 2008.

<sup>4</sup> GALLOWAY, Jock H., "The Mediterranean Sugar Industry", *Geographical Review*, vol. 67, no. 2, 1977, pp. 177–194.

<sup>5</sup> KLEIN, Ursula, *Technoscience in History: Prussia, 1750–1850*, Cambridge, The MIT Press, 2020.

<sup>6</sup> MARGGRAF, Andreas Sigismund, „Expériences chimiques faites dans le dessein de tirer un véritable sucre de diverses plantes, qui croissent dans nos contrées“, in *Histoire de l'Académie royale des sciences et belles lettres*, année 1747. Berlin: Haude et Spener, 1749, pp. 79–90.

<sup>7</sup> ACHARD, Charles-François and HEURTELOUP, N. (dir.), *Instruction sur la culture et la récolte des betteraves, sur la manière d'en extraire économiquement le sucre et le sirop*, translated by M. COPIN, Paris, Testu, 1811.

<sup>8</sup> ACHARD, Franz-Karl and DEROSNE, Charles (dir.), *Traité complet sur le sucre européen de betteraves; culture de cette plante considérée sous le rapport agronomique et manufacturier: traduction abrégée de M. Achard*, translated by M. D. ANGAR, Paris, M. Derosne et D. Colas, 1812.

<sup>9</sup> ACHARD, Franz Karl and THEILE, Drey (ed.), *Die europäische Zuckerfabrikation aus Runkelrüben, in Verbindung mit der Bereitung des Branntweins, des Rums, des Essigs und eines Caffee-Surrogats aus ihren Abfällen*, Leipzig, J. C. Hinrichs, 1809.

<sup>10</sup> NEUMANN, Karel Cyril, *Nástin dějin průmyslu cukrovarnického v Čechách. Období první. 1787–1830*. Praha, Komitét pro uspořádání kolektivní výstavy cukrovarnické, 1891.

provides an overview of how the sugar industry developed in the Kingdom of Bohemia, prominent representatives of the industry, valuable statistical data on the number of established sugar factories, how they functioned in crisis and subsequently shut down operations, as well as the amount of beets that were planted, grown and processed. However, it is both the book's contribution to the processing of sugar beets and also of maple sugar that adds to its interest and novelties in connection with the researched topic.

In discussing the French sugar industry, researchers can rely not only on generalising articles,<sup>11</sup> but also on valuable contributions from the history of grape processing<sup>12</sup> and prominent proponents,<sup>13</sup> whose positions in society influenced economic decision-making. Legislative support was provided by Jean-Baptiste Duvergier's collection and publication of laws,<sup>14</sup> which reflect the Napoleonic regime's support for the emerging industry. Of considerable importance is Matthieu Nombrot's dissertation that takes into account important aspects of the French sugar industry,<sup>15</sup> as is McMurtrie's work describing contemporary events along with excerpts from newspaper articles and reports from the Ministry of the Interior.<sup>16</sup>

While France had a rich source base made up of private individuals, Bohemia was falling behind. Because the kingdom's sugar industry was localised rather close to aristocratic estates and state support was very limited, there are limited sources of information largely found in geographically defined works<sup>17</sup> or in articles focusing on specific sugar factories.<sup>18</sup> František Dudek's books<sup>19</sup> provide a detailed description of these new sugar factories,<sup>20</sup> technical

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<sup>11</sup> LALOUX, Ludovic, "La bataille du sucre ou la défaite méconnue de Napoléon I<sup>er</sup>", *Artefact*, vol. 9, 2018, pp. 35–56.

<sup>12</sup> FOURNIER, Josette, "Essais de fabrication de sucre de raisin sous le Premier Empire", *Revue d'histoire de la pharmacie*, vol. 87, no. 322, 1999, pp. 227–234.

<sup>13</sup> CHAST, François, JULIEN, Pierre and MURATORI-PHILIP, Anne, "Parmentier et le sucre de raisin", *Revue d'histoire de la pharmacie*, vol. 89, no. 330, 2001, pp. 149–168.

<sup>14</sup> DUVERGIER, Jean-Baptiste, *Collection complète des lois, décrets, ordonnances, réglemens et avis du Conseil d'État: de 1788 à 1830 inclusivement, par ordre chronologique*, t. 16, 2<sup>nd</sup> edition, Paris, A. Guyot et Scribe, 1836 and DUVERGIER, Jean-Baptiste, *Collection complète des lois, décrets, ordonnances, réglemens et avis du Conseil d'État: de 1788 à 1830 inclusivement, par ordre chronologique*, t. 18, 2<sup>nd</sup> edition, Paris, A. Guyot et Scribe, 1836.

<sup>15</sup> NOMBLOT, Matthieu, "1812–1914: un siècle d'histoire et d'utilisation du sucre de betterave", dissertation, Université de Caen Normandie, Sciences pharmaceutiques, 2019.

<sup>16</sup> MCMURTRIE, William, *Report on the Culture of the Sugar Beet and the Manufacture of Sugar Therefrom in France and the United States*, Washington, Government Printing Office, 1880.

<sup>17</sup> JADLOVSKÝ, Filip, "Vývoj cukrovarů v České republice, jejich historický vývoj a současný stav", master's thesis, Masarykova univerzita, Přírodovědecká fakulta, 2020.

<sup>18</sup> FRONĚK, Daniel, "200 let řepného cukrovarnictví v České republice", *Listy cukrovarnické a řepařské*, vol. 126, no. 11, 2010, pp. 358–359 and NYPLOVÁ, Zdenka, "Kapitalistické začátky a krise zbraslavského cukrovaru", *Český lid*, vol. 37, no. 7/8, 1950, pp. 164–168.

<sup>19</sup> DUDEK, František, *Počátky řepného cukrovarnictví v Čechách. Příspěvek k hospodářským dějinám 30. a 40. let 19. století*, Poděbrady, Oblastní muzeum v Poděbradech, 1973.

<sup>20</sup> DUDEK, František, *Vývoj cukrovarnického průmyslu v českých zemích do roku 1872*, Praha, Academia, 1979.

procedures and a rich source base.<sup>21</sup> Books by Jan Vincent Diviš, based on germane archival sources, piece together fragments of the mosaic describing the beginnings of the Bohemian sugar industry<sup>22</sup> and document key details in the little-known period of the 1820s and 1830s,<sup>23</sup> as well as those from Oldřich Říha.<sup>24</sup>

Professional and thematic journals play an important role, whether those with an international reach like *Annales de chimie* or the *Journal de physique, de chimie, d'histoire naturelle et des arts*, whose published technological knowledge stood behind the dissemination and changes in original and new knowledge, or the *Bulletin* of the French Society for the Encouragement of National Industry. The current *Listy cukrovarnické a řepářské* includes studies of the issue of sugar factories in Bohemia, and their contributions, including illustrations.

There are also useful web links specifying the contemporary context for today's readers, such as a conversion of measurement units no longer used,<sup>25</sup> dates from the French Republican calendar<sup>26</sup> and the presentation of biographies of several important figures.<sup>27</sup> A large number of mostly period works are available on well-known websites such as Books.google.com and Scholar.google.com, and articles were found at Jstor.org, Persee.fr and Cairn.info. The digital database of the Bibliothèque nationale de France, Gallica.bnf.fr, provides several hundred thousand period materials including illustrations related to various human branches.

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<sup>21</sup> DUDEK, František, *Monopolizace cukrovarnictví v českých zemích do roku 1938*, Praha, Academia, 1985.

<sup>22</sup> DIVIŠ, Jan Vincenc, *Příspěvky k dějinám průmyslu cukrovarnického v Čechách, období druhé 1830–1860*, Kolín, Komitét pro uspořádání kolektivní výstavy cukrovarnické, 1891.

<sup>23</sup> DIVIŠ, Jan Vincenc, *Cukrovarnictví*, Praha, I. L. Kober, 1897.

<sup>24</sup> ŘÍHA, Oldřich, *Počátky českého cukrovarnictví*, Praha, Univerzita Karlova, 1976.

<sup>25</sup> Historical Currency Converter. *Historical Statistics*. Accessed on 13.03.2022. <https://www.historicalstatistics.org/Currencyconverter.html>, Jednotky, převody jednotek. *Jednotky*. Accessed on 05.04.2022. <https://www.jednotky.cz> and Measurements Converter. *Convert-me*. Accessed on 07.04.2022. <https://www.convert-me.com/en/>.

<sup>26</sup> The French Republican calendar. *Napoléon & Empire*. Accessed on 04.05.2022. <https://www.napoleon-empire.com/republican-calendar.php>.

<sup>27</sup> Free Online Encyclopedia. *Encyclopedia*. Accessed on 13.03.2022. <https://www.encyclopedia.com>.

## 2. Discovery and adoption of sugar extraction technology (1600–1797)

### Origins and technology of sugar cane processing

The discovery, development and worldwide spread of sugar cane meant an important change in the economic, social and political life of many cultures and regions<sup>28</sup> and it has become with each passing century an object of interest as its processing technology has improved.<sup>29</sup> The origins of “*saccharum officinarum*”, the noble cane, date back between 10,000 and 15,000 years ago to New Guinea and Polynesia.<sup>30</sup> Sugar was used in Indonesia, China and India as a gift to mortals, a commodity of general consumption, an article of luxury and a medicinal object. In the 21<sup>st</sup> century, India is considered the “home of sugar where the cultivation of sugarcane and the science of manufacturing sugar were developed in ancient times and from where it spread to different parts of the world”.<sup>31</sup>

The technology has been gradually enhanced from the domestication of cane in New Guinea through extraction of cane juice into crystals in China and India to the Persian invasion of India in 510 BC and subsequent Arab invasion of Persia in AD 642,<sup>32</sup> changes stabilised over the centuries due to acceleration of the westward diffusion of crops and processing techniques by the Arabs, who founded a new, sugar cane industry in the 10<sup>th</sup> century, implemented efficient irrigation systems<sup>33</sup> and erected sugar mills.<sup>34</sup>

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<sup>28</sup> The original root of the word, *çarkarâ*, derived from Sanskrit, underwent slight modifications into *saccharum* (Latin), *sukkar* (Arabic), *sukere* (Old French), *zucchero* (Italian), *Zucker* (German), *cukier* (Polish), *cukr* (Czech), and *sucre* (today's French). GANGI, Roberta. “Sugar cane in Sicily”. *Best of Sicily Magazine*. Accessed on 15.12.2021. <http://www.bestofsicily.com/mag/art143.htm>, **Macinnis**, *Bittersweet*, pp. 4–5 and TESTOT, Laurent. “Le prix du sucre”. *Histoire Globale*. Accessed on 15.12.2021. [http://blogs.histoireglobale.com/le-prix-du-sucre\\_844](http://blogs.histoireglobale.com/le-prix-du-sucre_844).

<sup>29</sup> Sugar cane usually grows to three meters in 10-16 months and is composed of the leaves, tops and stalk. The first two contain very low sugars, while the last provides sugar rich portions of about 20% sucrose. The cane requires capital, cheap labour and a humid, tropical climate, with plenty of irrigation, where winter temperatures are mild enough to permit continuous growth. BOUŠKOVÁ, Michaela, “Změny v pěstování a zpracování cukrovky”, bachelor thesis, Jihočeská univerzita v Českých Budějovicích, Zemědělská fakulta, 2011, p. 34 and **Gangi**, “Sugar cane in Sicily”, **Macinnis**, *Bittersweet*, p. 21 and KULKARNI, D. P., *Cane Sugar Manufacture in India*, New Delhi, The Sugar Technologist's Association of India, 1996, pp. 3–4.

<sup>30</sup> GUDOSHNIKOV, Sergey, JOLLY, Lindsay and SPENCE, Donald, *The World Sugar Market*, Boca Raton, CRC Press, 2004, p. 3, **Kulkarni**, *Cane Sugar Manufacture*, p. 1, **Macinnis**, *Bittersweet*, pp. xvii–xviii and 4, **Ouerfelli**, *Le sucre*, p. 16, SMITH, Andrew F. (ed.), *Sugar. A Global History*, London, Reaktion Books, 2015, p. 13 and **Testot**, “Le prix du sucre”.

<sup>31</sup> Sugar is mentioned in the Atharvaveda and Pratimoksha. **Kulkarni**, *Cane Sugar Manufacture*, p. 1.

<sup>32</sup> Sugar was used as medicine in the Roman Empire between the 4<sup>th</sup> century BC and the 1<sup>st</sup> century AD. **Ouerfelli**, *Le sucre*, pp. 16–17 and **Testot**, “Le prix du sucre”.

<sup>33</sup> **Galloway**, “The Mediterranean”, pp. 179–180 and **Gangi**, “Sugar cane in Sicily”.

<sup>34</sup> The Arabs employed mills and presses that were originally used to produce flour, extract oil from olives, and to crush grapes and other fruits. **Galloway**, “The Mediterranean”, pp. 184–185.



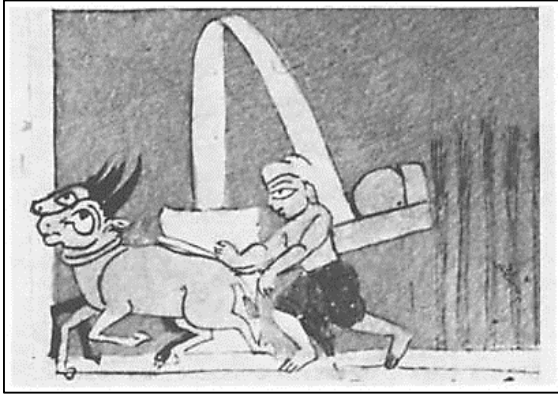


Figure 1: An Indian depiction. DANIELS, John and DANIELS, Christian, “The Origin of the Sugarcane Roller Mill”, *Technology and Culture*, vol. 29, no. 3, 1988, pp. 493–535, p. 509.

This preserved Indian depiction from about 1000 BC demonstrates the first steps of sugar cane processing:

“One pair of tethered mules were walking in a circle driving a vertical grinding mill, weighted by stones, to crush the cane stems placed in the mortar. The juice was then evaporated by boiling to leave a mixture of crystals and syrup.”<sup>35</sup>

This technology spread to the Islamic areas<sup>36</sup> in the 7<sup>th</sup> century: Mesopotamia, Syria, Israel, Palestine, the delta of the Nile and the Levant

coast. The know-how was also adopted in Morocco (682), Sicily (827) and Cyprus (911), in the 10<sup>th</sup> century in Crete, France, Spain and on the coasts of Italy, in the 11<sup>th</sup> century in Tunisia and northern Europe, and finally in the 13<sup>th</sup> century in England, taken there by crusaders that had encountered caravans with “sweet salt”.<sup>37</sup>

In the Mediterranean, the original technology took root due to the warm climate and underwent many changes. The first mention of the crop comes from 325 BC when the Roman Empire encountered “Indian canes that give honey in the absence of bees”.<sup>38</sup> The development in the 10<sup>th</sup> century was reflected in the use of irrigation and mills whose operation was labour intensive and inefficient:

“The cane stems were chopped into 33 centimetres long pieces, boiled, and then crushed at least twice in a mortar, after which they were milled, and then the residue, packed into sacks, was transferred to a press.”<sup>39</sup>

The extraction of juice was fundamental. In later stages, the cut cane was pressed with a large edge runner, replaced in 1449 by the two-roller horizontal and three-cylinder vertical roller

<sup>35</sup> Daniels, “The Origin of the Sugarcane”, p. 509 and Gudoshnikov, *The World Sugar*, p. 3.

<sup>36</sup> Slaves were composed of the Slavs, who were imported by Italian cities to the Islamic states; Africans sent to the Christian sugar islands; Greek, Bulgar, and Turkish prisoners of war and Tartars, who were transported to Crete, Cyprus and Morocco. FINDLAY, Ronald and O’ROURKE, Kevin H., *Power and Plenty. Trade, War, and the World Economy in the Second Millenium*, Princeton, Princeton University Press, 2009, p. 98 and 146 and Galloway, “The Mediterranean”, p. 190.

<sup>37</sup> Findlay, *Power and Plenty*, p. 50 and 58, Galloway, “The Mediterranean”, pp. 180–181, Gangi, “Sugar cane in Sicily”, Macinnis, *Bittersweet*, p. 19 and 21–23, Ouerfelli, *Le sucre*, pp. 24, 31, 67, 102–103, 131, 149 and 180, Smith, *Sugar*, pp. 16–17 and Testot, “Le prix du sucre”.

<sup>38</sup> Ouerfelli, *Le sucre*, p. 18.

<sup>39</sup> Daniels, “The Origin of the Sugarcane Roller Mill”, p. 499, Galloway, “The Mediterranean”, p. 184 and Ouerfelli, *Le sucre*, p. 242–245.

mills<sup>40</sup> and in 1452 by a more efficient water mill erected in Madeira.<sup>41</sup> The squeezed juice was stored in containers, whose use is known from the 30,000 vessels of sugar moulds and molasses pots excavated in Sicily in the 1980s, extremely handy for the procedure described below:

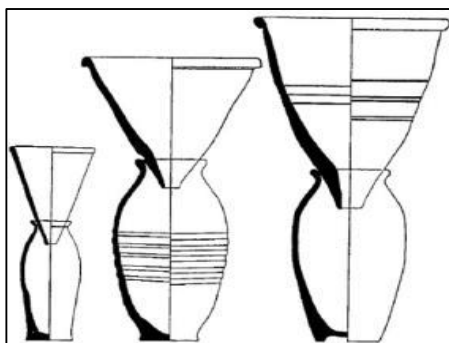


Figure 2: Conical vessels. SILBERMAN, Neil. „Crusaders, Venetians, and Sugar Cones.” Hanover, 1986. Accessed on 14.3.2022. <http://www.icwa.org/wp-content/uploads/2015/10/NAS-20.pdf>, p. 2.

“The extracted juice was boiled and poured into stoppered funnel-shaped clay moulds sitting on top of a clay jar. The stopper had kept the syrup from leaking out until it settled and the sugar begun to set. A day or so later it was removed and the molasses dripped into the jar beneath, leaving a cone of solid sugar in the funnel. That was either broken up into sugar powder or exported complete in boxes.”<sup>42</sup>

In the late 15<sup>th</sup> century, growing European trade in sugar opened up refineries in Venice, Bologna and Antwerp before spreading later to northern Europe<sup>43</sup> and they were able to create “the finest quality sugar by dissolving the crystals from the first boiling in water and reboiling and recrystallising two or three times.”<sup>44</sup> In summary, the methods consisting of a “crushing, extraction and crystallisation process, with adding water to a paste which became sugar crystal upon drying”.<sup>45</sup> This constituted the initial technology for obtaining sugar crystals and it lasted for several centuries<sup>46</sup> to become a model for processing sugar from various plants at the turn of the 19<sup>th</sup> century.

<sup>40</sup> Daniels, “The Origin of the Sugarcane Roller Mill”, p. 499–506 and 508.

<sup>41</sup> The cane was placed underneath a millstone with two cylinders, moved by water, which pressed and squeezed the cane, extracting all the juice. One water mill produced about 63 tonnes of sugar per year. Galloway, “The Mediterranean”, p. 191 and Ouerfelli, *Le sucre*, p. 226.

<sup>42</sup> “Sweet salt”: Sugar Production in Medieval Cyprus. Fergus Murray. Accessed on 11.12.2021. <https://www.fergusmurraysculpture.com/cyprus/history-notes-12-pages/viii-sweet-salt-the-medieval-sugar-industry/>.

<sup>43</sup> Galloway, “The Mediterranean”, p. 188.

<sup>44</sup> Galloway, “The Mediterranean”, p. 188, Macinnis, *Bittersweet*, pp. 19–21 and Ouerfelli, *Le sucre*, pp. 245–250.

<sup>45</sup> Gangi, “Sugar cane in Sicily”.

<sup>46</sup> Macinnis, *Bittersweet*, pp. 87–88.



Figure 3: Sugar production with Mediterranean technology, 1590. CROWLEY, John E., “Sugar Machines: Picturing Industrialized Slavery”, *The American Historical Review*, vol. 121, no. 2, 2016, pp. 403–436, p. 410.

Some innovations also followed. Du Monceau<sup>47</sup> described the “Jamaica train”, invented by English planters in 1700 and used by both the French in 1725 and the Cubans in 1780:

“[a set of] four large pans with a flat bottom put into masonry, so the flames hit only the base. The juice was obtained by adding lime water and egg white<sup>48</sup> into the liquid and heated up. Once the scum rose to the surface, the fire was reduced or damped down, and the scum scraped off after fifteen minutes. This would be repeated until a clear bright liquor was obtained and strained through a blanket.”

He demonstrated the details of the vessel, the involvement of chemical elements, and additionally showed how chemistry was playing a greater role in producing sugar crystals and why it would soon become essential for industry:

“The juice was put into a boiling vessel of more than 2,000 litres with the temperature raised to about 140°C. At this point, lime was added to coagulate impurities in the rising scum. When that ‘cracked’, a cock in the bottom was opened to drain the cleared liquid, leaving the ‘mud’ behind to be used in the making of rum. If the liquid was not tempered properly, the sugar would not crystallise, and if too much lime was added, the liquor would turn green from chlorophyll that would later form a dark sugar with a great deal of molasses. The answer was to turn to science: if Boyle’s litmus turned from red to blue, enough lime had been added.”

<sup>47</sup> Henri Louis Duhamel du Monceau (1700–1782) was a French botanist, chemist and an inspector general of the navy. His *Traité de la culture des terres* (I–VI, 1753–1761) applied British innovative technologies to French agriculture. “Duhamel Du Monceau, Henry-Louis.” *Encyclopedia.com*. Accessed on 13.03.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/duhamel-du-monceau-henri-louis>.

<sup>48</sup> Among the materials that cleared sugar were wood ash, milk, egg white, bullock’s blood, charcoal, lime, sulphurous acid, phosphoric acid, carbon dioxide, alum and lead acetate. **Macinnis**, *Bittersweet*, pp. 85–86.

Whether Du Monceau spoke of the right temperature, coagulation with chemical additives, or the methods of determining the acidity needed for the desired effects leading to crystal gain,<sup>49</sup> it was clear that, at this period of history, only the collaboration of the sciences could lead to the intended goal, which is why international connections at the scholarly level needed to be deepened and dynamised to apply the methods, which had been previously used to process cane, to other plants and crops.

### First incentives in favour of growing beets

The rising price and growing popularity of cane sugar had driven several attempts to find substitutes, people settling for bee honey or the juice of fruit, berries or carrots to sweeten their food.<sup>50</sup> A preference also began for one already known and spread crop, with the first detailed descriptions of the different forms of beet described by Caesalpinus<sup>51</sup> in *De plantis libri XVI* (1583) and Daléchamps<sup>52</sup> in *Historia generalis plantarum* (1587). In 1600, Olivier de Serres discovered “a kind of parsnip arriving recently from Italy that has a deep red root, thick leaves and the juice which is like a sugar syrup, and all is good to eat”.<sup>53</sup>

The first written reference to beets appeared in an old Assyrian text describing its cultivation around 800 BC in the gardens of the Babylonian kings. However, both the roots and the leaves were first widely consumed near both the Black and Caspian Seas and in the Neolithic period on the shores of the Mediterranean Sea and the Atlantic Ocean.<sup>54</sup> During the Middle Ages, the cultivation of beets spread into Northern Europe from areas that had once been dominated by the Roman Empire. In Charlemagne’s *Regulation concerning Landed Property (Capitulare de villis*, 812), the *beta* was specifically registered as “a plant which should be cultivated in the gardens of the imperial estates”.<sup>55</sup>

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<sup>49</sup> For the process of obtaining sugar in the 18<sup>th</sup> century see *ibid*, pp. 86–87.

<sup>50</sup> **Cooke**, *The Sugar Beet Crop*, p. 2.

<sup>51</sup> Andreas Caesalpinus (1519–1603) was an Italian physicist and botanist whose attempts to create a system of plant classification contributed to the establishment of a new scientific discipline – botany. “Andreas Caesalpinus.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/andreas-caesalpinus>.

<sup>52</sup> Jacques Daléchamps (1513–1588) was a French botanist and medic. His work is considered the most complete botanical compilation of its time. “Daléchamps, Jacques.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/dalechamps-jacques-or-jacobus-dale-champius>.

<sup>53</sup> **Cooke**, *The Sugar Beet Crop*, p. 2 and **Smith**, *Sugar*, p. 39.

<sup>54</sup> REISER, Philippe, *Avec ou sans sucre?*, Versailles, Éditions Quae, 2015, p. 81 and **Smith**, *Sugar*, p. 39.

<sup>55</sup> **Cooke**, *The Sugar Beet Crop*, p. 2 and **Reiser**, *Avec ou sans sucre*, p. 81.

It seems probable that beet varieties with edible leaves and sweet roots were grown in France and Spain at the time, with the first mention of its use in England coming in 1420, the red variety in 1548 and the white variety after 1570. By the end of the 16<sup>th</sup> century, the plant was most likely grown all over Europe.<sup>56</sup> As the areas where the beets were grown changed, so did the names. While the name *silga* was probably derived from the Greek *sicula* (coming from Sicily), the Romans coined a more common name in the 2<sup>nd</sup> century BC, *beta*.<sup>57</sup> Finally, today's appellation is credited to Linnaeus<sup>58</sup> who in 1753 named a single species – *Beta vulgaris*.<sup>59</sup>

The French Revolution saw the rise of mass sugar beet cultivation in Europe, prompted by changes in the social status of slaves in Saint Domingue, a French colony founded on the western side of Hispaniola in 1697. By the end of the 18<sup>th</sup> century, it was flourishing as the most profitable sugar producer in the New World but was “sacrificed by mismanagement and misunderstanding”<sup>60</sup> when the Old and New Worlds clashed.

Although the outbreak of the French Revolution had positive impacts in political, social and economic life, a significant exception was the claim by the National Assembly on 28 March 1790 that “the Declaration of the Rights of Man was not to apply to the colonies”.<sup>61</sup> The majority population of the French colony of Saint-Domingue, 24,000 people of colour (*sangs mêlés*), half a million slaves and several freed blacks, had hoped to gain the rights and benefits of liberal ideas, unlike the minority of 30,000 white planters and officials who promoted the royalist cause. Slaves expressed their disadvantage violently in a small uprising, in whose aftermath the Assembly acknowledged them the right to sit in parochial and colonial assemblies, a right that would be ignored by the planters.<sup>62</sup>

The arrival of an army of 6,000 in January 1792 did not quell the growing tensions. When even their commands to establish order were disobeyed by the royalist planters, the commissioners

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<sup>56</sup> **Cooke**, *The Sugar Beet Crop*, p. 2, **McMurtrie**, *Report on the Culture*, p. 7 and **Smith**, *Sugar*, p. 39.

<sup>57</sup> In both Greek and Roman civilisations, “the beet plant leaves were highly valued supplements to the ordinary diet”. **Cooke**, *The Sugar Beet Crop*, p. 1.

<sup>58</sup> Carolus Linnaeus (1707–1778) was a Swedish naturalist and botanist, famous for his creation of the system of binominal classification of living beings, fauna and especially flora, in 1735. “Carolus Linnaeus.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/history/news-wires-white-papers-and-books/carolus-linnaeus>.

<sup>59</sup> *B. vulgaris* comprised three varieties: wild/maritime, garden and foliage beet. For even more detailed division of species in the 20<sup>th</sup> century see **Cooke**, *The Sugar Beet Crop*, pp. 4–7.

<sup>60</sup> **Macinnis**, *Bittersweet*, pp. 72–73.

<sup>61</sup> **Macinnis**, *Bittersweet*, p. 71 and STINCHCOMBE, Arthur L., *Sugar Island Slavery in the Age of Enlightenment. The Political Economy of the Caribbean World*, Princeton, Princeton University Press, 1995, pp. 201–203.

<sup>62</sup> BEARD, John Rely, *The Life of Toussaint L'Ouverture, the Negro Patriot of Hayti*, Chapel Hill, DocSouth Books Edition, 2012, pp. 66–68, **Macinnis**, *Bittersweet*, pp. 71–72 and **Stinchcombe**, *Sugar Island Slavery*, pp. 203–204 and 233.

“called on the slaves for support and those whites, who did not escape to the ships, were killed”.<sup>63</sup> The masses of insurgents, led by Toussaint L’Ouverture (1743–1803), were set free in 1794 and four years later, after the acquisition of the southern tip of the island, the rebels began to be called Haitians.<sup>64</sup> The French army’s capitulation in November 1803 paved the way to liberated Haiti and provided Europe with an opportunity to develop a new industry.<sup>65</sup>

### Prussia’s pioneering experiments with beet roots

“The poor peasant, instead of an expensive sugar or a bad syrup, could use our plant sugar, provided that with the help of certain machines he squeezes the juice from these plants.”<sup>66</sup>

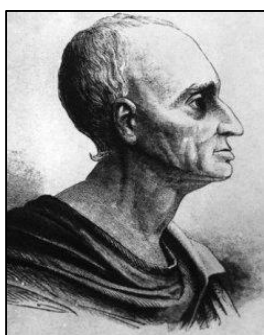


Figure 4: Andreas Sigismund Marggraf. *World Of Chemicals*. Accessed on 04.05.2022. <https://www.worldofchemicals.com/189/chemistry-articles/andreas-sigismund-marggraf-pioneer-in-analytical-chemistry.html>.

As Europe felt the shortage of sugar cane, it began looking into a crop whose popularity was expanding rapidly – the sugar beet.<sup>67</sup> The idea of transforming beets into an industrial crop, to be grown for sugar, came to the forefront in the first half of the 18<sup>th</sup> century in the Prussian *Académie des Sciences et Belles Lettres* and its physics class.<sup>68</sup> It was directed by chemist Andreas Sigismund Marggraf (1709–1782), regarded as a pioneer in extracting sugar from beet roots, and his experiments in 1747 at his pharmaceutical laboratory laid the foundations for a new industry.<sup>69</sup> Although he used skirret roots,<sup>70</sup> the methods he undertook worked with beets as well. For a better insight into the experiment, the essential steps are briefly introduced.

<sup>63</sup> Beard, *The Life*, pp. 69–70 and Macinnis, *Bittersweet*, p. 72.

<sup>64</sup> GIRARD, Philippe R., *The Slaves Who Defeated Napoléon. Toussaint Louverture and the Haitian War of Independence, 1801–1804*, Tuscaloosa, The University of Alabama Press, 2011, pp. 5–6, Macinnis, *Bittersweet*, pp. 72–74 and Stinchcombe, *Sugar Island Slavery*, p. 204 and 248.

<sup>65</sup> Cooke, *The Sugar Beet Crop*, p. 17, Girard, *The Slaves*, pp. 6–7, Macinnis, *Bittersweet*, pp. 74–75 and Smith, *Sugar*, p. 41.

<sup>66</sup> Marggraf, „Expériences chimiques“, pp. 88–89.

<sup>67</sup> It was already known that it was a biennial plant requiring two seasons to produce seed and that the growing season ran from March or early April until mid-September to mid-December. Once harvested, a typical beet was about 76% water and 16% sugar and brought two benefits: apart from integration into temperate zone farming systems, its roots could be dried and preserved for later consumption, while the tops with leaves served as excellent fodder for cattle and horses. Cooke, *The Sugar Beet Crop*, p. 2, Gudoshnikov, *The World Sugar*, p. 19 and Smith, *Sugar*, p. 39.

<sup>68</sup> Klein, *Technoscience in History*, p. 32.

<sup>69</sup> Marggraf never thought about making sugar as such: he only advised farmers on how to obtain sweet beet juice on their farm to make a sweet syrup because his methods were of a nature that could succeed only in the laboratory. Achard, *Le sucre européen*, p. i, McMurtrie, *Report on the Culture*, p. 8 and NEZDAROVÁ, Michaela, “Proměny cukrovarnictví ve východních Čechách z hlediska historického vývoje vybraných cukrovarů”, bachelor’s thesis, Univerzita Pardubice, Fakulta filozofická, 2014, p. 13.

<sup>70</sup> The skirret, known as “sugar root”, came from China to Europe around 1548. Macinnis, *Bittersweet*, p. 133.

“I cut the roots, dried, and pounded them in an iron mortar. I placed them into a vessel, where I poured four ounces of rectified spirit, boiled it, poured into a new vessel, added the spirit again and boiled it anew. I then put liquid into a linen bag, pressed out the juice and poured the rest into a flat vessel with a cork, storing it in a temperate place. In a few weeks I obtained crystalline salt with all the characteristic marks of sugar.”

Marggraf then poured the concentrated spirit to the newly obtained crystals again, brought the substance to a boil, removed the foaming impurities and in the next step

“I put some whites of eggs to the juice, and boiled it, scumming it continually, till no further impurities appeared upon the surface: I then passed it through a linen cloth, and the liquor was as transparent as the clearest wine. I left this liquid thicken in a covered vessel in a warm place and after six months the sugar is found in the form of small crystals, attached in abundance to the walls of the vessel.”

The crystals then had to be ridded of impurities in a process remarkably similar to how sugar loaves are formed in Sicily. After dipping the brass container in warm water, the syrup became more liquid so that it could be

“poured into perforated earthen vessels so the syrup could, in a warm place, flow into the lower container drop by drop. The crystals that remained on the sides were inserted between folded paper and slightly pressed. The paper soaked up a lot of juice and the sugar became purer. The obtained crystals were put to a new vessel, poured with water, brought to a boil and purified by egg whites and lime water.”

Marggraf then described in a simple experiment for determining the appropriate consistency. When rubbing the fluid between the fingers formed strings, it was necessary to remove the fluid from the fire and leave it in moderate temperatures for a few days.

“[After] placing it on another vessel and reheating it, the syrup evaporated, crystallised and, by adding lime water, all impurities were removed, leaving the liquid syrup in the lower vessel and crystals in the upper.”

He tried the same steps several times on beet roots, and in the end obtained “from 230 grams of white beet roots 15 millilitres of pure sugar, from 230 grams of skirrets 45 millilitres of pure sugar and from 230 grams of red beets roots 37 millilitres of pure sugar.”<sup>71</sup> Following these procedures, Marggraf demonstrated that “the sweet-tasting crystals obtained from beet juice were of exactly the same nature as cane sugar”.<sup>72</sup> Although the sugar content found in the roots of both red and white beet varieties<sup>73</sup> was low, leading to his decision to discontinue these

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<sup>71</sup> For the whole detailed procedure see **Marggraf**, „Expériences chymiques“, pp. 82–88. For more details of both experiments see **Macinnis**, *Bittersweet*, p. 132–134.

<sup>72</sup> **Marggraf**, „Expériences chymiques“, p. 80.

<sup>73</sup> Testimony from the British *Gentleman's Magazine* in 1752 demonstrates how Marggraf similarly experimented with seaweed in 1747 and the magazine claimed part credit. **Macinnis**, *Bittersweet*, pp. 131–132.

experiments,<sup>74</sup> the discovery of a plant that provides sugar and could be grown in temperate climates meant reassessing beets and glorifying its importance in agriculture.

Marggraf's experiments fell into oblivion and it took several decades before interest among the public was revived. The rediscovery of sugar extraction from beet roots was credited to Franz Karl Achard (1753–1821), Marggraf's disciple and successor as laboratory director and of the Academy's department of physics. His scientific projects included, among other things, "chemical studies of acids, salts and gems, meteorological measurements, or plant physiology"<sup>75</sup> that shaped his interest in sugar beets. In August 1782, the year Marggraf died, Achard started his beet projects, consisting of the cultivation of sugar beets and the extraction of sugar from beet juice on a large technical scale.<sup>76</sup>

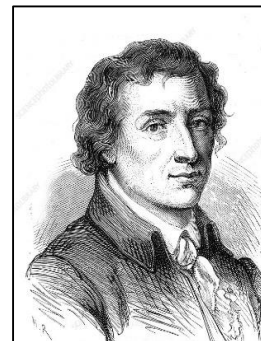


Figure 5: Franz Achard. *Science Photo Library*. Accessed on 20.04.2022. <https://www.sciencephoto.com/media/901506/view/franz-achard-german-chemist>.

Unlike his predecessor, Achard conducted his experiments outside the laboratory and over a much longer period, which reached 18 years. In 1782, after buying a manor in Kaulsdorf, near Berlin, he started cultivating sugar beets with a high sugar content. Within three years, he had cross-bred different types of beets to obtain as much sugar as possible and in the process created the white Silesian beet species that still exists today.<sup>77</sup> Between 1790 and 1798, Achard continued his endeavours and in November 1798 began experimenting on the large-scale production of beet sugar. To obtain sufficient funds, he sought financial support from King Frederick William III, which was granted.<sup>78</sup>

The funds awarded on the basis of Achard's findings from 1797<sup>79</sup> were put together by Derosne<sup>80</sup> and Angar, "our friend whose knowledge of the German language determined us to

<sup>74</sup> In addition to beets and skirrets, Marggraf also experimented with carrots, aloe, birch and grapes. **Gudoshnikov**, *The World Sugar* p. 6, **Klein**, *Technoscience in History*, p. 41, **Marggraf**, „Expériences chimiques“, pp. 89–90 and **Smith**, *Sugar*, pp. 39–40.

<sup>75</sup> **Klein**, *Technoscience in History*, p. 39.

<sup>76</sup> For Achard's scientific origins see *ibid*, p. 39–43.

<sup>77</sup> After testing many types of beets, he found out that "roots with white skin, white flesh and a conical shape were richest in sugar and of pure, sweet juice". **Cooke**, *The Sugar Beet Crop*, p. 9 and 13, **DRÁBEK**, Jakub, "K vývoji československého cukrovarnictví a řepářství od roku 1918 do konce druhé světové války", dissertation thesis, *Vysoká škola ekonomická v Praze, Národohospodářská fakulta*, 2020, p. 1 and **Smith**, *Sugar*, p. 40.

<sup>78</sup> The success was also due to a positive report from the commission of the Academy of Sciences. **Cooke**, *The Sugar Beet Crop*, p. 10 and **Smith**, *Sugar*, p. 40.

<sup>79</sup> **Achard**, *Le sucre européen*, p. iii and **McMurtrie**, *Report on the Culture*, p. 8.

<sup>80</sup> Pharmacist Charles Derosne (1780–1846), since 1823 a member of the Academy of Medicine in Paris, refined crude sugar with alcohol in 1808, improving by 1811 beet sugar processing methods Prussian chemists Hermstaedt and Achard had developed and later publishing them. "Derosne, Charles." *Encyclopedia.com*. Accessed on 03.05.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/derosne-louis-charles>.



bring from Leipzig the work of M. Achard”.<sup>81</sup> The comprehensive manual sums up the description of the beet and the effects of soil type, field preparation and fertilisation on the yield and quality of the crop, with beet selection, cultivation, and processing.<sup>82</sup> It also mentions the use of leaves as fodder for cattle, while other by-products were used to produce fertiliser, rum, spirits, vinegar, beer, tobacco and coffee surrogate.<sup>83</sup> Achard’s calculations for growing and harvesting beets are likewise intriguing. Mentioning deep ploughing, sowing seeds, employing six workers per day, weeding, double hoeing, harvesting and importing to the work site, he came to the conclusion that these initial steps cost approximately 45.55 francs (€215).<sup>84</sup>

Among other things, Achard lists in the second part of what turned out to be principal for the emergence of a new industry all stages of processing: “cleaning of beets, trituration, pressing to extract the juice, clarification of the juice, evaporation to make syrup and the conversion of the sugar syrup into raw sugar”.<sup>85</sup> What was required to obtain the desired sweet liquid was

“(1) a hollow cylinder that is filled with beets and that removes them once they are cleaned, (2) an engine for crushing that is composed of a large wheel moved by one or more oxen, then the pieces proceed to a (3) machine with four pierced cylinders able to grate 207 kg of beets per hour, and (4) under roller presses”.<sup>86</sup>

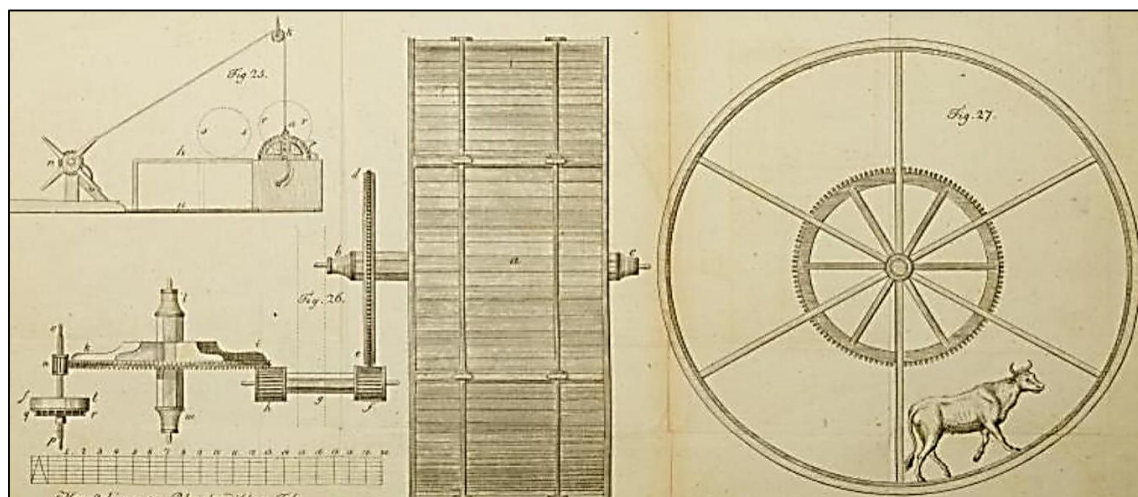


Figure 6: An ox-treadwheel serving for cutting beet roots. **Achard**, *Die europäische Zuckerfabrikation*, tab. III.

<sup>81</sup> **Achard**, *Le sucre européen*, p. xi.

<sup>82</sup> Achard was able to show that soil type, growing conditions and cultivation methods could influence sugar content and the level of unwanted non-sugars. **Achard**, *Instruction sur la culture*, pp. 1–10, **Achard**, *Le sucre européen*, pp. 1–26 and 30–32 and **Cooke**, *The Sugar Beet Crop*, p. 13.

<sup>83</sup> **Achard**, *Le sucre européen*, pp. xxii–xxiii and 83–93, LONDET, M. and L. BOUCHARD (dir.), *Annales de l’agriculture française ou Recueil encyclopédique d’agriculture*, t. 5, no. 26, Paris, M<sup>me</sup> V<sup>e</sup> Bouchard-Huzard, 1865, p. 372 and **McMurtrie**, *Report on the Culture*, p. 11.

<sup>84</sup> **Achard**, *Le sucre européen*, pp. 27–29.

<sup>85</sup> *Ibid.*, pp. 33–82.

<sup>86</sup> **Achard**, *Instruction sur la culture*, pp. 13–35 and **Achard**, *Le sucre européen*, pp. 34–35 and 42–44.

For the future handling of sugar juice, Achard lists the elements it contains, so that his next steps are justified to those knowledgeable in the subject and about chemical processes.<sup>87</sup> Once the juice was extracted, a ten-meter-long canvas would be spread

“which receives the pulps of the beets. The wooden cylinder is passed twice over the canvas and the juice is received in tin channel leading to a pot. To isolate crystalline sugar, it is necessary to clarify the juice with sulfuric acid, lime and albumen that interferes with the extraction of sugar, at heat brought up to 80 degrees. The structure is mixed with a wooden spatula and the pot is taken to an airy place”.<sup>88</sup>

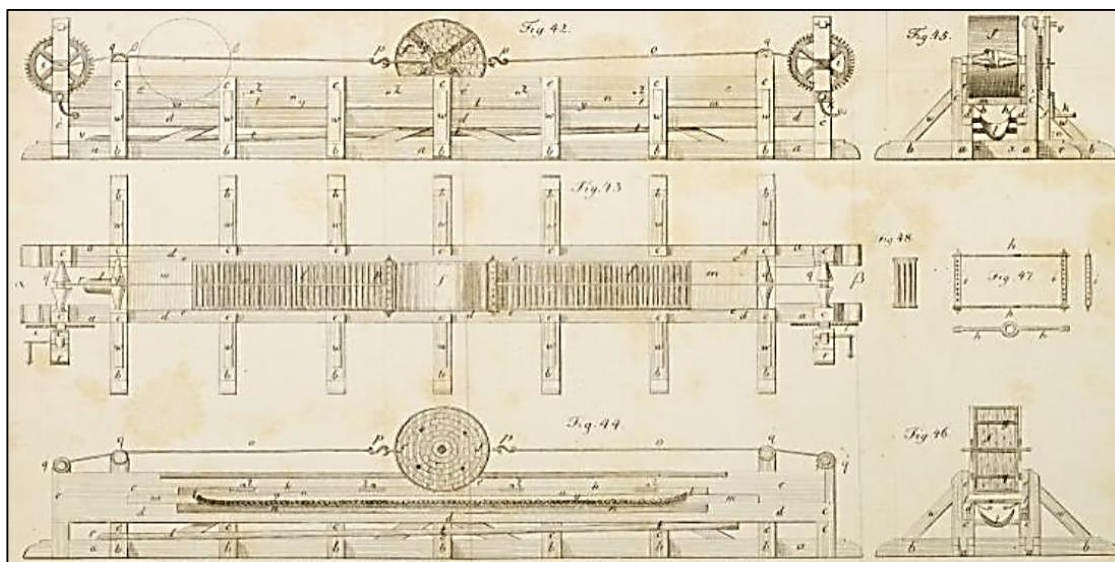


Figure 7: Pression of beets and extraction of the juice. **Achard**, *Die europäische Zuckerfabrikation*, tab. V.

The most fundamental step, brewing the obtained syrup, took place in

“a round copper cauldron, the bottom of which is flat and smooth. It is placed in a wooden vat, the edges of which are covered by the rim that is nailed to it so as not to allow steam, coming from a bottom copper pipe, to escape. One side of the vat is an opening to pass the pipe, that we fill precisely with putty and lead sheets, to allow vapours of water go into the space between the cauldron and the tank which surrounds it. The goal is to be able to heat large masses of beet juice without the risk of burning it.”<sup>89</sup>

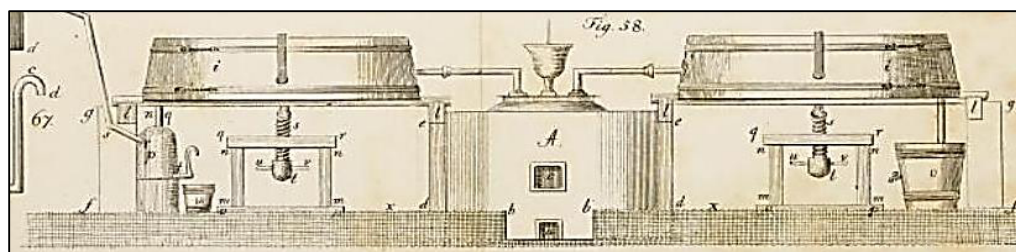


Figure 8: A steam machine for brewing and clearing the beet juice. **Achard**, *Die europäische Zuckerfabrikation*, tab. VI.

<sup>87</sup> In an acidic environment, sucrose is hydrolysed: each of its molecules absorbs a molecule of water and is broken down into glucose and fructose, and therefore well soluble in water. **Boušková**, “Změny v pěstování”, p. 34.

<sup>88</sup> **Achard**, *Le sucre européen*, pp. 46–48.

<sup>89</sup> *Ibid*, pp. 48–49 and 52.

The cauldron would no longer be heated once it had reached 79 degrees Celsius and a skimmer would strip away the thick black foam full of impurities, which had appeared on the surface. Thus cleared, the juice would be poured on a wool canvas and, after having passed it, received in a copper vase placed below. The remaining liquid was poured once again through the canvas and afterward stored in a cool place to “*prevent fermentation which the heat accelerates*”.<sup>90</sup> Having finished the mechanical operations, chemical reactions now took over:

“After sprinkling powdered white chalk on the bottom of the cauldron, we pour in the acidified juice from the day before. By the combination of the sulfuric acid with the lime, the carbonic acid becomes free and remains interposed in the juice. The quicklime, activated by the fire, absorbs the carbonic acid that the fire had removed from it, and the juice must be subsequently stored in closed vases. Poured back in the cauldron, we add skimmed milk by which all the parts separate from the juice and form a black crust, which is removed with a copper skimmer. The clear juice can be found below this crust.”<sup>91</sup>

Achard knew from following Marggraf’s simple method – checking the consistency of the fluid between the fingers – whether the syrup<sup>92</sup> was ready or needed to be boiled further. Boiling the fluid again, this time with evaporating cauldrons, the juice was poured into conical earthenware vessels and settled at a moderate temperature for a few days.<sup>93</sup> Achard distinguished two methods of extracting sugar. Regular crystallisation required less fuel but more labour, space, equipment and workers, and it was done in winter, while irregular crystallisation, carried out in summer, saved time and a number of workers, but demanded more fuel and skill.<sup>94</sup>

Based on this detailed knowledge, Achard submitted a proposal at the end of October 1799 to turn the academic laboratory he had been using into a sugar factory.<sup>95</sup> In the following months, “the laboratory was equipped with large simmering pans, iron kettles, and further instruments, a part of the laboratory building was used as a room for the crystallisation and another one served to store the cutting machines and presses, while the beets were stored in the cellar.”<sup>96</sup>

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<sup>90</sup> For the final phase of the mechanical part of the technology see **Achard**, *Le sucre européen*, pp. 58–59.

<sup>91</sup> **Achard**, *Instruction sur la culture*, pp. 38–53 and 59–63.

<sup>92</sup> While the clarified sugar juice consisted of water, crystallisable sugar, molasses or non-crystallisable syrup, gummy parts and lime sulphate, the foam was made up of albumen, extractive matter, carbonate and sulphate of lime and finally of caseous matter which comes from the added milk. **Achard**, *Le sucre européen*, p. 63.

<sup>93</sup> **Achard**, *Instruction sur la culture*, pp. 53–58 and **Achard**, *Le sucre européen*, pp. 64–68.

<sup>94</sup> The former was carried out by Marggraf and gave bigger crystals, while the latter provided sugar similar to that of India and was thus preferred. For more details on both methods see **Achard**, *Instruction sur la culture*, pp. 58–65 and 68–77 and **Achard**, *Le sucre européen*, pp. 68–82.

<sup>95</sup> “I wish to use the Academy’s laboratory as a sugar factory throughout the winter to produce a few hundred tonnes of sugar from beets.” **Klein**, *Technoscience in History*, p. 42.

<sup>96</sup> *Ibid*, p. 42.

Klein's review of Prussian scientific advancements provides a look at the university laboratory at the turn of the 19<sup>th</sup> century, which was very similar to Achard's at the academy. There were

“fifteen firmly installed large furnaces and smaller portable furnaces, two chimneys at the opposite walls, a large smelting furnace in the middle, others beneath the chimneys, various kind of instruments (retorts, coolers, tongs) placed upon or near the furnaces, a table with small chemical vessels between the windows, a cistern in one corner as well as a large iron mortar and pestle plus four smaller rooms for storing instruments and materials.”<sup>97</sup>

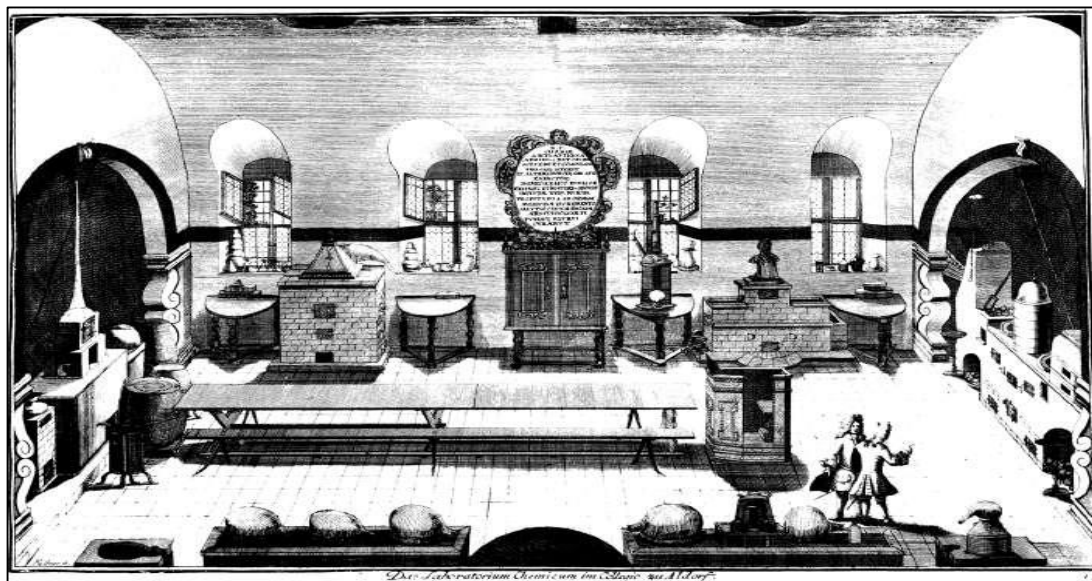


Figure 9: A makeshift university laboratory. Klein, *Technoscience in History*, p. 45.

The technological experiments started in January 1800 with “nine workers responsible for the handwork and five assistants who supervised the workers and recorded the results”.<sup>98</sup> They and their tools were moved in the summer of 1801 to the first experimental sugar factory that Achard had erected in Cunern, Silesia (today Konary, Poland), where the first campaign<sup>99</sup> of 250 t of beets took place in the early spring of 1802.<sup>100</sup> It cost 2.34 francs (€11) to process 51 kilograms

<sup>97</sup> The laboratory was originally equipped by Marggraf in 1753–1767. For a full impressive list of tools and equipment see *ibid*, pp. 44–47.

<sup>98</sup> *Ibid*, p. 43.

<sup>99</sup> The period from when the sugar beets are first harvested to the processing of the last beet. Farm to Table: Sugar Beet Harvest. *The Sugar Association*. Accessed on 10.03.2022. <https://www.sugar.org/blog/farm-to-table-sugar-beet-harvest/>.

<sup>100</sup> Besides sugar, spirits and vinegar from beetroot residues were also obtained here. Boušková, “Změny v pěstování”, p. 11, Cooke, *The Sugar Beet Crop*, p. 10, Gudoshnikov, *The World Sugar*, p. 6, Klein, *Technoscience in History*, p. 43, Reiser, *Avec ou sans sucre*, p. 81 and Smith, *Sugar*, p. 40.

of beets, so his usual annual harvest of 517 t of beets, carried out by 23 workers, amounted to 20,796 francs (€112,786). The amount of product extracted are listed below:<sup>101</sup>

AMOUNT	PRICE	EXTRACTED PRODUCTS		
		raw sugar	molasse	spirits
51 kg	2.34 fr.	–	–	–
517 t	20,796 fr.	23.7 t (4.6%)	13.6 t (2.7 %)	12.3 l

Table 1: Achard’s annual yields (by author).

Subsequent successful campaigns aroused the Prussian king’s interest and he appointed a commission in 1806 to report on Achard’s processes, specifically charging Doctor Valerius Wilhelm Neubeck to examine the methods.<sup>102</sup> Even though the commission was convinced that there was still room for improvement,<sup>103</sup> they reported their satisfaction with the machines, utensils, mechanical methods and chemical procedures<sup>104</sup> Achard had been using.

“We can therefore consider the manufacture of beet sugar as of very great importance and as having to increase the national wealth and the political and commercial independence, as a means of saving the consumption of wheat hitherto employed in the manufacture of spirits, and finally as a means of improving the land by feeding a greater number of cattle.”<sup>105</sup>

The technology supposedly came to a halt in 1806, when British cane sugar importers attempted to bribe Achard into abandoning his research, but their efforts came to no avail.<sup>106</sup> On the contrary, Achard managed to persuade the Prussian government, after his factory completely burnt down in 1807, to support him in opening a school for beet sugar production to teach foreign students, which was crucial for the spread of this technology all over the continent. But the collapse of the Continental System in 1814 brought no further need for it and in the same year the school was officially closed.<sup>107</sup>

<sup>101</sup> Table 1: Of the 70 kg of beets, Achard extracted circa 2 kg of sugar (2.9%) per day. **Achard**, *Le sucre européen*, p. 152 and 154–155, **McMurtrie**, *Report on the Culture*, p. 11 and **Reiser**, *Avec ou sans sucre*, p. 82.

<sup>102</sup> From 51 kilograms of beets, the commissaires obtained 3.5 litres of 20% spirit, 2.8 litres of water vinegar, 10.5 litres of distilled vinegar and 8.58 kilograms of cattle feed. **Achard**, *Le sucre européen*, pp. 138–139.

<sup>103</sup> For an excerpt, conclusions and questions to Achard see *ibid*, pp. 112–133, 136–141 and 142–159.

<sup>104</sup> Figure 10: **Nomblot**, “1812–1914”, p. 30.

<sup>105</sup> **Achard**, *Le sucre européen*, p. 163.

<sup>106</sup> The British cane sugar producers showed hostility to any advancement in beet technology and became aware of the dangerous competition from the Continent. **BRANÇON**, Denis and **VIEL**, Claude, “Le sucre de betterave et l’essor de son industrie : Des premiers travaux jusqu’à la fin de la guerre de 1914–1918”, *Revue d’histoire de la pharmacie*, vol. 87, no. 322, 1999, pp. 235–246, p. 238 and **Gudoshnikov**, *The World Sugar*, p. 7.

<sup>107</sup> **Cooke**, *The Sugar Beet Crop*, pp. 11–12.





Figure 10: Inside Achard's sugar factory, whose portrait appears on the left. **Nomblot**, "1812–1914", p. 30.

Sugar processing technology had nonetheless undergone enormous changes that were applied according to the possibilities and conditions of local areas. Sugar mills began to be used to crush the pulp, especially in the Mediterranean, in lieu of a simple mortar and the division of labour generally accelerated the process of obtaining sugar. As knowledge of cane processing spread, it began to be applied in times of scarcity to other crops as well. In Europe, political consequences put beets into the forefront because they were affordable, could withstand the mild climate zone and whatever was not needed to produce sugar could be completely used for fertiliser or cattle feed.

Prussian chemistry proved that sufficient sugar could be produced from beets while broad dissemination of sugar technology by the Prussian Academy of Sciences enabled it to spread far beyond Prussia. An important prerequisite for the adoption of these methods was the chemists' own experiments, which sought to point out the advantages of growing beets, and Archard's own thoroughness, together with his diligence, earned him the title of the father of the modern beet sugar industry that still exists today.

### 3. First individual experiments and their results (1797–1806)

#### Baron von Koppy's large-scale production

With slavery abolished in the Caribbean, expanding sugar beet production became a cheap substitute for sharply rising cane sugar prices.<sup>108</sup> The mild climate helped spread the technology from Prussia to Poland, Britain, France, Sweden and Prussian Silesia, with exports estimated at 4,120,000 francs (€19.5 million).<sup>109</sup> As it took hold in Sweden, England, Brussels and Russia, Johann Löwitz<sup>110</sup> contributed to its development when he discovered the cleansing properties of charcoal and it became a purifying agent for the syrup at a newly-established small beet sugar factory near Tula, Russia in 1802, among others.<sup>111</sup>

Back in Prussia, Achard's relatively fresh methods had been modified by his peers with even better results.<sup>112</sup> Wilhelm August Lampadius (1772–1842), professor of chemistry at the University of Freiberg, repeated Achard's methods and improved them in his sugar factory,<sup>113</sup> as well as Sigismund Hermbstaedt (1760–1833)<sup>114</sup> who extracted more brown sugar and syrup than his predecessors had managed. Large-scale experiments, standing out from the others, were carried out in 1805 by Moritz Baron von Koppy (1749–1814), who followed Achard's manufacturing principles to construct another sugar beet factory in Krayn, near Cunern.<sup>115</sup>

The whole 84-metre-long edifice consisted of a ground floor, first floor and vast attic. The main entrance was a covered shed *A*, through which carts bringing the beets and wood passed. Six

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<sup>108</sup> **Smith**, *Sugar*, p. 42.

<sup>109</sup> **Achard**, *Le sucre européen*, p. 151 and 160 and **Cooke**, *The Sugar Beet Crop*, p. 15.

<sup>110</sup> Johann Tobias Löwitz (1757–1804), a member of the St. Petersburg Academy of Sciences since 1793, produced an appreciable quantity of beet sugar in 1799 and used the charcoal to purify vodka and drinking water. "Lovits (Lowitz), Johann Tobias" *Encyclopedia.com*. Accessed on 14.04.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/lovits-lowitz-johann-tobias>.

<sup>111</sup> **Cooke**, *The Sugar Beet Crop*, p. 15, FIGUIER, Louis, "Industrie du sucre", in *Les merveilles de l'industrie ou Description des principales industries modernes*, tome 2, Paris, Jouvot et Cie, 1877, pp. 1–148, pp. 20–21, **Jadlovský**, "Vývoj cukrovarů", p. 32 and LALOUX, Ludovic. "La bataille du sucre ou la défaite méconnue de Napoléon I<sup>er</sup>", *Artefact*, vol. 9, 2018, pp. 35–56, p. 38.

<sup>112</sup> Achard himself acknowledged that his initial attempts were imperfect and yielded small amounts of sugar. **McMurtrie**, *Report on the Culture*, p. 11.

<sup>113</sup> From 51 kg of beets, he extracted 1.56 kg of sugar. "Procédé de Lampadius pour extraire le sucre de la betterave", DELAMÉTHÉRIE, Jean-Claude (dir.), *Journal de physique, de chimie, d'histoire naturelle et des arts*, t. 50, Paris, H. L. Perronneau, 1800, pp. 472–473 and **Neumann**, *Nástin dějin*, p. 3.

<sup>114</sup> Sigismund Hermbstaedt (1760–1833) founded in 1788 a technology magazine, in 1790 became a court apothecary and in 1808 a member of the Prussian Academy of Sciences and of the Technical Industrial and Trade Committee. "Hermbstaedt, Sigismund Friedrich." *Encyclopedia.com*. Accessed on 25.04.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/hermbstaedt-sigismund-friedrich>.

<sup>115</sup> Furthermore, two other factories were established at Athaldsleben and near Augsburg. **Cooke**, *The Sugar Beet Crop*, p. 10, **Achard**, *Le sucre européen*, p. xxxv and **McMurtrie**, *Report on the Culture*, p. 10.

compartments *a*, storing up to 620 t of beets, led from the shed and a beet gin *abc* set in motion by the oxen *B* drove two trituration trays in the machine *d* located in the laundry room *C*. The factory was also composed of a roller press *e*, a tank *f* intended for receiving the juice, a well *g* and a staircase *h* to the first floor. The juice was acidified in another room *D*, while the laboratory *E* contained two large clarifying boilers *a*, four evaporating boilers *b* and three furnaces *c*, which heated the boilers.

Scum and sediments were strained out by a canvas in the room *F*, where all the utensils were also stored, and any items combustible with wood were stored in the room *G*. Another roller press *a* along with the fermentation barrels *b*, containing malt and heated by two iron furnaces *c*, were found in the large room *H*. The adjoining room *J* was made up of large still vessels *b* where the beet residues were transformed into spirits through distillation, while the vinegar room *K* contained barrels with the vinegar that had been heated in the room *J* and later stored together with the rest of the liquids (syrup, molasses) in the cellar *L*.

The first floor (pictured above) housed employees and workers who stored pots, vases and other equipment in the room *N*, while the room *O* had an opening in the floor to allow the beet gin to function. The room *M*, exactly above the laboratory, was equipped with several hatches and ventilators to let air circulate, as well as the attic where the raw sugar was dried.<sup>116</sup>

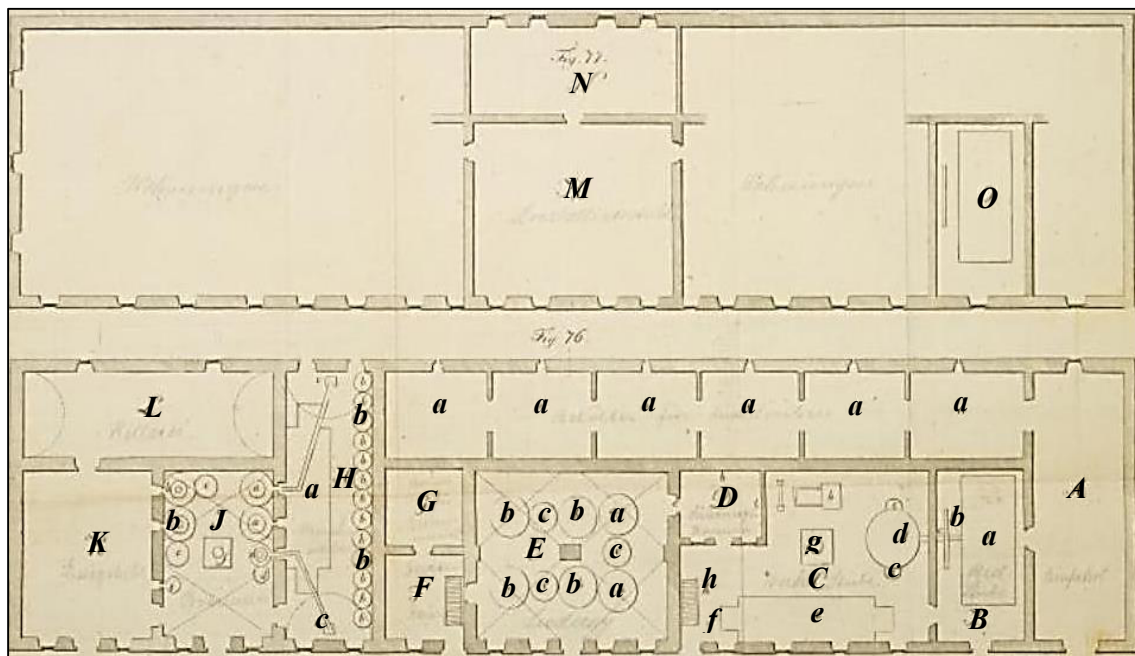


Figure 11: Koppý's experimental sugar beet factory. Achard, *Die europäische Zuckerfabrikation*, tab. VIII.

<sup>116</sup> For the distribution of the rooms and their purposes see Achard, *Le sucre européen*, pp. 94–98.



Kopy provided an overview of the factory staff, comprising an inspector who oversaw operations and the accounting, a foreman who repaired the machines, a refiner who extracted sugar, a distiller to handle spirits and vinegars, sixteen workers for various factory processes and two additional workers in winter that took care of fuel. He then listed expenses for lighting, fuel, repairs, necessary ingredients and borrowing costs. Kopy spent almost 21,197 francs (€100,444), an amount similar to Achard’s costs in 1801, which amounted to 20,796 francs.<sup>117</sup>

<b>inspector</b>	1,200 fr.	<b>16 workers</b>	5,760 fr.	<b>repairs</b>	1,200 fr.
<b>mechanic</b>	600 fr.	<b>2 workers</b>	236.80 fr.	<b>ingredients</b>	2,400 fr.
<b>refiner</b>	600 fr.	<b>fuel</b>	2,400 fr.	<b>interest</b>	6,000 fr.
<b>distiller</b>	600 fr.	<b>lighting</b>	200 fr.	<b>TOTAL</b>	<b>21,196.80 fr.</b>

Table 2: Kopy’s wages for employees and necessary expenses (by author).

In 144 working days out of the year, the staff employed by Kopy processed 517 t of beets, or approximately 3.6 t of beet per day, using one washing machine, two trituration machines, one press and 136 acidifying pots daily. Moreover, Kopy bought two clarification boilers, four evaporation boilers, 1,440 conical vessels, a large number of sediment pots and evaporating vessels. Besides that, the sugar factory needed baskets with handles or wheeled carts for transporting beets, six thermometers, a tin measure, a mortar for chalk, screens and sieves, four skimmers, canvases with eight frames and iron clamps to support and hold them, shovels and spatulas, two pokers for collecting the sediments, a lime kiln and various ingredients.<sup>118</sup>

This overall overview of the employees, machines and tools located in the factory led to high beet profits: the campaign of 1805-06 totalled 55 t of beets; the daily output was 3.6 t and the processing of one tonne amounted to 20.8 francs (€113). In the campaign of 1809–1810, Kopy’s harvest reached 254 t of beets and his factory delivered 355 kilograms of pure sugar every week. These results greatly reduced the excise duty on beet sugar.<sup>119</sup> In 1810, half a kilogram was sold for 3.70 francs (€20), while cane sugar cost five francs (€27).<sup>120</sup>

<sup>117</sup> Table 2: Ibid, p. 111 and 134.

<sup>118</sup> For a separated, detailed description of the machines, utensils, production of spirits with vinegar and ingredients such as sulfuric acid, limestone, chalk, skimmed milk, and yeast, see **Achard**, *Le sucre européen*, pp. 99–101, 101–103, 103–107 and 107–110.

<sup>119</sup> Kopy obtained between 4–6% raw beet sugars. **Cooke**, *The Sugar Beet Crop*, p. 11 and 13, “Kopy, Moritz von” and **McMurtrie**, *Report on the Culture*, p. 10–11.

<sup>120</sup> **Achard**, *Instruction sur la culture*, pp. 82–83.

The high revenues thus allowed Kopyy to cover the high costs incurred for the construction of the factory, pay his employees, and acquire machines, tools and ingredients totalling approximately 120,000 francs (€568,633).<sup>121</sup> The construction of the sugar factory almost exhausted Kopyy’s financial resources, not to mention the impact when his factory burned down in June 1811 and his request for state financial aid was rejected. While Kopyy’s son William did manage to rebuild the factory in 1815, the return of extensive cane sugar imports prompted him to close the business in 1822.<sup>122</sup>

The table below shows the difference in income and costs between 1802 and 1806: Achard’s knowledge had been improved by his colleagues to such an extent that Kopyy was able to grow more and better beets, had higher yields, gained more sugar and reduced his expenses, all from constant communications between learned circles and due to dynamic improvement in the technology that made Kopyy’s factory an example and a model for all sugar factories built in Europe during the first decades of the 19<sup>th</sup> century.

	F. ACHARD (1802)		M. KOPYY (1806)	
<b>daily beet processing</b>	70 kg		3,500 kg	
<b>daily amount of sugar</b>	2 kg		50.7 kg	
<b>price per 1 tonne of sugar</b>	40.2 fr.	€190	20.8 fr.	€113
<b>price per 517 tonnes of sugar</b>	20,796 fr.	€98,544	€21,196.80	€100,443

Table 3: Comparison of both first large-scale beet productions (by author).

### Initial experiments on Bohemian estates

Today’s Czech Republic has gone through long and difficult processes of transformation. Although the constituent parts of Bohemia, Moravia and Silesia are located in the centre of Europe, the historical “Czech lands have been distant from the economic, cultural and political centres with no marine harbours, large waterways and extensive fertile lowlands”.<sup>123</sup> The history of the Bohemian Crown Lands, as the region would be later called, began in Moravia, gained importance in Bohemia and, starting in the 16<sup>th</sup> century, was governed from decisions

<sup>121</sup> Building costs amounted to 68,000 fr. (322,225 €), machinery and utensils to 25,200 fr. (€119,413) and changes made to the land to 26,800 fr. (126,995 €). Achard, *Le sucre européen*, p. 135.

<sup>122</sup> History of Sugar. *Südzucker Group*. Accessed on 03.05.2022. <https://www.suedzucker.de/en/company/history/history-of-sugar> and “Kopyy, Moritz von.” *Deutsche Biographie*. Accessed on 03.05.2022. <https://www.deutsche-biographie.de/sfz44533.html>.

<sup>123</sup> PÁNEK, Jaroslav, TŮMA, Oldřich et al., *A History of the Czech Lands*, Praha, Karolinum Press, 2018, p. 25.

originating in Vienna, when the Kingdom of Bohemia in 1526 became part of the multinational monarchy under the Habsburgs, during whose rule significant progress was made.<sup>124</sup>

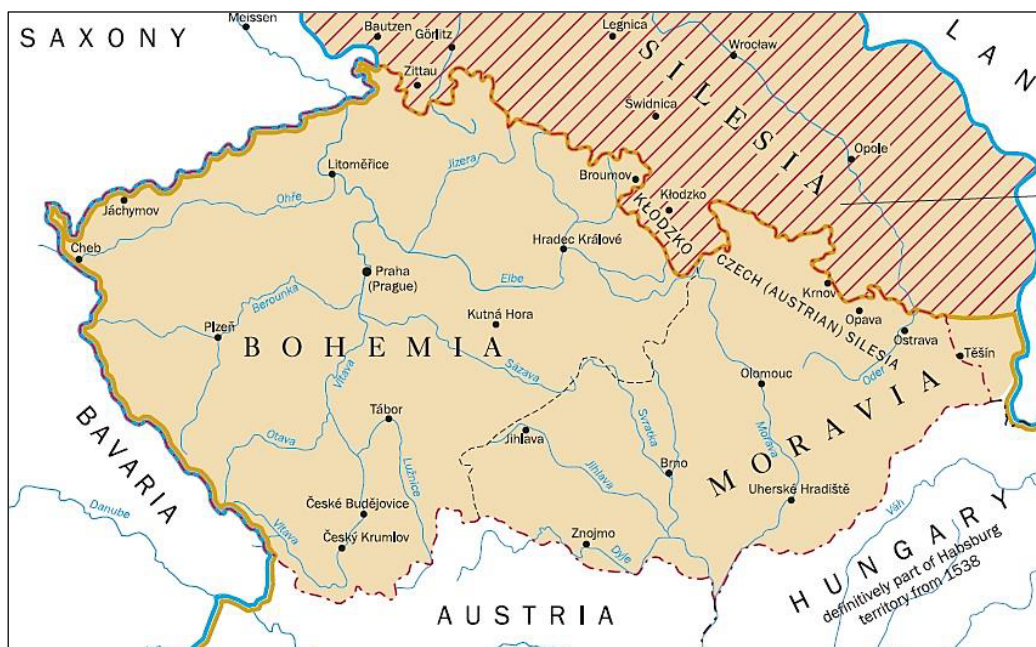


Figure 12: The future Czech Republic in the 17<sup>th</sup> and 18<sup>th</sup> centuries. **Pánek et al.**, *A History*, p. 713.

The prosperous industry began to take shape as early as the modern age. Cane sugar was imported from Egypt to Bohemia in 1344 during the reign of Emperor Charles IV.<sup>125</sup> The beetroot was already known in the 17<sup>th</sup> and 18<sup>th</sup> centuries, but the government in Vienna and Bohemian officials initially supported sweeteners such as bee honey and syrups from plants and trees. Proper impetus came in the 1770s when the Patriotic Economic Society (PES, *Vlastenecká hospodářská společnost*) issued instructions<sup>126</sup> for the cultivation of this new crop, introducing it into agriculture.<sup>127</sup>

The golden era of what would become the Bohemian sugar industry began in less than three dozen small beet sugar factories, but none of them survived for long. Their short existence and a relatively long interval between from another prosperous period in the 1830s meant that only “a modest number of materials and information has been preserved”.<sup>128</sup> However, the number of staff can be estimated, and it is known that they combined empiricism with alchemy in copious experiments. The primitive machines in these factories were efficient, driven by human

<sup>124</sup> For the beginnings of the development of the state see *ibid*, pp. 25–33.

<sup>125</sup> MADĚRA, Lukáš, “Výroba cukru v českých zemích dříve a nyní”, bachelor thesis, Západočeská univerzita v Plzni, Fakulta pedagogická, 2016, p. 17 and Neumann, *Nástin dějin*, p. 12.

<sup>126</sup> The treatise *On the growth and utility of beets* from 1770 and five years older *On the utility of sowing sugar beet*. Neumann, *Nástin dějin*, p. 4.

<sup>127</sup> Boušková, “Změny v pěstování”, p. 11, Dudek, *Vývoj*, p. 20 and Maděra, “Výroba cukru”, p. 18.

<sup>128</sup> Froněk, “200 let”, p. 358.

power except for two factories that used a pair of oxen and water power. Overall, these were small-scale operations.<sup>129</sup>

The first refinery for imported cane sugar and for beet syrup was established on 17 June 1787 in Zbraslav (called Königsaal), near Prague, on the site of the abolished Cistercian monastery.<sup>130</sup> Its director, Dutchman Joseph (de) Sauvaigne, founded a refinery in Klosterneuburg, Lower Austria in 1785 and wanted to expand his business to Bohemia, pushing through numerous advantages for his refinery so that it subsequently gained a monopoly over domestic cane sugar trade.<sup>131</sup> At the end of July 1787, Sauvaigne arrived with his builder Walchshofer from Klosterneuburg, sugar-master Gauss, and four journeymen from Hamburg and they started extracting the first amounts of sugar in four cauldrons on 11 September 1787.<sup>132</sup>

Refining took place in the east wing of the monastery, which resembled Koppý's factory. A nearby church served as a warehouse, the ground floor was filled with boiling rooms, the upper floors with ventilators and the other halls with storerooms and packing rooms.<sup>133</sup> Initially, nineteen people worked for Sauvaigne, with the number increased to sixty-two after 1790.<sup>134</sup> Five of them came from outside Bohemia, as well as the two foremen, one of whom was from Carniola, where he had moved from Klosterneuburg and coincidentally was from where Sauvaigne also came. It can be thus deduced that Sauvaigne was particular about cohesion with his Austrian refinery and brought the tradition, obviously inspired by Koppý's plans, to Bohemia together with his team.

In 1790, the refinery expanded and was producing up to 250 t of raw sugar and 50 t of refined sugar each month, which would be then delivered in the form of lumps to a warehouse in Prague and from there sent to public warehouses in Linz, Vienna and Brünn (now Brno, Czech Republic). In 1795, the refinery was visited by Achard himself from Kaulsdorf, 360 kilometres

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<sup>129</sup> **Jadlovský**, "Vývoj cukrovarů", p. 31 and 33 and **NOVÁK**, M., "Pohled do vývoje cukrovarnictví", seminar paper, Vysoká škola chemicko-technologická, Katedra učitelství a humanitních věd, 2011, p. 6.

<sup>130</sup> **FALTUSOVÁ**, Simona, "Cukrovarnický průmysl v České republice – geografická analýza", master thesis, Jihočeská univerzita v Českých Budějovicích, Pedagogická fakulta, 2010, p. 31, **Jadlovský**, "Vývoj cukrovarů", p. 31, **Maděra**, "Výroba cukru", p. 18, **NÁRODNÍ TECHNICKÉ MUZEUM**, *Cukrovarnictví, cukrovary a cukrovarníci. Fenomén českého hospodářství v 19. a 20. století*, Praha: NTM, 2011, Prameny a studie 47, p. 19, **Neumann**, *Nástin dějin*, p. 9, **Nezdarová**, "Proměny cukrovarnictví", p. 14, **POKORNÁ**, Bohdana, "Cukrovarnictví a vznik železniční sítě na Novobydžovsku", bachelor thesis, Univerzita Hradec Králové, Filozofická fakulta, 2015, p. 13 and **Říha**, *Počátky*, pp. 15–24.

<sup>131</sup> **FEXO VÁ**, Lucie, "Nymburský cukrovar pod vedením Hanuše Karlíka", master's thesis, Univerzita Karlova v Praze, Katolická teologická fakulta, 2017, p. 14.

<sup>132</sup> **Nyplová**, "Kapitalistické začátky", p. 164 and Státní oblastní archiv v Praze, Velkostatek Zbraslav, NAD 213.

<sup>133</sup> *Ibid.*, pp. 164–165.

<sup>134</sup> The staff consisted of three foremen, 17 journeymen, 24 officials and 18 day labourers. **Nyplová**, "Kapitalistické začátky", pp. 165–166.

away,<sup>135</sup> who could have possibly shared new methods he had invented, and after that visit the refinery was processing an average of 700 t of colonial sugar per year, from which 50% of pure sugar was obtained.<sup>136</sup>

Sugar sales were in deep decline as early as 1793 amidst a steep rise in sugar prices, possibly be attributed to the effects of the slave rebellion in Haiti. Three years later, the monastery was put up for auction at 1,250 gulden (€7,600) and sold in 1800.<sup>137</sup> As a result of “unfavourable competition and primitive craft equipment, the Zbraslav refinery suffered heavy material losses,”<sup>138</sup> and virtually ceased operating in May 1802, dismissing all workers in early July 1803.<sup>139</sup> With the Zbraslav completely shut down, Bohemia was now completely dependent on imported foreign sugar juice.<sup>140</sup>

Both the increase in prices for sugar factory equipment and the purchase of more expensive tools testify to the growing quality of manufactured accessories and utensils. Salaries also rose because more technically educated workers were needed, and so did their number. Achard employed 14 people, Kopyy 22 and Sauvaigne 62. This growth in headcount was evidence of the complexity and division of labour, which required increasingly more trained staff.

Another refinery was founded in 1789 in northeastern Neuohof (today Nový Dvůr) by canvas merchant František Sperling, who became acquainted with sugar refining during his travels in Portugal.<sup>141</sup> However, its operations were terminated in 1798 after “an accident that allegedly struck a shipment of colonial raw material [sugar] at sea and the careless supervision of a factory that seduced workers to steal sugar goods”.<sup>142</sup> There was also a request to establish a refinery in Kaurzin (today Kouřim) in July 1799, but due to lack of experience it was rejected.<sup>143</sup>

The beet sugar factories were not as successful as the cane factories since the farmers did not know exactly how to plant and process the crop and the technology was still in its infancy. Anyway, the first attempt to process beets appeared in 1802, when Count Rudolf Vrbna built the proto-sugar making factory in southwestern Horschowitz (today Hořovice), where the

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<sup>135</sup> **Maděra**, “Výroba cukru”, p. 18, **Neumann**, *Nástin dějin*, p. 9 and **Nyplová**, “Kapitalistické začátky”, p. 167.

<sup>136</sup> **Fexová**, “Nymburský cukrovar“, p. 14, **Nyplová**, “Kapitalistické začátky“, pp. 164–166 and **Pokorná**, „Cukrovarnictví“, p. 13.

<sup>137</sup> **Neumann**, *Nástin dějin*, p. 9 and **Nyplová**, “Kapitalistické začátky“, p. 167.

<sup>138</sup> **Neumann**, *Nástin dějin*, p. 2.

<sup>139</sup> **Nyplová**, “Kapitalistické začátky“, pp. 166–167.

<sup>140</sup> **Fexová**, “Nymburský cukrovar“, p.15.

<sup>141</sup> **Froněk**, “200 let“, p. 358, **Maděra**, “Výroba cukru“, p. 18, **Nezdarová**, “Proměny cukrovarnictví“, p. 14 and **Pokorná**, “Cukrovarnictví“, p. 13.

<sup>142</sup> **Pokorná**, “Cukrovarnictví“, p. 13.

<sup>143</sup> **Neumann**, *Nástin dějin*, pp. 10–11.

initiative came from Konrad Adam's experiments with beets in Vienna, from where he moved to Horschowitz in 1800.<sup>144</sup>

In this factory, the beets were hand-grated and pressed, their cleared juice boiled in a cauldron and left to settle. Production usually ended here because the obtained juice would be then transported to the Zbraslav refinery for further processing.<sup>145</sup> About 3.8 hectolitres of juice were extracted from 650 kilograms of beets, or one kilogram of beets providing 5.8 litres of juice.<sup>146</sup> Nevertheless, the small amount of crystallised syrup produced at excessive cost led to the factory's slow decline and subsequent closure in 1805 and to a complete halt in the growing and processing of beets in Central Bohemia for several years.<sup>147</sup>

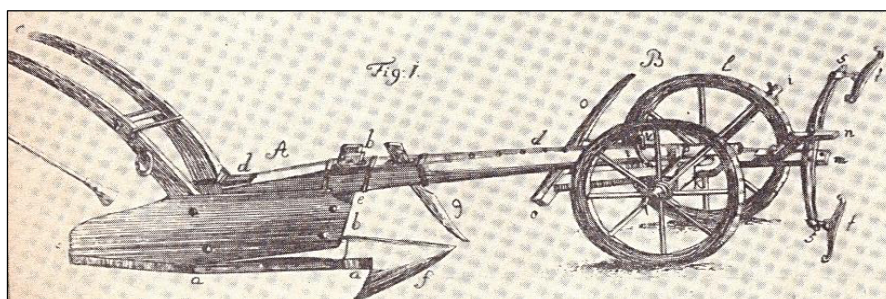


Figure 13: An instrument for efficient ploughing of the soil. JÍLEK, František et al., *Studie o technice v českých zemích 1800–1918*, t. 1, Praha, Národní technické museum, 1983, p. 30.

### Promising endeavours from French chemists

France's dynamic development of the sugar industry was instigated in the 18<sup>th</sup> century by the processing of imported sugar cane from Saint-Domingue and Martinique, the world's largest cane producers at the time. In 1735, cane was processed in 15 port refineries, but this figure had risen as early as the 1780s to 25 facilities in Orléans, 26 in Bordeaux, five in Nantes and 15 in Marseille.<sup>148</sup> Beets having been introduced to France by the Andrieux and Vilmorin families<sup>149</sup>

<sup>144</sup> Boušková, "Změny v pěstování", p. 12, Drábek, "K vývoji", p. 1, Dudek, *Vývoj*, p. 19, Národní technické muzeum, *Cukrovarnictví*, p. 19, Neumann, *Nástin dějin*, p. 11, Nezdarová, "Proměny cukrovarnictví", p. 14, Novák, "Pohled do vývoje", p. 6 and Pokorná, "Cukrovarnictví", p. 14.

<sup>145</sup> Boušková, "Změny v pěstování", p. 14.

<sup>146</sup> Neumann, *Nástin dějin*, p. 11.

<sup>147</sup> Boušková, "Změny v pěstování", p. 14.

<sup>148</sup> In 1850, there were more than 300 refineries in France. MACHKOVÁ, Hana, "Cukrovarnický průmysl ve Francii", *Listy cukrovarnické a řepařské*, vol. 129, no. 11, 2013, pp. 356–358, p. 356.

<sup>149</sup> Claude Geoffroy and Pierre d'Andrieux established a family business focusing on the plant seed trade in 1743. Vilmorin Clause et Cie. *Encyclopedia.com*. Accessed on 26.05.2022. <https://www.encyclopedia.com/books/politics-and-business-magazines/vilmorin-clause-et-cie>.



in 1775, Philippe-Victoire Lévêque de Vilmorin (1746–1804) would bring Silesian varieties to both build excitement and lay the foundations of the future industry.<sup>150</sup>

It started with a meeting of the French Royal Academy of Sciences on 16 May 1777, when the announcement by Andreas Marggraf of sugar crystals on beet roots was met with such incredible response that he was initiated into the Academy: “I have the honour to inform you that the King has appointed Sieur Margraff to the place of foreign associate of the Academy of Sciences.”<sup>151</sup> The foreign associate<sup>152</sup> was a recognised figure of the Academy, and as cheap sugar production spread among scholars and manufacturers,<sup>153</sup> the Academy played a key role

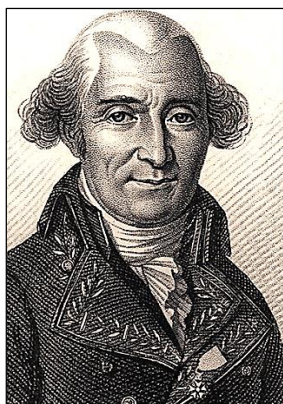


Figure 14: Nicolas Deyeux.  
*Napoléon & Empire*.  
Accessed on 17.06.2022.  
<https://www.napoleon-empire.net/personnages/deyeux.php>.

in bringing the new technology to France.

As a member of commissions assessing the usefulness of sugar producing methods, Nicolas Deyeux (1745–1837)<sup>154</sup> is considered the true promoter of French beet processing, publicising new extraction techniques. Appreciation was also expressed to Deslozières, Hapel La Chenaye and Bermond from France<sup>155</sup> and to the Prussians Würzer and Bloch, while Rauch’s work was rejected.<sup>156</sup> In January 1801, Lampadius’ work proved to be exceptional for he had improved Achard’s methods and, as proof, sent a box of beet sugar samples upon which it was proposed to print the manual.<sup>157</sup>

<sup>150</sup> Laloux, “La bataille”, p. 39, Neumann, *Nástin dějin*, p. 6 and VILMORIN, Jacques Lévêque de, *L’hérédité chez la betterave cultivée*, Paris, Gauthier-Villars et Cie, 1923, p. 34.

<sup>151</sup> Académie des sciences, *Procès-verbaux*, vol. 96, Paris, Académie des sciences, 1777, p. 349.

<sup>152</sup> They “applied to those sciences for which they have more inclination and talent”. DELAUNAY, Bernard, *La pensée technique de l’Académie royale des sciences (1699–1750), Volume 2: annexes*, Paris, 2013, dissertation, Université Paris 1 Panthéon-Sorbonne, Centre d’histoire des sciences et des techniques, pp. 3–4.

<sup>153</sup> Early works include BASSE, Detmar, *Instruction pour cultiver et pour exploiter la betterave à sucre*, Paris, L’imprimerie de Ch. Fr. Cramer, 1799 and COMMEREILL, Abbé de, *Instruction sur la culture, l’usage, et les avantages de la betterave champêtre*, Paris, L’imprimerie royale, 1786.

<sup>154</sup> Pharmacist Deyeux was interested in technological advances and published in several scholarly magazines. He was awarded for his description of the chemical composition of milk (1790) and blood (1791). He became a member of the *Institut* in 1797 and in 1804 the emperor’s first apothecary. “Nicolas Deyeux.” *Napoléon & Empire*. Accessed on 17.06.2022. <https://www.napoleon-empire.net/personnages/deyeux.php>.

<sup>155</sup> Deslozières promoted the extraction of sugar from carrots (1799), while Hapel La Chenaye advocated sugar whitening (1801). *Institut de France*, Académie des sciences, *Procès-verbaux des séances de l’Académie*, t. I, Hedaye, L’Observatoire d’Abbadia, 1910, pp. 407–408, 527, 530, 535 and 543–544. Bermond tried to cultivate cane in France, but unsuccessfully (Jun 1797). Brançon, “Le sucre”, p. 237, Delamétherie, *Journal de physique*, pp. 371–372, *Institut de France*, *Procès-verbaux*, t. I, p. 224 and McMurtrie, *Report on the Culture*, p. 8.

<sup>156</sup> Würzer shared his translated work (1801), Bloch a method on obtaining syrup from beets (1799). *Institut de France*, *Procès-verbaux*, t. I, p. 546 and *Institut de France*, Académie des sciences, *Procès-verbaux des séances de l’Académie*, t. II, Hedaye, L’Observatoire d’Abbadia, 1912, p. 375. Rauch’s methods were deemed impractical and expensive (1801). *Institut de France*, *Procès-verbaux*, t. II, p. 274 and 310–311.

<sup>157</sup> “Essays made in small and large, on the means of extracting sugar from chard or white perry, with theoretical and practical considerations on this subject”. *Institut de France*, *Procès-verbaux*, t. II, p. 268 and 295–298.

The founding of a new industrial branch in France was incited by Achard himself, having briefly described the whole process and adding that “this new manipulation will greatly facilitate the manufacture of sugar and will further reduce its price”.<sup>158</sup> The letter, sent to van Mons,<sup>159</sup> had been read out to the *Institut National* in the autumn of 1799 and it appointed a commission to examine Achard’s methods consisting of the most notable scientists of the time: chemists Deyeux, Louis Nicolas Vauquelin (1763–1829), Jean-Antoine Chaptal (1756–1832), Jean Darcet (1724–1801), Louis-Bernard Guyton-Morveau (1737–1816) and Antoine-François Fourcroy (1755–1809), pharmacist Antoine-Auguste Parmentier (1737–1813), agronomist Henri-Alexander Tessier (1741–1837) and botanist Jacques Philippe Cels (1740–1806).<sup>160</sup> On 25 June 1800, the conclusions were read:<sup>161</sup>

- “1. [...] It is certain that the beet which grows in France [...] contains sugar as well as the same species grown at Berlin that Achard worked upon.
2. The sugar may be extracted by various processes and that it acquires by aid of repeated purifications all the qualities of cane sugar.
6. It remains to be demonstrated that the beet may up to a certain point supplant the cane.
8. [...] That Achard is the first to have made fortunate application of this discovery, both in announcing the favourable quantity, that may be extracted, and pointing out the processes to which we could resort for success.”<sup>162</sup>

Thoroughly following up on Achard’s methods, the *Institut National* spent 250 francs (€1,243.70) to harvest and cultivate the beets and 150 francs (€746.30) on processing them. The result was the production of 15.64 kilograms of unrefined and 8.96 kilograms of clear sugar from 1 tonne of beet at a price of 1.80 francs (€9) per kilogram.<sup>163</sup> Even though their conclusions

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<sup>158</sup> ACHARD, F. K., “Procédé d’extraction du sucre de betterave”, *Annales de chimie*, t. 32, 1799, pp. 163–168, p. 168.

<sup>159</sup> Originally a Belgian pharmacist, Jean-Baptiste van Mons (1765–1842) later became a chemist. He maintained correspondence with foreign scientists and developed a network of knowledge across the European continent. “Jean-Baptiste van Mons.” *Nature*. Accessed on 07.05.2022. <https://www.nature.com/articles/150286c0>.

<sup>160</sup> The commission was appointed in May 1799. Achard, *Le sucre européen*, p. iv, **Institut de France**, *Procès-verbaux*, t. I, p. 581, **Londet**, *Annales de l’agriculture*, p. 372 and **McMurtrie**, *Report on the Culture*, p. 8.

<sup>161</sup> *Rapport fait à la classe des sciences mathématiques et physiques, de l’Institut national, par la commission chargée de répéter les expériences de M. Achard, sur le sucre contenu dans la betterave*, in DELAMÉTHÉRIE, Jean-Claude (dir.), *Journal de physique, de chimie, d’histoire naturelle et des arts*, t. 51, Paris, J.-J. Fuchs, 1800, pp. 371–389 and **Institut de France**, *Procès-verbaux*, t. II, pp. 183–184 and 210.

<sup>162</sup> **Delaméthèrie**, *Journal de physique*, t. 51, pp. 388–389.

<sup>163</sup> *Ibid*, pp. 385–386.



were generally favourable, they suggested several improvements<sup>164</sup> and the investigation “had the effect to dampen any enthusiasm that may have been aroused in France”.<sup>165</sup>

The members also invited anybody “who want[s] to perfect the work relating to the extraction of sugar from beet”<sup>166</sup> to do so. As Achard’s methods became better known, the number of articles highlighting beets and their processing grew<sup>167</sup> and several attempts were made to build beet factories, such as two erected in 1800 near Paris, one at Saint-Ouen and the other in the

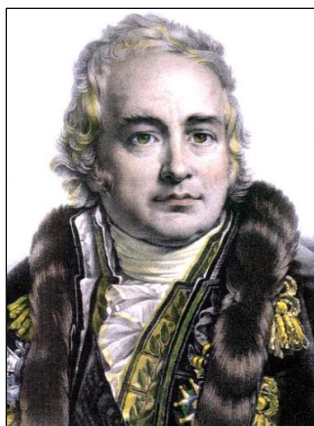


Figure 15: Jean Antoine Chaptal. *Dreamstime*. Accessed on 17.06.2022. <https://www.dreamstime.com/stock-photos-jean-antoine-chaptal-image19910863>.

old abbey of Chelles. But both failed.<sup>168</sup> To acquire more quantities of sugar, Napoleon Bonaparte (1769–1821) even resumed slavery in 1802,<sup>169</sup> but it brought no significant supply of cane sugar. So scholarly societies stepped in.

Jean Antoine Chaptal (1756–1832),<sup>170</sup> a commission member, published pioneering works about the subject<sup>171</sup> and through the *Société d’encouragement pour l’industrie nationale*, which he presided between 1801 and 1832, he provided the needed impetuses for commercial and industrial reforms.<sup>172</sup> The *Société’s Bulletin*<sup>173</sup> served as a means for disseminating knowledge, benefited from interconnectivity between members located in all corners of the

<sup>164</sup> Achard was condemned because he, as an amateur, had not communicated his experiments before performing them. **Delamétherie**, *Journal de physique*, t. 51, pp. 382–384 and **McMurtrie**, *Report on the Culture*, p. 9.

<sup>165</sup> **McMurtrie**, *Report on the Culture*, pp. 9–10.

<sup>166</sup> **Delamétherie**, *Journal de physique*, t. 51, p. 379.

<sup>167</sup> GUYTON-MORVEAU, L.-B., “Expériences et observations sur le Sucre”, *Annales de chimie*, t. 25, 1798, pp. 37–50, “Mémoire sur la culture des betteraves à sucre en France”, *Annales de chimie*, t. 38, 1801, pp. 329–332, SCHERER, A. N., “Note sur l’extraction du sucre de la betterave”, *Annales de chimie*, t. 30, 1799, pp. 299–302 and VAN MONS, J.-B., “Sur la culture de la betterave, destinées à la fabrication du sucre d’Europe. Extrait de l’ouvrage de M. Achard sur cette matière”, *Annales de chimie*, t. 33, pp. 67–73.

<sup>168</sup> **Achard**, *Le sucre européen*, p. v, **Neumann**, *Nástin dějin*, p. 6 and **PERRIER-ROBERT**, Annie and **BERNARDIN**, Marie-Paule, *Le grand livre du sucre*, Paris, Solar, 1999, p. 23.

<sup>169</sup> It allegedly came from the influence of his wife Josephine and the economic interests of her family, who owned large cane plantations in Martinique. **Machková**, “Cukrovarnický průmysl,” p. 356, **Stinchcombe**, *Sugar Island Slavery*, pp. 236–237 and **Reiser**, *Avec ou sans sucre*, p. 83.

<sup>170</sup> Figure 15: Chemist Chaptal, count de Chanteloup (1808) and French peer (1819), was a former Minister of the Interior (1800–1804). During this stint, he adopted many measures for economic enhancement, implemented extensive investments in the health care and practice with science into the educational system, founded the central Statistical office and decreed the foundation of a national museum at Louvre. Jean Antoine Chaptal. *Dreamstime*. Accessed on 17.06.2022. <https://www.dreamstime.com/stock-photos-jean-antoine-chaptal-image19910863>.

<sup>171</sup> **CHAPTAL**, Jean-Antoine, “Rapport fait à l’Institut National par la Commission chargée de répéter les expériences de M. Achard, sur le Sucre contenu dans la Betterave”, *Annales des arts et manufactures*, Thermidor 1800, pp. 181–224 and **CHAPTAL**, Jean-Antoine, “Suite du Mémoire sur la Manière d’extraire le Sucre contenu dans la Betterave”, *Annales des arts et manufactures*, Fructidor 1800, pp. 321–332.

<sup>172</sup> **GILLISPIE**, Charles Coulston, *Science and polity in France: The Revolutionary and Napoleonic Years*, Princeton, Princeton University Press, 2004, p. 631 and **HORN**, Jeff, *The Path Not Taken: French Industrialization in the Age of Revolution, 1750–1830*, Cambridge, The MIT Press, 2006, pp. 202–203.

<sup>173</sup> The full title *Bulletin de la Société d’encouragement pour l’industrie nationale*.

French Empire and shared both local and foreign knowledge. In addition, the *Annales de chimie* and the *Journal de physique* spread specialised knowledge, too,<sup>174</sup> by experts speaking on topics ranging from the chemical properties of metals to the study of sugar in human urine.

However, these magazines could not alone put the sugar industry on a prosperous footing, the stumbling blocks being the unprofessionalism and ignorance of the experiments. Despite many attempts with substitutes such as turnips, apples, carrots, pears, plums, parsnips, potatoes, chestnuts, or stalks of maize for expensive and increasingly unavailable cane sugar,<sup>175</sup> inexperience, primitive tools and an inadequate work environment led to failure. Since neither of these plants could supplant sugar cane, Chaptal's promise to "[begin looking] in turn for sugar in all the plants cultivated in France"<sup>176</sup> contained the hope that extracting sugar from beets would not be forgotten and that either the people, or the government, would soon return to it. And as he said, so it happened.

### Trade war with Britain

The origin of the modern economic warfare between Britain and France goes back to mercantilism, which pushed for increased trade at the expense of its adversary. Britain fired the first shots in the late 18<sup>th</sup> century conflict when it blocked the port of Brest in 1793 and France responded by banning British products. The resumption of war in 1803 led to the capture of French vessels and the next year to a blockade of all French ports.<sup>177</sup> After the defeat of the French fleet at the Battle of Trafalgar in October 1805, Napoleon Bonaparte returned the blow on 21 November 1806 with an attempt to destroy British export trade lines. His intention was to forbid all imports of British goods into Continental Europe and interdict all ships arriving at European ports directly from either Britain or her colonies:

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<sup>174</sup> The full titles *Annales de chimie, ou Recueil de mémoires concernant la chimie et les arts qui en dépendent, et spécialement la pharmacie* and *Journal de physique, de chimie, d'histoire naturelle et des arts, avec des planches en taille-douce*.

<sup>175</sup> **Brançon**, "Le sucre", p. 236, **Delamétherie**, *Journal de physique*, p. 372, **Dudek**, *Vývoj*, p. 19, **Fournier**, "Essais de fabrication", p. 232, **GANIÈRE**, Paul. "La bataille du sucre". *Napoleon.org*. Accessed on 28.05.2022. <https://www.napoleon.org/histoire-des-2-empires/articles/la-bataille-du-sucre/>, **Institut de France**, *Procès-verbaux*, t. II, p. 310, **Národní technické muzeum**, *Cukrovarnictví*, p. 19, **Nezdarová**, "Proměny cukrovarnictví", p. 15, **Novák**, "Pohled do vývoje", p. 6 and **McMurtrie**, *Report on the Culture*, p. 8.

<sup>176</sup> **CHAPTAL**, Jean-Antoine and **CHAPTAL**, Antoine (ed.), *Mes souvenirs sur Napoléon par le C<sup>te</sup> Chaptal*, Paris, Librairie Plon, 1893, p. 117.

<sup>177</sup> **AASLESTAD**, Katherine B. and **JOOR**, Johan (eds.), *Revisiting Napoleon's Continental System. Local, Regional and European Experiences*, Palgrave Macmillan, Basingstoke, 2015, p. 3 and **HECKSCHER**, Eli F. and **WESTERGAARD**, Haral (ed.), *The Continental System. An Economic Interpretation*, Oxford, Clarendon Press, 1922, pp. 13–29.

“England extends to vessels and trade goods the right of conquest. [...] This monstrous abuse of right has no other object than [...] to elevate the commerce and industry of England upon the ruin of the industry and commerce of the Continent. We have therefore resolved [...] to declare the British Isles in a state of blockade, [...] to prohibit all trade and correspondence with the Isles [...] and to seize any goods or property belonging to England.”<sup>178</sup>

Such a step had a far-reaching negative impact on almost the entire economy of Europe, and the reply to it did not take long. On 11 November 1807, the British responded with a series of “Orders in Council” that obliged it to “seize neutral ships carrying goods from enemy colonies directly to their mother countries,”<sup>179</sup> resulting in cane sugar disappearing from groceries.<sup>180</sup> “Faced with the growing scarcity of sugar”,<sup>181</sup> the Emperor ordered on 17 December 1807 that “any vessel of any nation, which [...] will have submitted to a voyage in England, is declared denationalised. Whether the said vessels enter our ports or those of our allies, they will be captured by our ships and declared good and rightful booty. The British Isles are thus declared in a state of blockade, at sea as well as on land.”<sup>182</sup>

The embargo, called the Continental System,<sup>183</sup> shook the cane sugar market,<sup>184</sup> with imports falling from an estimated 23,587 t of raw cane sugar in 1806 to only 5,000 t by 1812. Prices rose threefold, climbing to € 57 per kilogram. Moreover, the duty has quadrupled since 1810, while the custom revenues dropped from 51 million francs (235 million euros) in 1806 to 11.5 million francs (5.3 million euros) in 1809.<sup>185</sup> Such significant changes in the prices and supplies

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<sup>178</sup> For the full text of the Berlin decree see **Duvergier**, *Collection complète*, t. 16, pp. 54–55.

<sup>179</sup> They could still carry goods from enemy colonies to their own home ports, or from enemy colonies to British ports, or from British ports to enemy ports. Neutral vessels would have to put into British ports if they wanted to ship goods to France. **Findlay**, *Power and Plenty*, p. 368.

<sup>180</sup> **Aaslestad**, *Revisiting*, p. 4 and 89, **ABBOTT**, Elizabeth, *Le sucre, une histoire douce-amère*, translated by Benoît PATAR and Richard DUBOIS, Montréal, Fides, 2008, p. 189 and **CONTOUR**, Solange, “Le Val-d’Oise betteravier au XIXe siècle et dans la première moitié du XXe siècle”, *Mémoires de la Société historique et archéologique de Pontoise, du Val d’Oise et du Vexin*, vol. 98, 2016, pp. 271–372, p. 272.

<sup>181</sup> **Findlay**, *Power and Plenty*, p. 374.

<sup>182</sup> For Bonaparte’s Milan decree see **Duvergier**, *Collection complète*, t. 16, pp. 201–202.

<sup>183</sup> **Cooke**, *The Sugar Beet Crop*, pp. 15–16, **Fournier**, “Essais de fabrication”, pp. 227–228, **Machková**, “Cukrovarnický průmysl,” p. 356, **Reiser**, *Avec ou sans sucre*, p. 83 and **Smith**, *Sugar*, p. 41.

<sup>184</sup> To make matters worse, the whole transatlantic trade war was crowned by the promulgation of the United States’ “Non-Intercourse Act” of March 1809 that closed American ports to Britain and France and banned trade with their colonies as well. French and American imports were down slightly more than 50% in 1807–1814. **Findlay**, *Power and Plenty*, pp. 367–369.

<sup>185</sup> Table 4: **Aaslestad**, *Revisiting*, p. 42 and 95, **Brançon**, “Le sucre”, p. 238, **Chaptal**, *Mes souvenirs*, p. 117, **Dudek**, *Vývoj*, p. 19, **Fournier**, “Essais de fabrication”, p. 227, **Heckscher**, *The Continental System*, p. 292, **HOBHOUSE**, Henry, *Seeds of Change. Six Plants That Transformed Mankind*, Berkeley, Counterpoint, 2005, p. 93, **McMurtrie**, *Report on the Culture*, p. 23, **Novák**, “Pohled do vývoje”, p. 6 and **SNODGRASS**, Mary Ellen, *World food: an encyclopedia of history, culture, and social influence from hunter-gatherers to the age of globalization*, t. 1, Armonk, Sharpe Reference, 2013, p. 187.

of cane sugar led to the conviction that it was more advantageous to import this commodity through the Ottoman Empire or Russia instead of from overseas colonies,<sup>186</sup> but the state of war between the British Empire and Napoleonic France and the movement of Napoleon's troops made it unthinkable.

1800–1806				1807–1813				
IMPORT	DUTY		PRICE	IMPORT	DUTY	PRICE		
1802–1806	1802–1803	1805–1806	1806	1809–1813	1810	1809	1810	1812
23,587 t/year	€2.7–4	€4–4.6	€16	5,000 t/year	€21.7	€78.3	€43.5	€57

Table 4: Development of cane sugar prices, imported quantity and imposed duties (by author).

Achard's selflessness spread beet technology far beyond Prussia to Russia, Bohemia, Moravia and France. Beets became a respected crop that started to be both refined and processed. However, the first attempts in the Kingdom of Bohemia were not successful because of incomplete familiarisation with the methods, while France had a commission composed of the era's most illustrious chemists to give beet cultivation the space to become accepted. The sudden economic crisis changed conditions in agriculture and, instead of an overseas commodity, crops were sought that resembled cane sugar in colour and taste. Many attempts followed, but with none of them working, there was a necessity to look for other alternatives, which were soon found.

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<sup>186</sup> Neumann, *Nástin dějin*, p. 12.

## 4. Emergence and decline of the beet industry (1806–1815)

### Maple and grapes, the first sugar substitutes

The unexpected turnaround from the imposition of the Continental System provoked a startling reaction from people. In an effort to fill the gap caused by the embargo of cane sugar, large and small producers resorted to extracting sugar from available crops. In the recently established Empire of Austria from the ruins of the now-dissolved Holy Roman Empire, attention was paid to maple, while grapes were largely processed in the French Empire. As sugar processing technology developed in tandem with the decline of both the number of maples suitable for tapping and grape harvests, both France and Austria realised that the original Prussian discoveries for producing sugar from the harvesting and cultivation of relatively undemanding beets would be a reasonable substitute in times of extremely expensive sugar cane.

In the wake of the blockade, cheap and easy maple sugar production was first recommended.<sup>187</sup> The technique for extracting maple sugar had been exploited by French settlers in Canada during the 18<sup>th</sup> century, from where traveling chemists, like Nicolas Lémery (1645–1715), tried to introduce Canadian maple and their sap into France.<sup>188</sup> Although the French commission stated in 1800 that “this tree seemed at first to offer the resource which had been sought for so long,”<sup>189</sup> it was favoured more in German-speaking lands.

In Prussia, between the fall of 1796 and the spring of 1799, the Department of Trade and Industry investigated the production of sugar using maple syrup. Here, Gottlob Johann Christian Kunth (1757–1829) and Hermbstaedt showed Juti with Marabelli in Pavia and Jacquin in Vienna how to extract a syrup from corn and carrots, and the Swede Stalhamener how to obtain a birch syrup.<sup>190</sup> Moreover, he taught count Gusow’s labourers to apply the technology,<sup>191</sup> spreading it further to the east.

As early as 1767, Doctor Willberg from Gmünd, Lower Austria extracted maple sugar, while Count Zichy planted 20,000 maples in 1794. In 1800, university professor Jacquin carried out experiments in the Vienna Prater which were so successful that they were taken over by other manufacturers. One hundred and fifty kilometres away in Eisgrub, Moravia (today Lednice, Czech Republic), princely council Theobald Walberg planted over 30,000 maples and in 1809

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<sup>187</sup> Neumann, *Nástin dějin*, p. 4 and Nezdarová, “Proměny cukrovarnictví”, p. 15.

<sup>188</sup> Brançon, “Le sucre”, p. 236.

<sup>189</sup> Chaptal, “Rapport”, p. 188.

<sup>190</sup> Ibid, pp. 189–192.

<sup>191</sup> Chaptal, “Rapport”, p. 190 and Klein, *Technoscience in History*, p. 250.

opened a refinery, which was followed in 1810 by the construction of other refineries north in Plumau (now Plumlov) and Liban (now Libáň) to the northwest,<sup>192</sup> where Karel Böhringer tapped maples for their sap on a large scale and described the method for it.<sup>193</sup>

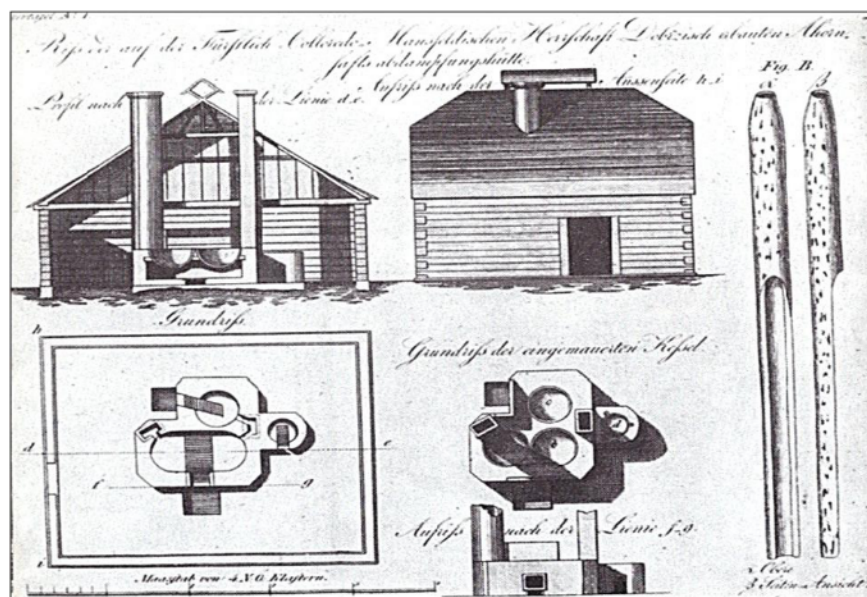


Figure 16: Boiling station for maple juice in Dobříš (1812). **Dudek**, *Vývoj*, p. 193-6.

Two separate and competitive assessments of sugar production in Bohemia and Moravia were undertaken in 1809–1811 to determine which method of production would be prioritised. They pitted Josef Bohumír Mikan (1743–1814), a botany professor at Charles University in Prague who promoted cheap maple sugar production without any complex devices, against beet sugar advocate Karel Augustin Neumann (1771–1866), a chemistry professor at Prague Polytechnic. Mikan and maple sugar prevailed because the Austrian government – given the French preference for beets – considered beets unpatriotic and not worth planting.<sup>194</sup>

In 1811, there was an assessment in Austria that the amount of sugar extracted depended on the nature of the maple, the weather and when the tree would be tapped, prompting maples to be planted in desolate locations and forests. However, the effort proved to be only experimental. The main drawbacks were the small number of trees, poor access to them<sup>195</sup> and the lack of

<sup>192</sup> Europe had knowledge about American farmers that “practised the process [of extracting sugar] without any difficulty” from the manual by a certain Doctor Rush from Philadelphia. **Chaptal**, “Rapport”, p. 188, **Dudek**, *Vývoj*, p. 19 and 23 and 64 and **Novák**, “Pohled do vývoje”, p. 21.

<sup>193</sup> The first key experiments were carried out only in 1810, after the manual *Über die Zucker-Erzeugung aus dem Saft des Ahornbaumes in den k. k. österreichischen Staaten* had been published. **Neumann**, *Nástin dějin*, pp. 64–67.

<sup>194</sup> **Dudek**, *Vývoj*, p. 26, **Neumann**, *Nástin dějin*, pp. 67–70, **Novák**, “Pohled do vývoje”, p. 18 and 22 and **Říha**, *Počátky*, pp. 53–55.

<sup>195</sup> “They grow [...] in the bottom of valleys or on the tops of hills.” **Figuier**, “Industrie du sucre”, p. 74.

adult maples, as sap could not be tapped from them until they had grown for about thirty years, not to mention the much higher price.<sup>196</sup> Although the largest production of maple sugar took place in Eastern Bohemia, where 4,860 kilograms of syrup and 3,068 kilograms of sugar were produced in 1812,<sup>197</sup> the production of maple sugar, along with other experiments, would be shut down due to high financial demands.<sup>198</sup>

TOWN	Terezín	Hořovice	Semily	Žleby	
YEAR	1794	1812	1812	1812	1812
PLANT	carrots	birch sap	starch	corn sap	maize
JUICE	–	56 hl	–	9 hl	–
SYRUP	–	52 kg	–	100 kg	20 kg

Table 5: 18<sup>th</sup> and 19<sup>th</sup> century maple sugar production in Bohemia (by author).

While maple was the major substitute for the lack of sugar cane in the Habsburg Monarchy, grapes primarily filled this role in France because of the country’s centuries-long tradition of wine production. Even before the Continental System had been decreed, various substitutes for expensive and hard-to-obtain cane sugar had been suggested, such as the first major attempts by chemist Pierre-Joseph Macquer (1718–1784) to extract grape sugar in 1776 which took him several months to get a clear syrup.<sup>199</sup> Parmentier followed Macquer’s experiments in the 1780s and, due to his numerous efforts and dedication, he is now considered to be the sole representative of grape sugar methods.

Parmentier,<sup>200</sup> “veteran of the rural and domestic economy,”<sup>201</sup> encouraged the French public to manufacture grapes into syrups and crystallised sugar. In his *Recherches sur les végétaux nourrisans* (1781), he wrote about a chestnut with crystallisable sugar. In response to the

<sup>196</sup> Achard, *Le sucre européen*, p. 162, Chaptal, “Rapport”, p. 187 and 189–190, Dudek, *Vývoj*, p. 26, Froněk, “200 let”, p. 358, Jadloviský, “Vývoj cukrovarů”, p. 31 and Neumann, *Nástin dějin*, p. 5.

<sup>197</sup> Table 5: The production fell to 81 kg in 1815. *Archives des découvertes et des inventions nouvelles, faites dans les Sciences, les Arts et les Manufactures, tant en France que dans les Pays étrangers*, Paris, Treuttel et Würtz, 1812, pp. 394–396, Maděra, “Výroba cukru”, p. 18 and Nezdarová, “Proměny cukrovarnictví”, p. 16.

<sup>198</sup> Fexová, “Nymburský cukrovar”, p. 16, Neumann, *Nástin dějin*, p. 6 and Nezdarová, “Proměny cukrovarnictví”, p. 15.

<sup>199</sup> CHAPTAL, Jean-Antoine, “Sur les Vins”, *Annales de chimie*, t. 36, 1800, pp. 3–49, pp. 37–41.

<sup>200</sup> Antoine-Augustin Parmentier was an apothecary and a member of the Royal Society of Agriculture in Paris. He became famous for his analysis of potatoes (1771), wheat and flour (1776), chestnuts (1780), milk (1790 and 1799) and chocolate (1786 and 1803). Throughout his life, he evinced a strong interest in public health. “Parmentier, Antoine-Augustin.” *Encyclopedia.com*. Accessed on 19.06.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/parmentier-antoine-augustin>.

<sup>201</sup> Achard, *Le sucre européen*, p. vi.



publication of these notes, a certain Barret tried experimenting with chestnuts in 1800–1805, but in vain. Other experiments with maize brought no desired results, unlike sweet potatoes. But the latter could not withstand frost.<sup>202</sup>

Even though Parmentier had planted beets, he was not convinced of them ever becoming the main source of sugar. With wine exports halted by the Continental System, he sought to utilise the accumulated grape stocks<sup>203</sup> and, ceding experiments with beets to Deyeux, turned to the grapes. Parmentier even advocated<sup>204</sup> that southern regions would produce grapes, while northern areas would focus on honey: “It is especially in the south of France where the different species of grapes are, almost every year, richer in sugar.”<sup>205</sup>

Parmentier’s leverage culminated in 1808 with his appointment to a commission seeking a new source of sugar, a new role he took so enthusiastically<sup>206</sup> that over the next two years he published extended and enhanced manuals<sup>207</sup> for the public in which, as the editor said, “all classes of citizens, from the statesman to the simple inhabitant of the countryside, will find particular means of economy and general views dictated by the most active philanthropy”.<sup>208</sup> Although the praise was greatly overstated, it remains the truth that he was intensively involved in grape sugar and staunchly refused beet sugar.<sup>209</sup>

Parmentier’s successor, Joseph Louis Proust (1754–1826),<sup>210</sup> spent twenty-three years in Spain examining the local grapes and their sugar content in order to make similar experiments in France.<sup>211</sup> Successful experiments – carried out independently of Parmentier – resulted in the

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<sup>202</sup> *Traité sur la culture et les usages des pommes de terre, de la patate, et du topinambour* from 1789. **Brançon**, “Le sucre”, p. 236, **Chast**, “Parmentier”, p.151 and **Figuier**, “Industrie du sucre”, p. 83.

<sup>203</sup> **Chast**, „Parmentier”, p. 151 and **McMurtrie**, *Report on the Culture*, p. 13.

<sup>204</sup> As a member of the board of the Parisian hospices, Parmentier, in letters to the prefects, relied on his fame and advocated grape sugar. **Chast**, „Parmentier”, p. 150, 152 and 155.

<sup>205</sup> *Le Moniteur universel*, no. 159, 7 June 1808, pp. 624–625.

<sup>206</sup> Archives nationales (Pierrefitte-sur-Seine), Subsistances F/11 294–295, ‘Documents divers’: ‘Renseignemens résultant de la Correspondance relative à la fabrication du Syrop et du Sucre de Raisin, an 1810’.

<sup>207</sup> *Instruction sur les moyens de suppléer le sucre dans les principaux usages qu’on en fait pour la médecine et l’économie domestique* (1808), its extended edition (1809), *Traité sur l’art de fabriquer les Sirops et les Conservees de Raisins, destinés à suppléer le Sucre des Colonies dans les principaux usages de l’économie domestique* (1810), *Aperçu des résultats obtenus de la fabrication des sirops et des conservees de raisins dans le cours des années 1810 et 1811* (1812) and finally *Nouvel aperçu des résultats obtenus de la fabrication des sirops et conservees de raisins dans le cours de l’année 1812* (1813). For more details see **Chast**, „Parmentier”, pp. 155–158 and 165.

<sup>208</sup> *Ibid*, p. 156.

<sup>209</sup> In July 1810, he said: “Do not be surprised, sir, if I defend grape syrup with the interest of paternity; it is a child I would like to see weaned before going down to the grave.” *Ibid*, p. 161.

<sup>210</sup> Proust held the position of chief pharmacist at the Salpêtrière Hospital in 1776 and taught in Spain from 1785, with several breaks, until the end of 1806. He is considered to have discovered glucose. “Joseph Louis Proust.” *Encyclopedia.com*. Accessed on 19.06.2022. <https://www.encyclopedia.com/people/science-and-technology/chemistry-biographies/joseph-louis-proust>.

<sup>211</sup> **Fournier**, “Essais de fabrication”, pp. 228–229.



presentation of the methods in June 1805 at the Academy of Sciences and in the publication in the *Annales de chimie*.<sup>212</sup> It took another three years for Proust to write the first, modern publication<sup>213</sup> on extracting grape sugar, which would inspire other manufactures.<sup>214</sup>

Although both pharmacists worked to improve methods in the same field, the more experienced Parmentier became jealous of the younger Proust, now universally recognised as having discovered grape sugar. Proust isolated it in 1799, presented his findings in 1805 and published the first manual in 1808, much earlier than Parmentier, who emulated and was hostile towards Proust's medal, awarded by the *Société d'agriculture de la Seine* in May 1808 for his contribution to the development of the technology for extracting grape sugar.<sup>215</sup>

In March 1810, Proust and Fouques apprised Minister of Interior Jean-Pierre Bachasson, Count of Montalivet (1766–1823) of their first extracted kilograms of grape sugar, upon which the latter reported to Emperor Napoleon that “Proust extracted sugar from grape syrup and Fouques has found the means to whiten it and give it the consistency and colour of cane sugar”.<sup>216</sup> On 18 June 1810, Bonaparte signed a decree appropriating 100,000 francs (€543,447) and the Order of the Legion of Honour<sup>217</sup> to Proust and 40,000 francs (€217,378) to Fouques on condition that both would be obliged to establish a grape sugar factory in a southern department.<sup>218</sup>

Meanwhile, state support was expanding. In August 1810, 200,000 francs (one million euros) would be distributed among twelve establishments if each produced at least 10 t of sugar.<sup>219</sup> However, only three of them met the conditions: in Mèze (36 t), Pézenas (20 t) and a complex of factories in Bergerac (16 t). Other major grape sugar factories were opened on the coast (Marseille, Toulon), close to border with Spain, where grape sugar was discovered (Béziers, Toulouse), or inland (Bergerac, Blois); Hérault and Dordogne were among the most profitable

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<sup>212</sup> *Mémoire sur les méthodes d'extraction et les propriétés du sucre de raisin*. Chast, „Parmentier”, p. 155.

<sup>213</sup> VALÉE, Antoine, *Traité élémentaire sur le sucre de raisin, sa fabrication, ses propriétés et ses usages dans l'économie domestique et commerciale*, Paris, D. Colas, 1808.

<sup>214</sup> In December 1807 it was chemist Fouques and in June 1809 pharmacist Laurens, who even received a prize from the *Académie de Marseille*. Fournier, “Essais de fabrication”, p. 229.

<sup>215</sup> Parmentier eventually won over the public and Proust gave in: “I leave Parmentier to his own thoughts. [...] It is for the fourth time that we see him putting his name to works that do not belong to him.” Ibid, pp. 229–231.

<sup>216</sup> *Bulletin de la SEIN*, t. 9, Paris, Imprimerie de M<sup>me</sup> Huzard, 1810, pp. 160–162 and McMurtrie, *Report on the Culture*, p. 14.

<sup>217</sup> Chaptal, *Mes souvenirs*, p. 118 and Fournier, “Essais de fabrication”, p. 230.

<sup>218</sup> Proust's poor health hindered his ability to fulfil conditions, unlike Fouques who planted and harvested grapes with beets. Fournier, “Essais de fabrication”, pp. 230–231 and McMurtrie, *Report on the Culture*, pp. 14–15.

<sup>219</sup> Limouzin from Albi cleared the first grape juice in 1811, a process that has become a hallmark in beet processing technology. Brançon, “Le sucre”, p. 242, Figuiet, “Industrie du sucre”, p. 23 and Snodgrass, *World food*, p. 187.

departments. In total, 11 departments produced about 1,306 t of grape syrup and grape sugar, while the entire French Empire produced around 2,500 t in total.<sup>220</sup>

LOCATION	Mèze	Pézenas	department Hérault	Bergerac	French Empire
SYRUP	–	–	928 t	219 t	2,500 t
SUGAR	36 t	20 t	56 t	16 t	

Table 6: 19<sup>th</sup> century production of grape sugar in the French Empire (by author).

But the decree never anticipated a disastrous harvest just before grapes were to become the only source of sugar in France in 1811,<sup>221</sup> but it happened.<sup>222</sup> Montalivet urged the prefects to continue vine growing efforts both in the south, centre and north of France,<sup>223</sup> but success could not last long for the grape sugar’s glucose<sup>224</sup> fermented faster and the regime did not sufficiently encourage citizens to take action. The harvest descended from mediocre (1809) to catastrophic (1810) and could not compete with beets (1811–1812), spelling the quick end of the grape sugar industry (1813).<sup>225</sup>

### Napoleon’s promotion of dynamic industrial growth

*“Chemists gave birth to it, technicians and machinists will lead it to adulthood.”*<sup>226</sup>

As grape sugar’s star was falling, beet technology was gaining momentum. In 1810,<sup>227</sup> three years after Achard’s sugar factory had completely burnt down, there was established “a practical school for instruction as complete as possible to make known to our people as well

<sup>220</sup> Table 6: *Archives des découvertes*, pp. 384–386, **Chast**, “Parmentier”, p. 158, **Fournier**, “Essais de fabrication”, pp. 230–232, **Heckscher**, *The Continental System*, p. 292 and *Le Moniteur universel*, no. 256, 13 September 1811.

<sup>221</sup> “From 1 January 1811, at the latest, the sugar of grapes shall replace in all public establishments the sugar of cane.” **McMurtrie**, *Report on the Culture*, p. 15.

<sup>222</sup> In September 1810, Proust wrote: “I find myself in the cruellest position: the harvest fails completely. A decree may well move the citizens of the Empire to its will, but it cannot make grapes grow where there are none.” **Fournier**, “Essais de fabrication”, p. 231.

<sup>223</sup> **Fournier**, “Essais de fabrication”, pp. 230–231 and **McMurtrie**, *Report on the Culture*, p. 15.

<sup>224</sup> Glucose crystallises significantly differently than sucrose in beets, which has a longer shelf life. **Chast**, “Parmentier”, p. 160.

<sup>225</sup> Support from the government and learned societies were not enough to arouse interest, and the industry was maintained by pharmacists, chemists and vineyard owners. **Fournier**, “Essais de fabrication”, pp. 232–233 and **Nezdarová**, “Proměny cukrovarnictví”, p. 14.

<sup>226</sup> **Brançon**, “Le sucre”, p. 242.

<sup>227</sup> In 1812, Johann Gottlob Nathusius (1760–1835) founded a sugar factory at the Althaldensleben monastery in the Kingdom of Westphalia. Although it was the most modern facility in Prussia at the time and produced 10 tonnes of sugar beet a year, it closed in 1820. **MAUMENÉ**, Edme-Jules, *Traité théorique et pratique de la fabrication du sucre*, tome 1, Paris, Dunod, 1876, p. 5.

as to foreigners the processes employed in the extraction of sugar from beet roots”.<sup>228</sup> Achard<sup>229</sup> offered two training courses: the first (in October 1812) introduced the production of bulk sugar and waste processing and the second (in November 1812) taught production in smaller factories.<sup>230</sup> The turnover of students then effectively spread the new technological industry over time throughout the continent.

Looking eastward, the technology took hold in Russia and the number of factories grew from four in 1810 to ten in 1812.<sup>231</sup> In the same year, chemist Gottlieb Kirchoff (1764–1833) treated potato starch with sulfuric acid to artificially obtain glucose.<sup>232</sup> The methods were enhanced by General Blankenagel together with Louis Walkhoff and adopted at sugar factories in Russia and Poland, which treated the residues by the hydraulic press and crushed the pulps in a machine similar to those used in spinning mills to card wool.<sup>233</sup> However, Napoleon’s invasion of Russia and “the destructive passage of foreign and contending armies destroyed this and other more flourishing industries”.<sup>234</sup>

As beet processing was enjoying a rebirth in Prussia and Russia, the French were also actively promoting it. In July 1807, chemist Antoine-Alexis Cadet de Vaux (1743–1828)<sup>235</sup> “formally called for a new examination of the beet question,”<sup>236</sup> while a son of the famous family, Pierre-Philippe-André Levêque de Vilmorin (1776–1862), started propagating Silesian sugar-beet seed.<sup>237</sup> Due to the growing business network, André Vilmorin was familiar with the seeds found in Europe and knew very well which were of good quality.

Achard let himself be heard again<sup>238</sup> in October 1808 when he contacted an editor of *Moniteur*. Besides stating his own successes in obtaining beet sugar, his claim that “*it is perfectly proven*

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<sup>228</sup> **McMurtrie**, *Report on the Culture*, p. 24.

<sup>229</sup> In 1808, Achard published a compact manual *Instruction sur la culture de la betterave*. **Chast**, „Parmentier”, p. 150, **McMurtrie**, *Report on the Culture*, p. 24 and **Nezdarová**, “Proměny cukrovarnictví”, pp. 13–14.

<sup>230</sup> **Neumann**, *Nástin dějin*, pp. 43–44.

<sup>231</sup> SMITH-PETER, Susan, “Sweet development: The sugar beet industry, agricultural societies and agrarian transformations in the Russian empire 1818–1913”, *Cahiers du Monde russe*, vol. 57, no. 1, 2016, pp. 101–124, p. 106

<sup>232</sup> *Bulletin de la SEIN*, t. 13, Paris, Imprimerie de M<sup>me</sup> Huzard, 1814, p. 15 and **Figuier**, “Industrie du sucre”, p. 143.

<sup>233</sup> **Figuier**, “Industrie du sucre”, p. 104 and **McMurtrie**, *Report on the Culture*, p. 24.

<sup>234</sup> **McMurtrie**, *Report on the Culture*, p. 25.

<sup>235</sup> His treatise *Procédé pour obtenir de la betterave du sucre blanc et cristallisable* in 1807 sparked interest in beets. FOURNIER, Josette, “L’approvisionnement en sucre sous le Blocus continental. I – Louis-Joseph Proust et le sucre de raisin”, *L’Actualité chimique*, vol. 6, no. 204, 1997, pp. 31–37, p. 33.

<sup>236</sup> The article published in the *Bibliothèque des propriétaires ruraux*. **Achard**, *Le sucre européen*, p. v–vi.

<sup>237</sup> **Achard**, *Le sucre européen*, p. x and **Cooke**, *The Sugar Beet Crop*, p. 13.

<sup>238</sup> Achard was in touch with Scherer in Austria and van Mons in France, finding from them advocates of his technology in both countries. **Laloux**, “La bataille”, p. 39.

that the manufacture of beet sugar can become a very important industrial object for Europe”<sup>239</sup> soon rang true. With the help of J. P. Boudet, chief pharmacist at the Army of the Rhine, who had travelled to Koppy’s sugar factory in Krayn in 1809, observed the technique and demonstrated it into a manual<sup>240</sup> he sent to Parmentier,<sup>241</sup> a great wave of interest in beets arose in France to which the government gave unprecedented support.

This advocacy arose in 1810 in a report to Napoleon from yet another commission, of which Parmentier happened coincidentally to be a member, about the production of grape sugar.<sup>242</sup> Negligible grape harvests and the foundation of the experimental school led it to refocus on Achard’s methods, which had earlier been deemed so costly, now with a few modifications. Enhanced processes were soon employed by industrialist Louis Crespel-Delisse (1789–1865), who built the first modern beet sugar factory in Lille to extract the earliest ever industrial beet sugar with the help of steam engines, presses and juice pumps.<sup>243</sup>

Delisse prompted future developments in the second half of 1810. While chemist Pierre Figuier (1759–1817) continued Löwitz’s experiments of charcoal to purify sugar and was the first to apply it to beet juice,<sup>244</sup> Pierre Drapiez extracted five tonnes and Secci 15 tonnes of beet sugar in Lille and Doubs respectively, Mathieu de Dombasle ran a sugar factory near Nancy in 1810 and Duhamel du Monceau, inspired by Achard, wrote a manual on sugar extraction.<sup>245</sup> Derosne used Figuier’s method with Payen and Pluvinet in their sugar factories in Grenelle and Clichy-la-Garenne,<sup>246</sup> harvested one tonne of beets and sent one loaf of beet sugar to Minister Montalivet, with Maximin Isnard (1758–1825) and Jean-Pierre Barruel (1780–1838) obtaining half the amount and being sent two loaves.<sup>247</sup>

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<sup>239</sup> *Le Moniteur universel*, no. 276, 2 October 1808.

<sup>240</sup> The manual contains fourteen clearly explained procedures for obtaining beet sugar crystals. BOUDET, J. P., “Extrait d’un Mémoire de M. Boudet, Pharmacien en chef à l’armée du Rhin, sur une fabrique de sucre de Betteraves, établie en Silésie”, *Bulletin de Pharmacie*, t. 1, no. II, Paris, D. Colas, février 1809, pp. 76–85.

<sup>241</sup> *Le Moniteur universel*, no. 61, 2 March 1811.

<sup>242</sup> Together with Chaptal, Vauquelin and Claude Louis Berthollet (1748–1822). **Chast**, “Parmentier”, p. 156.

<sup>243</sup> **Cooke**, *The Sugar Beet Crop*, p. 18, **Ganière**, “La bataille”, **Laloux**, “La bataille”, p. 44 and PRINSEN-GEERLIGS, H. C., *The World’s Cane Sugar Industry*, Altrincham, Norman Rodger, 1912, p. 16.

<sup>244</sup> The results were read out in the Montpellier *Société des sciences et lettres* in December 1810 and published in the *Bulletin de pharmacie* a year later. **Brançon**, “Le sucre”, p. 242 and **Figuier**, “Industrie du sucre”, pp. 21–23.

<sup>245</sup> *Bulletin de la SEIN*, t. 10, Paris, Imprimerie de M<sup>me</sup> Huzard, 1811, pp. 56–62, **Laloux**, “La bataille”, p. 44, **McMurtrie**, *Report on the Culture*, pp. 17–18, MONCEAU, Duhamel Du and BERTRAND, J.-E. (dir.), *Art de raffiner le sucre*, Paris, Moronval, 1812, **Nomblot**, “1812–1914”, p. 38, SANDFORD, Daniel Keyte, *The Popular Encyclopedia*, vol. II, part II, Glasgow, Blackie & Son, 1841, p. 809 and **Vilmorin**, *L’hérédité*, p. 34.

<sup>246</sup> The manufacturers have achieved “a marvelous success”. **Figuier**, “Industrie du sucre”, pp. 23–24.

<sup>247</sup> Derosne used imported Silesian beet seeds ripened in Franche-Comté. **Achard**, *Le sucre européen*, p. viii–ix and xxii, **Brançon**, “Le sucre”, p. 242, *Bulletin de la SEIN*, t. 10, pp. 62–65, *Bulletin de la SEIN*, t. 11, Paris, Imprimerie de M<sup>me</sup> Huzard, 1812, pp. 6–15, **Chaptal**, *Mes souvenirs*, p. 118, DEYEUX, Nicolas, “Mémoire sur

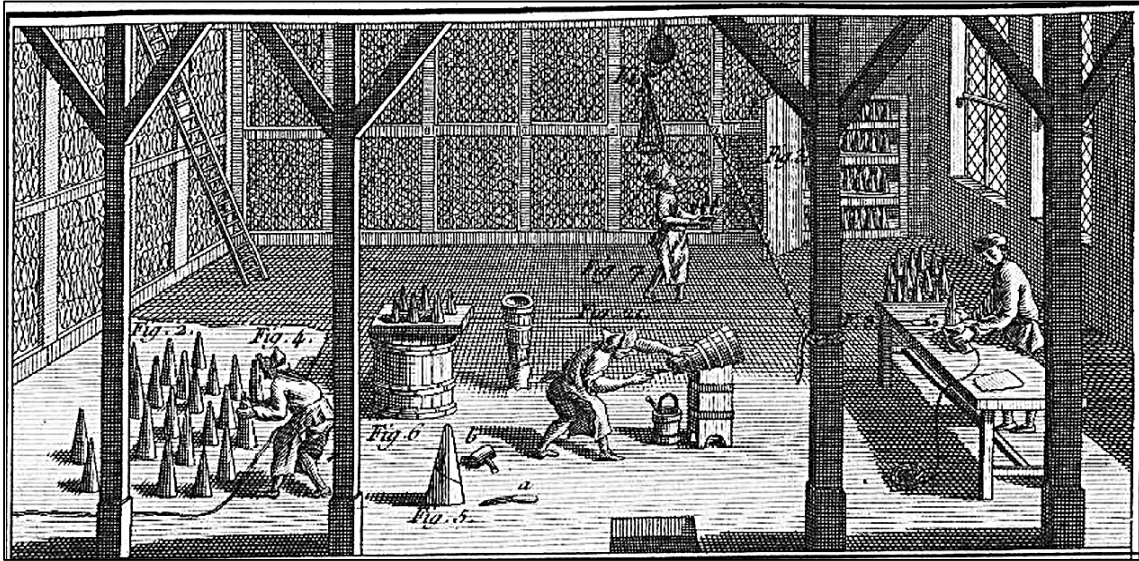


Figure 17: Preparation of sugar loaves in a heated room. **Monceau**, *Art de raffiner*, planche VI.

The number of fruitful experiments in beet technology<sup>248</sup> was growing, as evidenced by de Vaux, Chaptal<sup>249</sup> and the jointly written work by Barruel and Isnard. In cooperation with Deyeux, they presented enhanced and cost-effective methods in their concise manual, stating that “if we contribute to the establishment of numerous sugar factories, we shall consider ourselves lucky to have taken part in it.”<sup>250</sup> Their adaptation met with great acclaim and gained Napoleon’s attention, appointing both men to develop the industry. The decree promulgated on 25 March 1811<sup>251</sup> announced that:

“1. It will be put in our Empire up to 32,000 hectares for cultivation of beets suitable for the manufacture of sugar.

7. The commission will designate the most suitable places for the establishment of six experimental schools, where the manufacture of beet sugar will be taught.

l’extraction du sucre de betterave”, *Annales de chimie*, t. 77, 1811, pp. 42–62, **Figuiet**, “Industrie du sucre”, p. 20, **Laloux**, “La bataille”, p. 44, **Londet**, *Annales de l’agriculture*, p. 372 and **Neumann**, *Nástin dějin*, p. 7.

<sup>248</sup> In 1811, a new machine was perfected for cutting and pulping beet and extracting its juice. **CLOUT**, H. D. and **PHILIPS**, A. D. M., “Sugar-Beet Production in the Nord Département of France during the Nineteenth Century”, *Erdkunde*, vol. 27, no. 2, 1973, pp. 105–119, p. 106.

<sup>249</sup> De Vaux presented the *Procédé pour obtenir de la betterave un sucre blanc et cristallisable* (1807) and Chaptal both *Mémoire sur l’extraction en grand du sucre de betterave et quelques considérations sur la culture de la betterave* (1810) and *Rapport sur la fabrication du sucre de betterave* (1812). **Brançon**, “Le sucre”, pp. 239–240.

<sup>250</sup> **BARRUEL**, Jean-Pierre and **ISNARD**, Maximin, *Mémoire sur l’extraction en grand du sucre des betteraves, et quelques considérations sur leur culture*, Paris, Madame Huzard, 1811, p. 12.

<sup>251</sup> **Brançon**, “Le sucre”, p. 240, **Cooke**, *The Sugar Beet Crop*, p. 16, **Figuiet**, “Industrie du sucre”, p. 19, **Gudoshnikov**, *The World Sugar*, p. 6, **Neumann**, *Nástin dějin*, p. 6, **Perrier-Robert**, *Le grand livre*, p. 24 and **VIGREUX**, Pierre, “Aux origines du savoir agro-alimentaire : la création de l’École Nationale des Industries Agricoles (Douai, 1893)”, *Revue du Nord*, vol. 72, no. 285, 1990, pp. 255–289, p. 258.

10. Barruel and Isnard, who perfected the processes of extracting beet sugar, will be specially charged with the direction of two of the six experimental schools.

11. The Minister will give them, as a gratuity, the sum necessary for the formation of the said establishments, which sum will be taken from the fund of one million [6.4 million €] ... for the encouragement of the manufacture of beet sugar.”<sup>252</sup>

By supporting the emerging sugar industry, France now joined Prussia, Austria, the Kingdom of Italy and even Denmark, where about forty sugar factories were built in 1811.<sup>253</sup> However, the requirements foreshadowed that “we can undertake with confidence to establish beet sugar factories, but it is especially to the large landowners that they will be profitable”.<sup>254</sup> Small businesses could not obtain state financial support for planting many hectares of land, harvesting several hundred tonnes of beet and presenting a satisfactory amount of beet sugar and it became evident that not many manufacturers could comply with the decree. So a certain banker stepped in and took the beet industry a significant step forward.

Already familiar with the sugar industry since 1801, when he set up a sugar factory in Passy, west of Paris, the industrialist Jules Paul Benjamin Delessert (1773–1847)<sup>255</sup> did not start producing beet sugar until 1808. The influence of his fellowship with industrious Chaptal led him to compete for the highest quality beet sugar. Luckily, Delessert now had the new Bonmatin method<sup>256</sup> available to him, a technique that first used lime first and then sulfuric acid to achieve perfect purification of beet juice. Combining both the obsolete Achard and innovative Bonmatin methods in his factories in Nantes, Blois, Montargis and Pas-de-Calais<sup>257</sup> rewarded him with around four thousand tonnes of beet sugar between 1810 and 1812.<sup>258</sup>

Delessert’s motto of “having good grating machines, good presses, good furnaces and clever workmen, it is hard not to succeed”<sup>259</sup> was addressed to his Parisian colleague Jean-Baptiste Quéruel (1779–1845), who produced and refined beet sugar on an industrial scale at the end

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<sup>252</sup> THIBAudeau, Antoine Claire, *Décret impérial au Palais des Tuileries, le 25 Mars 1811*, Paris, L’imprimerie de Mossy, 1811.

<sup>253</sup> **Abbott**, *Le sucre*, p. 191 and **Cooke**, *The Sugar Beet Crop*, p. 18.

<sup>254</sup> *Le Moniteur universel*, no. 61, 2 March 1811.

<sup>255</sup> Artillery officer Delessert helped found the SEIN in 1801. In 1802, he was appointed regent of the Banque de France and two years later became a member of the Chamber of Commerce. **Laloux**, “La bataille”, p. 51.

<sup>256</sup> **Sussy**, Jean-Baptiste Collin de, *Description des moyens et procédés employés à Paris par le sieur Bonmatin pour extraire le sucre de la betterave*, Paris, L’imprimerie impériale, 1812, pp. 9–16.

<sup>257</sup> **Brançon**, “Le sucre”, p. 240.

<sup>258</sup> “Molasses.” *Encyclopedia.com*. Accessed on 16.06.2022. <https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/food-and-cooking/molasses>.

<sup>259</sup> **Brançon**, “Le sucre”, p. 241 and **Chast**, “Parmentier”, p. 160.

of 1811, upon which the factory sent two loaves of sugar to Napoleon.<sup>260</sup> On 2 January 1812, Delessert boasted to Chaptal, who passed the information to the Emperor. The latter left for Passy to observe the sugar factory and found its chief in front of the facility. Satisfied with what he saw, Napoleon praised Delessert's contribution by awarding him the Order of the Legion of Honour, making him a baron and ordering him to build another 12 facilities in France.<sup>261</sup>



Figure 18: Sucre de betterave. *Hussardises*. Accessed on 21.04.2022. <https://les-apn-belgique.webnode.fr/news/sucre-de-bettrave/>.

After Chaptal declared the Bonmatin method “the most simple, the most certain, and the most economical process that I am acquainted with,”<sup>262</sup> the future Minister of Commerce and Manufacture Jean-Baptiste Collin de Sussy (1750–1826) ordered the local prefects to hand over two thousand copies to “entrepreneurs, students in the experimental schools, learned societies, chambers of commerce, consultative chambers of manufacture, to pharmacists and to all those who have tried to manufacture indigenous sugar”.<sup>263</sup> This dissemination of information soon bore fruit, in the department of Bas-Rhin, citizens extracted one kilogram of beet sugar.<sup>264</sup>

De Sussy's step signalled the regime's shift towards beets since there was no other option available under the Continental System. Starting from 1 January 1813, “sugar from the two Indies is prohibited and considered as a goods of English manufacture or coming from the trade

<sup>260</sup> The factory produced 74 kg of beet sugar. **Laloux**, “La bataille”, p. 52 and **Neumann**, *Nástin dějin*, p. 6.

<sup>261</sup> **Abbott**, *Le sucre*, p. 190, **Chaptal**, *Mes souvenirs*, p. 119, **Ganière**, “La bataille”, *Le Moniteur universel*, no. 3, 3 January 1812, **Machková**, “Cukrovarnický průmysl,” p. 356 and **Neumann**, *Nástin dějin*, p. 7.

<sup>262</sup> *The Repertory of Arts, Manufactures, and Agriculture*, 2<sup>nd</sup> series, vol. 24, London, 1814, p. 378.

<sup>263</sup> **Sussy**, *Description des moyens*, p. 8.

<sup>264</sup> *Le Moniteur westphalien*, no. 302, 18 December 1812.



of England.”<sup>265</sup> The state therefore came up with another nationwide measure on 15 January 1812, when Napoleon published his second decree<sup>266</sup> introducing the beet culture to France, creating several facilities for sugar production and training factory staff, motivating students in the developing industry and teaching them how to establish and run a successful sugar factory:

“1. Barruel’s and Isnard’s factory and those in Wachenheim, Douai, Strasbourg and Castelnaudari are established as special chemical schools for the production of beet sugar.

2 & 3. One hundred pharmacy, medicine and chemistry students will be attached to these schools. Each will be given an indemnity of one thousand francs [€4,738].

4. There will be measures to sow one hundred thousand metric arpens [40,000 ha] of beets.

12 & 13. Four Imperial beet sugar factories will be established in 1812 [...] and will be prepared to manufacture two million kilograms of raw sugar.”<sup>267</sup>

Due to the catastrophic harvest, caused by an unusually devastating drought the previous year, former Minister of the Interior Chaptal<sup>268</sup> joined the promotion of beets in 1812. By proposing to create a central facility that would bring together “thirty to forty people skilled in chemistry and forty children of refiners from Orleans, Antwerp, Marseille, Hamburg and Amsterdam,”<sup>269</sup> he wanted to make France a centre of international sugar teaching. The growth of smaller local sugar factories, which at the same time served as experimental schools based on the Prussian model, was stimulated by a significant step – the granting of licenses.

According to Section 5 and 9, “five hundred licenses for the manufacture of beet sugar shall be granted throughout the empire [...] with the obligation to establish a factory capable of manufacturing at least ten thousand kilograms of raw sugar from 1812 to 1813.”<sup>270</sup> The requested amount seemed unattainable, but the state resorted to an economic tool to encourage sugar factory owners to make greater yields. Section 10 proclaimed that “any individual who has manufactured at least ten thousand kilograms of raw sugar shall have the privilege [...] that

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<sup>265</sup> **Thibaudeau**, *Décret impérial*.

<sup>266</sup> **Abbott**, *Le sucre*, p. 190, **Brançon**, “Le sucre”, p. 241, **Dudek**, *Vývoj*, p. 20, **Figuier**, “Industrie du sucre”, p. 25, **Machková**, “Cukrovarnický průmysl,” p. 356, **Neumann**, *Nástin dějin*, p. 7, **Perrier-Robert**, *Le grand livre*, p. 25, **Smith**, *Sugar*, p. 41 and **Vigreux**, “Aux origines”, pp. 258–260.

<sup>267</sup> **Duvergier**, *Collection complète*, t. 18, pp. 106–107.

<sup>268</sup> The area of cultivated land on his Chanteloup estate increased from 20 hectares in 1806 to 50 hectares in 1812, yielding 1,000 tonnes of beets. **Brançon**, “Le sucre”, p. 239 and **Nomblot**, “1812–1914”, p. 36.

<sup>269</sup> **BRANÇON**, Denis and **VIEL**, Claude, “L’approvisionnement en sucre sous le Blocus continental. II – Jean-Antoine Chaptal et le sucre de betterave”, *L’actualité chimique*, vol. 7, no. 205, 1997, pp. 34–38, pp. 35–36, **Brançon**, “Le sucre”, p. 240 and **McMurtrie**, *Report on the Culture*, p. 20.

<sup>270</sup> **Duvergier**, *Collection complète*, t. 18, pp. 106–107.





Figure 19: Factory licence. ROUET, Christian, “Une manufacture de sucre à Rambouillet“. *Le Pays d’Yveline*. Accessed on 26.06.2022. <https://yveline.org/une-manufacture-de-sucre-a-rambouillet/>.

no grant or tax shall be placed on the product of his manufacture during the span of four years.”<sup>271</sup>

Section 14 further stated that “a beet sugar factory will be established in our domain of Rambouillet, capable of manufacturing twenty thousand kilograms of raw sugar.”<sup>272</sup> The three-storey building opened on 30 June 1812 and was producing 244 kilograms of raw sugar from up to 15 t of beets each day. The sugar factory employed twenty people at the end of

1812 and by April 1813 the number had risen to 83.<sup>273</sup> In March 1814, Rambouillet accommodated famished French troops who “threw themselves furiously upon the beet”.<sup>274</sup> They nearly destroyed the factory’s equipment and, together with the subsequent reopening of the cane sugar market, production halted.

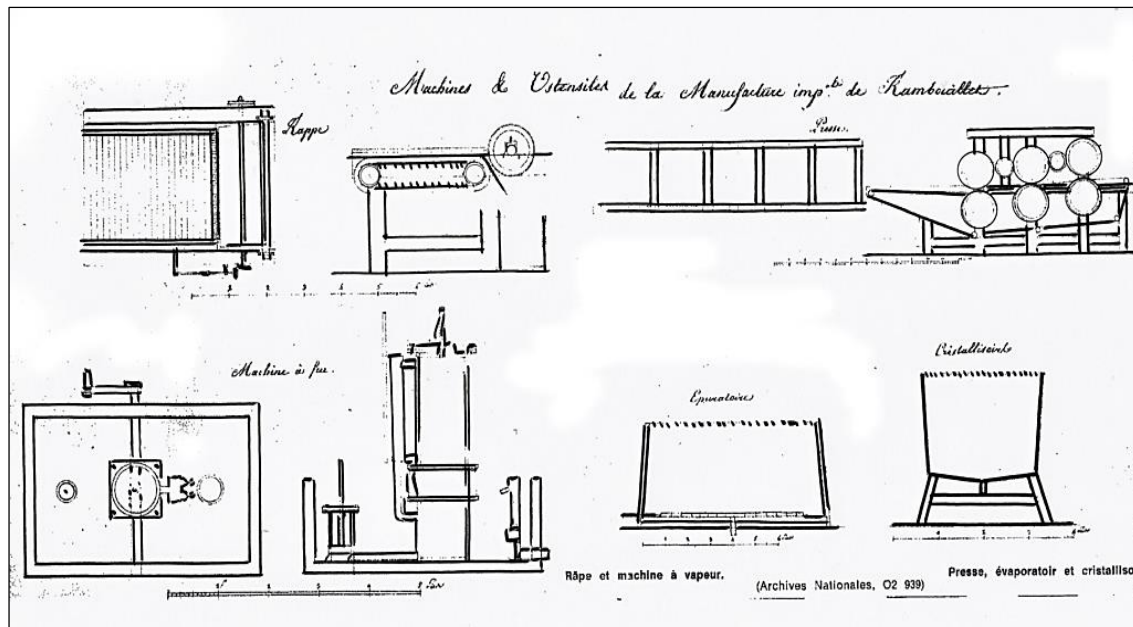


Figure 20: The Rambouillet sugar factory. Rouet, “Une manufacture”.

<sup>271</sup> Ibid, pp. 106–107.

<sup>272</sup> Ibid, p. 107.

<sup>273</sup> In terms of equipment, boilers, grinding mills and warehouse were located on the ground floor, while the ovens, conical forms and staff quarters were found upstairs. They were operated by 35 men, 42 women and half a dozen children. Rouet, “Une manufacture”.

<sup>274</sup> SPARY, E. C.; *Feeding France. New Sciences of Food, 1760–1815*, Cambridge, Cambridge University Press, 2014, p. 312.

State aid was reflected in the Nord department, whose advantage was that beets had been grown in neighbouring Flanders since 1784. New enthusiasm came in 1810 from “largely urban-based merchants, industrialists and staff of the prefecture”<sup>275</sup> that helped to spread the seeds and the processes. Already in 1811, the most sown areas of the Empire were located around factories in Lille, Valenciennes, Aubry and Douai, strongly encouraged by the Douai agricultural society and sub-prefect Mascher. Even though successful beet production was impossible in the early years,<sup>276</sup> the Nord would turn into the most prosperous department in the whole Empire.<sup>277</sup>

ARRONDISSEMENT OF THE <i>NORD</i>	AREA IN HECTARES PLANTED WITH BEET		
	1811	1812	1813
<b>Lille</b>	160.29	787 (↑ 391%)	947 (↑ 20%)
<b>Douai + Valenciennes</b>	210.74	800 (↑ 280%)	1,011 (↑ 26%)
<b>the whole department</b>	377.24	1,808 (↑ 379%)	2,220 (↑ 23%)

Table 7: The condition of beet sugar production in Nord department (1811–1813) (by author).

However, the Napoleonic regime’s initial enthusiasm for the new crop vanished, and not just because of the current war and conscription of a large number of men from farmsteads.<sup>278</sup> There was reluctance among some farmers to “abandon traditional forms of cultivation for new and untried crops, sow improper soils and utilise poor-quality seeds”.<sup>279</sup> Of all the government’s plans, only 21% of the proposed area was planted, only 334 concessions were granted and from them a mere 158 actually operated, and only 31% of beet sugar was produced.<sup>280</sup> To sum up all the shortcomings leading to the failure of the industry, there was an

“inefficient and ill-prepared central government initiative, insufficient seeds or no seeds at all, late proclamation of the decree, little encouragement, lacking transport facilities or sugar factories resulting in decayed beets, defective machines and unskilled workers”.<sup>281</sup>

<sup>275</sup> Clout, “Sugar-Beet Production”, p. 106.

<sup>276</sup> It required “the purchase of good quality seeds and the abundant use of manures, together with intensive ploughing, weeding and thinning out”. Ibid, p. 107.

<sup>277</sup> Table 7: Ibid, p. 107.

<sup>278</sup> Laloux, „La bataille“, p. 53.

<sup>279</sup> Instead of Silesian beets, they had been given poor-quality seeds from Utrecht, which dampened their willingness to cultivate beet. Clout, „Sugar-Beet Production“, p. 108.

<sup>280</sup> Clout, „Sugar-Beet Production“, pp. 107–108, Cooke, *The Sugar Beet Crop*, pp. 16–17, Heckscher, *The Continental System*, p. 293, Laloux, „La bataille“, p. 53 and Prinsen-Geerligs, *The World’s Cane*, p. 17.

<sup>281</sup> Clout, „Sugar-Beet Production“, pp. 107–108, Laloux, “La bataille”, pp. 47–50 and Nombrot, “1812–1914”, p. 33.

Either way, France had developed a very favourable environment for the beet industry and, even though the sugar factories would disappear after a few years of operation,<sup>282</sup> they left fertile ground for a new boom.

YEAR	1811	1812		1813		1814		1815	
<b>FACTORIES</b>	40	192	↑ 380%	300+	↑ 56%	213	↓ 29 %	200	↓ 6%
<b>SUGAR IN t</b>	271	1,615	↑ 496%	2,850	↑ 76.5%	4,000	↑ 40%	2,500	↓ 37%

Table 8: The beet sugar industry in France (1811–1815) (by author).

### Rise and fall of the Bohemian beet sugar factories

“We often look to meet our needs with precious crops and products from abroad which could be grown in our homeland with considerable benefit and in surplus.”<sup>283</sup>

In the first two decades of the 19<sup>th</sup> century, sugar production in Bohemia was protected from cane sugar competition by the Continental Blockade. The impulse came from abroad when Bohemian manufacturers started to put Achard’s *Instruction* from 1808 into practice. But the founding fever<sup>284</sup> would peak between 1810 and 1812 with the establishment of a total of 15 large-scale beet sugar factories<sup>285</sup> of which six were founded on the initiative of nobles or their officials and nine were set up by burghers and merchants.<sup>286</sup>

The equipment in the sugar factories was rather primitive. With few exceptions comprised of a washing machine, grinder and presses driven by waterpower or gins and graters pulled by a pair of oxen, workers relied only on their own strength and power. The strenuous preparation of the beets required a division of labour with each worker operating a simple manual tool like

<sup>282</sup> Table 8: ARRINGTON, Leonard J., “Science, Government, and Enterprise in Economic Development: The Western Beet Sugar Industry”, *Agricultural History*, vol. 41, no. 1, 1967, pp. 1–18, p. 2, **Abbott**, *Le sucre*, pp. 190–191, **Brançon**, “Le sucre”, p. 243, **Contour**, “Le Val-d’Oise”, p. 273, **Ganière**, “La bataille”, **Gudoshnikov**, *The World Sugar*, p. 6, Heckscher, *The Continental System*, p. 293, History of sugarbeets. *CropWatch*. Accessed on 15.05.2022. <https://cropwatch.unl.edu/history-sugarbeets>, **Laloux**, “La bataille”, p. 49, 53 and 56, *Le Moniteur universel*, no. 8, 8 January 1812, **McMurtrie**, *Report on the Culture*, p. 20 and 22, “Molasses”, **Prinsen-Geerligs**, *The World’s Cane*, p. 16 and **Snodgrass**, *World food*, p. 187

<sup>283</sup> **Neumann**, *Nástin dějin*, p. 36.

<sup>284</sup> **Dudek**, *Vývoj*, p. 21, **Jadlovský**, “Vývoj cukrovarů”, p. 32, **Nezdarová**, “Proměny cukrovarnictví”, p. 14, **Novák**, “Pohled do vývoje”, p. 6 and **Pokorná**, “Cukrovarnictví”, pp. 14–15.

<sup>285</sup> **Drábek**, “K vývoji”, p. 1, **Dudek**, *Vývoj*, pp. 19–20, **HŮLOVÁ**, Vanda, “Vliv pěstování cukrové řepy a výroby cukru na krajinu mikroregionu Hrušovanska”, Master thesis, Masarykova univerzita, Pedagogická fakulta, 2013, p. 20, **Národní technické muzeum**, *Cukrovarnictví*, p. 24, **Neumann**, *Nástin dějin*, p. 13, **Nezdarová**, “Proměny cukrovarnictví”, p. 14 and **Novák**, “Pohled do vývoje”, p. 6.

<sup>286</sup> **Dudek**, *Vývoj*, pp. 25–27.

graters, presses, cutters, evaporators, pans, and in 1820s even hydraulic presses. While the mechanical work was based on empiricism and estimation, technological knowledge covered chemical purification. These facilities could hardly be called factories, but more “manufactory-type plants with factory production elements”.<sup>287</sup>

One of the first such facilities was founded by Ludvík Fischer at Count Pötting’s estate in Žáký (then called Schak), near Prague, and in 1810 it was producing beet sugar, spirits and coffee substitutes.<sup>288</sup> The technique adopted by Fischer – externally grown seedlings later transplanted into the field – lasted until the 1850s and inspired the PES to “encourage interest in the production of sugar from local sources”.<sup>289</sup> To farm 7.6 hectares of beets, he followed Achard

“[when] the women washed the beets with brooms in wooden washtubs or hand-roller washers made of willow wicker. A hand-powered metal disc grater was used to grind the beet into a pulp, which was packed into tarpaulins and pressed in hand presses. The pressed juice was cleaned with sulphuric acid and de-acidified with chalk and lime, clarified with milk and filtered through a cloth. The concentrated syrup was clarified by sedimentation and either crystallised in clay bowls (6–8 weeks) or in conical loaves (15 days).”<sup>290</sup>



Figure 21: The insight of the factory in Kanálka. **Froněk**, “200 let”, p. 359.

<sup>287</sup> Depending on the size of the sugar factory, the number of workers ranged from 20 to 40, mostly using disc graters, presses, clarifying, evaporating and thickening cauldrons, pans and a steam engine inspired by Achard. **Dudek**, *Vývoj*, pp. 23–24 and 27, **Froněk**, „200 let“, p. 359 and **SMRČEK**, Otto, “Výroba strojů a technologického zařízení pro cukrovary v českých zemích v době průmyslové revoluce”, *Listy cukrovarnické a řepařské*, vol. 126, no. 9–10, 2010, pp. 296–299, p. 296.

<sup>288</sup> **Boušková**, “Změny v pěstování”, p. 11, **Drábek**, “K vývoji”, p. 1, **Dudek**, *Vývoj*, p. 20, **Fexová**, “Nymburský cukrovar”, p. 17, **Froněk**, “200 let”, p. 358, **Jadlovský**, “Vývoj cukrovarů”, p. 34, **Maděra**, “Výroba cukru”, p. 18, **Neumann**, *Nástin dějin*, pp. 11–12 and 15–16 and **Ríha**, *Počátky*, p. 56.

<sup>289</sup> **Fexová**, “Nymburský cukrovar”, p. 17.

<sup>290</sup> **Dudek**, *Vývoj*, p. 20 and **Neumann**, *Nástin dějin*, pp. 28–32.

Bowl crystallisation provided 6% of beet sugar, while the loaves granted 5% of extracted beet sugar. The sugar factory's operations soon attracted the interest of the imperial government in Vienna and also the Bohemian PES, which sent an expert commission to Žáky which determined production to have been only profitable due to high sugar prices, and yet the net profit in 1810 was almost 94% of the total profit for syrup, spirits and coffee. In the end, the gold medal awarded to Fischer was intended to encourage others to develop similar industrial undertakings, provided "he would initiate everyone into the processing of beet sugar".<sup>291</sup>

The decree of 12 March 1811 ordered the commission that had visited Žáky to issue a "brief, comprehensible manual suitable for the general instruction of the audience".<sup>292</sup> Copies were to be distributed to all officials on the farms and another 1,000 copies to Vienna and other hereditary landholdings. The intention was to encourage these officials to use the treatise and order them to report annually on sugar production and successes. The content of the decree was then published in official newspapers in Prague, Vienna, and other magazines.<sup>293</sup> It also ordered numerous attempts to obtain sugar, to contribute to the development of technology and to produce an annual report on beet sugar production.<sup>294</sup>



Figure 22: Jakub Veith.  
MAREK, Blahoslav,  
"Čtvrt tisíciletí od  
narození Jakuba Veitha",  
*Listy cukrovarnické  
a řepářské*, vol. 124,  
no. 7–8, 2008, p. 240.

Jakub Veith, a cloth merchant, described the sugar industry in great detail from study trips undertaken abroad and he was even in contact with Achard. In 1810, Veith obtained permission to establish a sugar factory at his own Liboch (now Liběchov) estate, north of Prague, where he used steam-heated cauldrons and water-wheel driven cutting machines. The first beet sugar, spirits and vinegar were extracted in 1811, the same year when his sugar factory in Semil (now Semily) was set up. The latter produced only syrup, which was turned into sugar in Liboch, but the Semil factory was shut in 1812.<sup>295</sup> Veith's estate factory remained open until 1821 and between 1816 and 1821 it was the only beet sugar producer in Bohemia.<sup>296</sup>

In 1812, a sugar factory was established in Schleb (now Žleby) on the estate of Prince Auersperg. Although the production of maple sugar here accounted for half of total production

<sup>291</sup> Dudek, *Vývoj*, pp. 20–21 and Neumann, *Nástin dějin*, p. 19.

<sup>292</sup> Neumann, *Nástin dějin*, p. 20.

<sup>293</sup> Ibid, p. 20.

<sup>294</sup> Ibid, pp. 20–21.

<sup>295</sup> Drábek, "K vývoji", p. 1, Dudek, *Vývoj*, p. 21, Maděra, "Výroba cukru", p. 18, Marek, "Čtvrt tisíciletí", p. 240, Nezdarová, "Proměny cukrovarnictví", p. 14, Novák, "Pohled do vývoje", p. 6 and Říha, *Počátky*, p. 63.

<sup>296</sup> Froněk, "200 let", p. 358, Maděra, "Výroba cukru", p. 19 and Marek, "Čtvrt tisíciletí", p. 240.

in Bohemia, beet growing was not so successful: 94 t of beet grown and another 31 t of crops purchased from the sugar factory in Tschaslau (today Čáslav), but the resulting 1.4 t of raw sugar shows that not everywhere were either the technology or the tools used properly.<sup>297</sup>

Joseph Emanuel Malabaila de Canal (1745–1826)<sup>298</sup> founded one of the oldest botanical gardens in Bohemia in 1791, named Kanálka after him. Its purpose was to “*enhance agriculture and arboriculture through lectures and practical demonstrations*”.<sup>299</sup> In order to accelerate the development of sugar beet technology in Bohemia, Canal, as PES president, sent a study group to Achard’s experimental sugar factory in the autumn of 1811 to get acquainted with beet growing and the operation of a sugar factory.<sup>300</sup>

The group was led by Canal’s colleague, Professor Franz Wilibald Schmidt (1764–1796),<sup>301</sup> who had since 1812 been in charge of sugar production courses and of the newly established university laboratory at the Klementinum in the centre of Prague.<sup>302</sup> In the same year, Canal took advantage of innovative knowledge to establish a sugar factory in his garden “equipped with a steam boiler whose steam flew around two copper pans and accelerated the clarification and thickening of beet juice with uniform and adjustable heating”.<sup>303</sup> Both Schmidt and Canal ended their endeavours in 1814, Schmidt having taught only three students, the university laboratory closed and the garden deteriorating after Canal’s death.<sup>304</sup> Nonetheless, the division of labour was exemplary:

“One woman removed the roots, the other brought the beets to a room where a third washed them with a broom in a vat. The crop was then grated on a wooden disc with a grating plate, the cuttings wrapped in a tarpaulin and inserted into a vice, which squeezed beet juice out of them. The juice was clarified with acid and placed in a steam-heated pan the next day, where it was cleaned and evaporated. After pouring into conical containers or clay bowls, either syrup or crystalline sugar was made.”<sup>305</sup>

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<sup>297</sup> Such cooperation between two sugar factories was not unusual and demonstrates the interest entrepreneurs had in the new industry. **Dudek**, *Vývoj*, p. 23 and 185.

<sup>298</sup> Philanthropist Count Canal founded one of the oldest Czech botanical gardens in 1791, endorsed teaching at the nearby Botanical Institute and supported botanical works. “Malabaila de Canal, Joseph Emanuel” *BOTANY.cz*. Accessed on 24.05.2022. <https://botany.cz/cs/malabaila/>.

<sup>299</sup> *Ibid.*

<sup>300</sup> **Neumann**, *Nástin dějin*, pp. 44–45 and **Nezdarová**, “Proměny cukrovarnictví”, p. 15.

<sup>301</sup> “Schmidt, Franz Willibald.” *BOTANY.cz*. Accessed on 16.06.2022. <https://botany.cz/cs/schmidt/>.

<sup>302</sup> **Dudek**, *Vývoj*, pp. 23–24, **Neumann**, *Nástin dějin*, p. 47 and 56–57 and **Novák**, “Pohled do vývoje”, p. 22.

<sup>303</sup> **Dudek**, *Vývoj*, p. 22 and **Nezdarová**, “Proměny cukrovarnictví”, p. 15.

<sup>304</sup> At the end of the century, the garden was completely subdivided and built up. **Boušková**, “Změny v pěstování”, pp. 11–12, **Dudek**, *Vývoj*, pp. 22–24, “Malabaila de Canal, Joseph Emanuel”, **Neumann**, *Nástin dějin*, p. 62, **Nezdarová**, “Proměny cukrovarnictví”, p. 15, **Novák**, “Pohled do vývoje”, p. 22 and **Říha**, *Počátky*, p. 73.

<sup>305</sup> **Dudek**, *Vývoj*, pp. 22–23.



To process each day a half tonne of beet, Canal's workers used either Achard-inspired equipment or own-made tools. Four graters cut the washed beets, while a vice with planks squeezed the juice, and a modern steam machine boiled it, a process known since Achard times. One reason the technology spread may have been Achard becoming a corresponding member of the PES presided by Canal.<sup>306</sup>

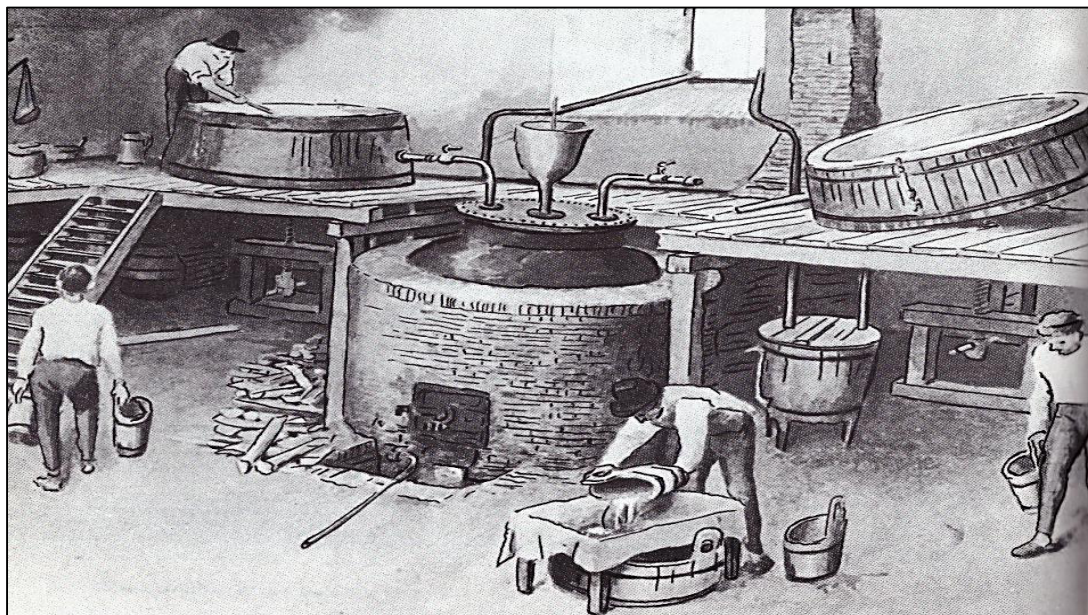


Figure 23: Canal's steam machine resembled Achard's machine. **Dudek**, *Vývoj*, p. 193-8.

In addition to the new facilities, Antonín Richter reopened the former Zbraslav cane refinery in 1812. Even though he had been granted a permit to refine beet sugar, his business failed soon after the fall of Napoleon.<sup>307</sup> Zbraslav was one of the last sugar beet factories established as none would be set up after 1813 and the existing facilities were disappearing.<sup>308</sup> The reason for the decline lay, besides sugar factories being part of larger prosperous economic units, in most of them falling into the category of separate, small and primitive syrup establishments. While being part of an estate saved the bigger factories, the smaller businesses would fade even after the slightest fall in demand for its low-quality and expensive sugar.<sup>309</sup>

The existential problems the beet industry faced after 1814 in Bohemia were similar to what was being experienced in France: poor ploughing, insufficient soil fertilisation, primitive technique and processing technology,<sup>310</sup> the reluctance of most entrepreneurs to fund larger

<sup>306</sup> **Neumann**, *Nástin dějin*, p. 40–43 and **Řiha**, *Počátky*, p. 67.

<sup>307</sup> **Neumann**, *Nástin dějin*, p. 9 and **Nyplová**, “Kapitalistické začátky“, p. 168.

<sup>308</sup> **Dudek**, *Vývoj*, p. 24 **Neumann**, *Nástin dějin*, p. 55.

<sup>309</sup> **Dudek**, *Vývoj*, p. 25.

<sup>310</sup> In 1812, the most productive Czech sugar factories produced 13.6 t and in 1813 a mere 12.5 t of beet sugar. **Neumann**, *Nástin dějin*, p. 39, 51 and 57.

capital investments, cane sugar returning to the market, and, last of all, the state considering beets *unpatriotic*, thereby putting little effort into supporting the cultivation of a crop whose popularity was rather tepid.<sup>311</sup>

The number of new Bohemian beet sugar factories<sup>312</sup> was pitifully smaller than in France, and from 1813 it was trending downward. Falling price for overseas sugar discouraged the establishment of new sugar factories, some of the existing ones were closed and those still turning a significant profit reduced their production. As a result, not a single of the original sugar factories survived, and once cane reached the newly established German Confederation, there would be no beet processing for several years until driven by new impetus at the end of the 1820s.

SUGAR BEET CAMPAIGN	SUGAR FACTORIES			PROCESSED BEETS	SYRUP	RAW SUGAR
	NEW	FAIL	TOTAL			
1810/1811	2	–	2	1,298 t	–	–
1811/1812	7	–	9	2,000 t	126 t	4 t
1812/1813	6	1	14	1,650 t	54 t	14 t
1813/1814	–	7	8	1,500 t	31 t	14.4 t
1814/1815	–	3	4	320	12.5	0.6
1815/1816	–	–	4	283.5	23.6	–
1816/1817	–	3	1	200	19	–

Table 9: The number of sugar factories in Bohemia and produced beet sugar (1810–1817) (by author).

When Napoleon closed Continental ports to imported cane sugar, halting its supply, it sparked new experiments with other, untried crops with maple and grapes coming to the fore. While maple sap was tapped mainly in Bohemia and Moravia, over time the amount of sugar that could be derived from the sap and even the sap itself began falling, as did the number of old, locally available trees. Even as supporters of sugar beet cultivation appeared, the Austrian

<sup>311</sup> **Dudek**, *Vývoj*, pp. 23–24 and 26, **Hůlová**, “Vliv pěstování”, p. 20, **Jadlovský**, “Vývoj cukrovarů”, p. 36 and **Maděra**, “Výroba cukru”, p. 18, **Neumann**, *Nástin dějin*, p. 43 and 59–60 and **Novák**, “Pohled do vývoje”, p. 22.

<sup>312</sup> Table 9: **Dudek**, *Vývoj průmyslu*, p. 162.



government nonetheless decided to extract sugar from sap for a purely ideological reason – Bonaparte’s own vehement promotion of beets made them an unpatriotic symbol of the defeated Austrian Empire, therefore consigning sugar beet production to abandonment for some time.

On the other hand, the second French commission recognised Achard’s methods and began spreading them itself, following up with an enormous number of trials that were published in newspapers, professional journals and in the authors’ own manuals. The production of a larger amount of beet sugar then led to an increase in its price.<sup>313</sup> These efforts were further strengthened when the first decree of March 1811 promised a high financial reward. By applying the Bonmatin method, Benjamin Delessert successfully obtained a refined beet sugar, two loaves of which were sent to Napoleon in January 1812. Such an act incited the Emperor to issue another decree that, following the example of Achard, set up experimental schools and granted licenses for the establishment of sugar factories.

1799		1800		1810		1813		1814		1815	
0.60 fr.	€3.30	1.8 fr.	€9	7.40 fr.	€40	12 fr.	€58	20 fr.	€97	1.40 fr.	€7.80

Table 10: Changes in beet sugar prices (1799–1815) (by author).

As news of French successes spread throughout Europe, several facilities would be established in both Russia and Bohemia. Because of the language skills of the nobles and the officials that managed the estates, and the proximity of them to Prussia and Silesia, both processing and the organisation of the factories were similar to their counterparts there. One of the first sugar factories was built in Žáký, near Prague, as early as 1810, followed by fourteen more and a university laboratory, too. However, both French and Bohemian sugar factories struggled with the lack of beets that would have made running the factories profitable, the proper tools, carts to transport the beets and skilled workers. The collapse of Napoleon’s French Empire, which had artificially supported the industry, also led to the demise of most beet sugar factories which were once again replaced by cane refineries.

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<sup>313</sup> Table 10: **Achard**, *Instruction sur la culture*, pp. 82–83, **Achard**, *Le sucre européen*, p. 160, **Barruel**, *Mémoire*, pp. 7–8 and 10, **Contour**, “Le Val-d’Oise”, p. 273, **Delamétherie**, *Journal de physique*, t. 51, p. 386, **Figuier**, “Industrie du sucre”, p. 24 and 26, **Ganière**, “La bataille” and **Institut de France**, *Procès-verbaux*, t. II, p. 310.

## 5. Resurgence of the sugar beet industry

“The beet sugar industry had developed sufficiently, so it was not hazardously unknown or insufficiently examined.”<sup>314</sup>

Little hope was given to a revival of the beet sugar industry, over which the French and Austrian governments had had a protectionist policy, in the years immediately following the Congress of Vienna. Yet, the art was not forgotten, and, even with the supply of cane sugar restored, new beet sugar factories would later begin to flourish, using previously published manuals and treatises to obtain an abundant harvest of beets and amounts of sugar. This intermezzo when cane sugar dominated set the stage for a new wave of beet sugar factories, which appeared in full strength during the 1830s and slowly displaced cane refineries.

State economies entered the 1820s and 1830s with machines and techniques from the Napoleonic era about to undergo major enhancements.<sup>315</sup> Some of the initial tools resembled Achard’s equipment, and various testing demonstrated that screw presses held a much greater advantage over levers, which were considered expensive and inconvenient; jacks, which required frequent repairs; and hydraulic presses, which did not allow acceleration of the lever.<sup>316</sup> Many old accessories were still in use and appeared in numerous French writings.

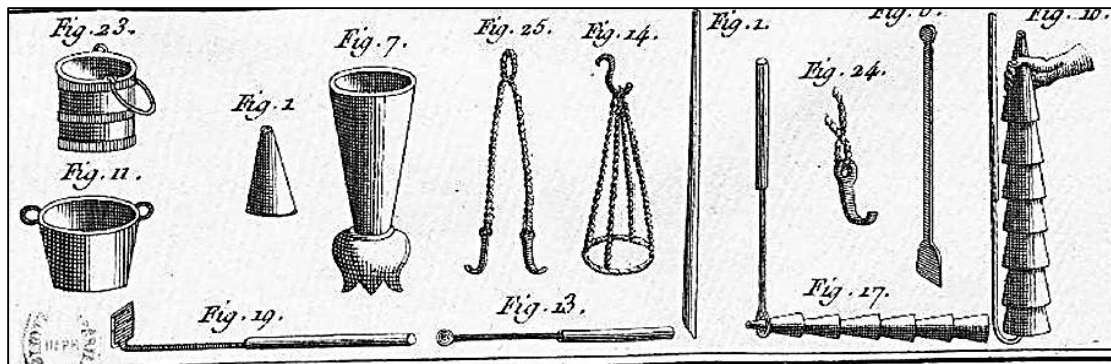


Figure 24: Juice buckets, lump containers, hanging moulds for syrup moulds and wooden spatulas for mixing, **Monceau**, *Art de raffiner*, planche IV.

In Bohemia, manufacturers encountered slow development of these methods, whose biggest shortcoming was the lack of necessary knowledge about the industry and use of machines, with which their workers had to grapple. The estate owners used machines with simple operation

<sup>314</sup> MÁLEK, Vlastimil, “České cukrovary v 50. letech 19. století”, *Listy cukrovarnické a řepářské*, vol. 126, no. 9–10, 2010, pp. 280–283, p. 280.

<sup>315</sup> Sugar mills were brought from abroad and enhanced on the Continent so “our forge masters could supply our colonies with them” and make profits. *Bulletin de la SEIN*, t. 17, Paris, Imprimerie de M<sup>me</sup> Huzard, 1818, p. 68.

<sup>316</sup> *Bulletin de la SEIN*, t. 12, Paris, Imprimerie de M<sup>me</sup> Huzard, 1813, pp. 197–208.

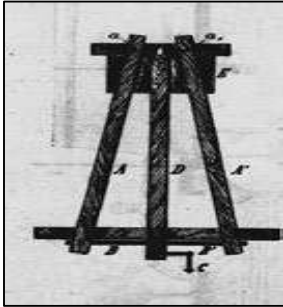


Figure 26: A press with boards. Neumann, *Nástin dějin*, pp. 40–41.

from France. For example, a grater (right), was turned by a handle around a horizontal axis, into whose box beets were placed and pressed against the grater. The mash fell into the tank under the grater, was carried in bags to the press for pressing, and there four

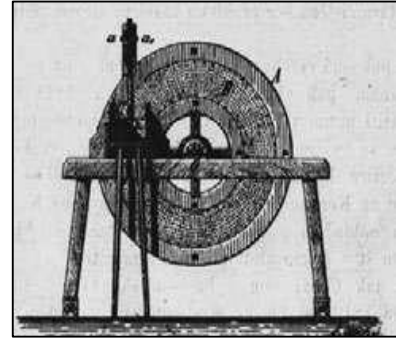


Figure 25: A hand-powered grater. Neumann, *Nástin dějin*, pp. 40–41.

workers would place it between the boards (left). The pressure of the cutting boards would squeeze the mash out of the bags and the extracted juice, drained into the lower tank, could be further processed.<sup>317</sup>

Although Europe had faced waves of armies that consumed the produced sugar and destroyed entire sugar factories,<sup>318</sup> in some countries they were flourishing once again. In the east, beets continued to be widely grown after 1814 because the assorted levies on sugar were a major source of Russia's income. In 1822, the government imposed a high tariff on raw cane sugar amounting to 15% of its value. Moreover, it forbade the import of refined cane sugar for beet protectionist reasons and, as a consequence, there were twenty beet sugar factories in 1832.<sup>319</sup> In Silesia, knowledge gathered from Belgium, the Bas-Rhin department and Prussia served William de Koppý well in his own endeavours.<sup>320</sup>

France and the German Confederation were entering a new era with dissimilar approaches to how to establish factories. Whereas only a small amount of capital was needed to erect a new sugar factory in Central Europe, France promoted the establishment of modernising enterprises of greater importance which would include steam engines.<sup>321</sup> The procedures also differed: where the French clarified the juice with lime and later neutralised it with sulfuric acid, sulfuric acid was used before lime in the Confederation, and the Bohemians combined both methods.<sup>322</sup>

In France, however, more beet sugar factories and refineries survived because of favourable tariff policies that encouraged domestic sugar production. In addition, the government paid significant premiums for the export of refined sugar, enabling it to be profitable. To summarise,

<sup>317</sup> Neumann, *Nástin dějin*, pp. 40–41.

<sup>318</sup> Clout, "Sugar-Beet Production", p. 108 and Neumann, *Nástin dějin*, p. 60.

<sup>319</sup> The number of factories slowly increased from 4 (1810), 10 (1812) and 8 (1825) to 20 (1832). Gudoshnikov, *The World Sugar*, pp. 6–7 and Smith-Peter, "Sweet development", pp. 105–107.

<sup>320</sup> *Bulletin de la SEIN*, t. 18, Paris, Imprimerie de M<sup>me</sup> Huzard, 1819, pp. 228–237.

<sup>321</sup> Faltusová, "Cukrovarnický průmysl", p. 31 and Jádlovský, "Vývoj cukrovarů", pp. 36–37.

<sup>322</sup> Dudek, *Vývoj*, pp. 35–38 and Neumann, *Nástin dějin*, p. 6.

the French sugar industry was “run much more rationally by intelligent men with scientific and technical insight, with more perfect instruments, methods and larger fixed capital”.<sup>323</sup> Although “basic discoveries were made in Germany, the practical development of the beet industry on the European continent took place in France”.<sup>324</sup>

### France, the second cradle of the beet industry

In 1815, Napoleon’s abdication and exile, the opening of continental ports and intervention by the British returned cane sugar to mainland Europe<sup>325</sup> at a reduced price of 1.60 francs (€8.90) per kilogram from the previous 3–4 francs (€33.4–44.5).<sup>326</sup> However, the position of cane on the European market became shaky when tariffs were charged on the thousands of tonnes of cane sugar flowing from Martinique, Guadeloupe and Réunion. The levy imposed on these imports was 60 francs (€291) for every 100 kilograms of foreign sugar and 40 francs (€194) per 100 kilograms on colonial sugar<sup>327</sup> to France. There was now “little option but to develop beet sugar for domestic consumption”<sup>328</sup> even though it had lost 75% of its value.

Because beet sugar production had dropped drastically between 1817 and 1819 to almost zero, it ceased to be competitive and was all but abandoned.<sup>329</sup> But the law of 18 July 1822, increasing import tariffs on foreign sugar, encouraged the relaunch of production in France.<sup>330</sup> Also contributing to the return of sugar beet production was a favourable customs policy, state financial support, cooperation from producers, better technological procedures (lime purifying, spodium<sup>331</sup> filtration) and technical improvements (mechanical cutters, hydraulic presses and

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<sup>323</sup> **Diviš**, *Příspěvky*, p. 1.

<sup>324</sup> **Cooke**, *The Sugar Beet Crop*, p. 18.

<sup>325</sup> **Abbott**, *Le sucre*, p. 191, **Clout**, “Sugar-Beet Production”, pp. 108–109, **Cooke**, *The Sugar Beet Crop*, p. 18, **Gudoshnikov**, *The World Sugar*, p. 6, **Macinnis**, *Bittersweet*, p. 135, **Neumann**, *Nástin dějin*, p. 59, **Nezdarová**, “Proměny cukrovarnictví”, p. 15 and **Smith**, *Sugar*, p. 41.

<sup>326</sup> **Clout**, “Sugar-Beet Production”, p. 109.

<sup>327</sup> **Abbott**, *Le sucre*, p. 191, **Clout**, “Sugar-Beet Production”, p. 108, **Contour**, “Le Val-d’Oise”, p. 273, **HITIER**, **Henri**, *Plantes industrielles*, Paris, B. Baillièrre et fils, 1905, p. 12, **McMurtrie**, *Report on the Culture*, p. 27 and **Prinsen-Geerligs**, *The World’s Cane*, p. 17.

<sup>328</sup> Beet sugar remained completely free of all taxes. **Macinnis**, *Bittersweet*, pp. 135–136.

<sup>329</sup> The beet was even proclaimed a Napoleonic symbol by the royalists that needed to be eliminated. **Nomblot**, “1812–1914”, p. 40 and 42 and **Rouet**, “Une manufacture”.

<sup>330</sup> L’histoire du dimanche – Le sucre de betterave, une production imposée par Napoléon lors du blocus continental de 1806. *France 3 Régions*. Accessed on 28.06.2022. <https://france3-regions.francetvinfo.fr/hauts-de-france/l-histoire-du-dimanche-le-sucre-de-betterave-une-production-imposee-par-napoleon-lors-du-blocus-continental-de-1806-2074036.html>.

<sup>331</sup> Spodium, charcoal from bones, is a product obtained by annealing bones without giving them access to air. In the sugar industry, it is used to decalcify and decolorise the juice. “Spodium.” *Leporelo.info*. Accessed on 03.07.2022. <https://leporelo.info/spodium>.

steam).<sup>332</sup> As cane sugar production fell,<sup>333</sup> along with fluctuating taxes and duties and numerous prolific technical progress<sup>334</sup> that sped up production of beet sugar, making the 1820s “the renaissance of sugar beet”.<sup>335</sup>

	1816	1818	1820	1822
<b>PRODUCTION OF CANE</b>	17,000 t	30,000 t	41,000 t	52,000 t
<b>PRICE OF CANE</b>	€8.90	€4.50	€4.90	€4.20

Table 11: Production and prices of cane sugar per one kilogram (1816–1822) (by author).

The prerequisite for this renaissance was factories which that had continued to thrive at several locations despite all political circumstances. The survival of the French sugar industry was ensured by Louis Crespel-Delisse, whose sugar factory in Arras had been operating since 1814 and served as an example for others, namely Oudard’s in Ville-Roter, Dombasle’s in Nancy, André’s in Pont-à-Mousson, Chaptal’s in Chanteloup, and Bernard’s in Sussy.<sup>336</sup> Crespel-Delisse’s factories in Arras and Lille, both reopened in 1817, also symbolised real training schools where delegations from France and foreign countries learned new technologies, later adopting and even enhancing some of them. Consequently, the number of factories reached 103 in 1828<sup>337</sup> and continued to grow through the activities of prominent men.

There were several elaborate experiments,<sup>338</sup> in which Chaptal played a leading role,<sup>339</sup> following the withdrawal of the Allied armies (Britain, Austria, Prussia and Russia) in 1818. Among many other devices, his Chanteloup factory<sup>340</sup> was furnished between 1816 and 1823 with a gin, grater, presses, boilers, moulds and stoves,<sup>341</sup> suggesting other manufacturers were using the same tools. Chaptal presented his experience in a treatise<sup>342</sup> mentioning all the

<sup>332</sup> Dudek, *Počátky*, p. 7.

<sup>333</sup> Table 11: Clout, “Sugar-Beet Production”, p. 109 and Nomblot, “1812–1914”, p. 41.

<sup>334</sup> Fexová, „Nymburský cukrovar“, p. 18 and Nomblot, “1812–1914”, p. 42.

<sup>335</sup> FUTTERA, Ladislav, „140 let vlečkové dopravy do cukrovaru Dobrovice (1870–2010)“, seminar paper, Gymnázium Dr. Josefa Pekaře, 2010, p. 12.

<sup>336</sup> Abbott, *Le sucre*, p. 191, Clout, “Sugar-Beet Production”, p. 109, Diviš, *Příspěvky*, p. 2, Figuiet, “Industrie du sucre”, p. 26, McMurtrie, *Report on the Culture*, p. 27, Neumann, *Nástin dějin*, p. 7, Prinsen-Geerligs, *The World’s Cane*, p. 17, Říha, *Počátky*, p. 88 and Sandford, *The Popular Encyclopedia*, pp. 809–810.

<sup>337</sup> Clout, “Sugar-Beet Production”, p. 109, Diviš, *Příspěvky*, p. 2, Gudoshnikov, *The World Sugar*, pp. 6–7, Neumann, *Nástin dějin*, p. 7 and Nezdarová, “Proměny cukrovarnictví”, p. 16.

<sup>338</sup> Sandford, *The Popular Encyclopedia*, pp. 809–810.

<sup>339</sup> CHAPTAL, Jean-Antoine, *Chimie appliquée aux arts*, t. 2, Paris, Crapelet, 1807, pp. 473–492 and CHAPTAL, Jean-Antoine, *De l’industrie française*, t. 2, Paris, Antoine-Augustin Renouard, 1819, pp. 54–5 and 179–182.

<sup>340</sup> Brançon, “Le sucre”, p. 239 and Heckscher, *The Continental System*, p. 294.

<sup>341</sup> Brançon, “Jean-Antoine Chaptal”, p. 37.

<sup>342</sup> The daily processing of beets cost him 200 francs, that is 1,014 €. CHAPTAL, Jean-Antoine, *Mémoire sur le sucre de betteraves*, Paris, Madame Huzard, 1818, pp. 10–38 and 40–42.

necessities in detail, but from the use of primitive hand tools it could be read that France was still waiting for more developed technology.

Since Chaptal “was very concerned about the development of beet sugar industry,”<sup>343</sup> he, in the position of Director-General of Commerce and Manufactures, drew the prefects’ attention to the beet industry to properly disseminate the technology:

“The manufacture of beet sugar is no longer a problem. [...] I will make it my duty to send you instructions on the most perfect mode of manufacture to ensure full success in each facility. [...] His Majesty has already spoken to me several times of his desire to see the manufacture of indigenous sugar resumed with activity: he proposes to grant it the most suitable encouragement to accelerate its development.”<sup>344</sup>

The trend of establishing factories was accelerated by the practical activities of an agronomist and a chemist. Christophe-Joseph-Alexandre Mathieu de Dombasle (1777–1843) published a paper in which he “gave definite instructions for the rational manufacture of beet sugar”.<sup>345</sup> He had gained experience from extracting potash out of beets and by manufacturing potatoes.<sup>346</sup> In his manual, he regretted that initial development of the industry had been forestalled by French manufacturers lacking the capital and knowledge, while praised the factories already operating on solid foundations. Dombasle even fell out with Chaptal after supporting the establishment of small farmers’ sugar factories.<sup>347</sup>

Dombasle’s contribution improved upon existing methods he had applied in 1810–1813. His success lay in two groups of 72 people working in six-hour shifts, with each person always in the same position, which he had automated, making the entire division of labour more efficient. An inventory of Dombasle’s accounts shows both salary and equipment costs, which included, for example, hundreds of fathoms of firewood, lime and charcoal reserves, wool and cotton filters, boilers, machine maintenance, taxes, and interest. For 150 days of work, Dombasle spent 114,480 francs (€ 813,131).<sup>348</sup>

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<sup>343</sup> Neumann, *Nástin dějin*, p. 6.

<sup>344</sup> *Bulletin de la SEIN*, t. 14, Paris, Imprimerie de M<sup>me</sup> Huzard, 1815, pp. 73–74.

<sup>345</sup> Prinsen-Geerligs, *The World’s Cane*, p. 17.

<sup>346</sup> *Bulletin de la SEIN*, t. 15, Paris, Imprimerie de M<sup>me</sup> Huzard, 1816, pp. 260–266 and *Bulletin de la SEIN*, t. 16, Paris, Imprimerie de M<sup>me</sup> Huzard, 1817, pp. 299–302.

<sup>347</sup> DOMBASLE, Christophe-Joseph-Alexandre Mathieu de, *Faits et observations sur la fabrication du sucre de betteraves et sur la distillation des mélasses*, 2<sup>ème</sup> édition, Paris, Madame Huzard, 1822, p. viii, xi–xii and 31–38.

<sup>348</sup> The staff consisted of 62 male and two female workers, one director, two clerks, one refiner and four foremen. For a more detailed overview of the entire list see **Dombasle**, *Faits*, p. 96–97, 184–199 and 212.

Augustin-Pierre Dubrunfaut (1797–1881) travelled to factories, where he observed the techniques developed and used by the most progressive manufacturers and brought this knowledge about the state of the industry. Besides Dombasle and Chaptal, he visited Cafler, Duke of Ragusa Grèvet-Pélé, General Preval, Masson and Demars.<sup>349</sup> This gave rise to an extensive manual in 1825 describing individual procedures to the smallest detail and providing an overview of all utensils needed for running a sugar factory, such as baskets, a gin with sprockets, hydraulic presses, tanks, thermometers, and spatulas. Dubrunfaut’s final profit was 163,432.81 francs (€1,166,526) for 120 days of work.<sup>350</sup>

beetroots	harvest	molasse	price/kg	expense	gain	final profit
4,114 t	185 t	153.9 hl	€3.78	€695,264	€1,861,790	<b>€1,166,526</b>

Table 12: Dubrunfaut’s accounting of profits and expenses (by author).

Changes in the business environment were accompanied by new machines and enhanced techniques for each individual step. When the beets were cleaned, they were washed in a lattice cylinder Hugues Champonnois enriched in 1829 with sedimentation through the spaces between the battens. While the grating machine, a rotating cylindrical grater with blades, still remained, it now grated uncooked slices of beets instead of cooked and stringy cuttings. A step further was noted in extracting beet pulps for which hydraulic presses were no longer preferred. Instead, a new process of maceration was introduced:

“The beet was cut into ribands and plunged into boiling water which was admitted into the machine at regular intervals in regular doses. The ribands remain passing through the circuit of the machine for one hour with steam occasionally keeping up the heat. The sugar contained in the ribands dissolved and remained in solution in the water, while the ribands were discharged on the side of the machine opposite to that where they entered it. The liquor containing the saccharine flowed off in another direction to the defecating pans. The advantage was that maceration gave rather more and better product while requiring a great deal less labour, the disadvantage was that it took a great deal more fuel and did not leave the pulp in so good taste for feeding.”<sup>351</sup>

The sugar solution was initially defecated, or purified, by lime and sulfuric acid, but these were replaced by Dombasle’s more effective whitewashing. Purified juice was clarified not with beef blood or skimmed milk, but with a decolouring and deodorising medicinal charcoal that Löwitz and Figuier had already started using in 1802 and 1810, respectively. Dumont’s filters

<sup>349</sup> **McMurtrie**, *Report on the Culture*, p. 27.

<sup>350</sup> DUBRUNFAUT, Auguste-Pierre, *Art de fabriquer le sucre de betteraves*, Paris, Bachelier, 1825, pp. 480–498.

<sup>351</sup> Other methods for obtaining juice were the Pecqueur press, hot maceration (named *exosome* by René Dutrochet) and the Pelletan levigator. **Dombasle**, *Faits*, p. 110 and 115–120, **Nomblot**, “1812–1914”, pp. 63–66 and **Sandford**, *The Popular Encyclopedia*, p. 810.

superseded previous clarification because they contained water-soaked granular pieces of charcoal that co-worked with the aid of canvas filters, and in Britain the evaporation technique had been enhanced by Edward Charles Howard’s vacuum stove, which boiled the juice in a closed vessel under reduced pressure.<sup>352</sup>

The method of crystallisation received no significant improvements because evaporator ovens and conical moulds were still being used until the middle of the 19<sup>th</sup> century. In the meantime, Dombasle promoted so-called “steam graining”, which made “raw sugar of a beautiful blond colour that I only rarely obtain from raw sugar cooked over an open flame.”<sup>353</sup> It saved considerable fuel and was regarded as a key step forward for the industry. Even though “the progress was more in the mastery of know-how, craft and operations than in the machines and technique,”<sup>354</sup> these introduced innovations greatly reduced both work and consumption of fuel so that the industry could continue developing at less cost.<sup>355</sup>

STEP	OLD	NEW	FROM
cleaning	hand or side of the knife in wooden crates	in a lattice cylinder	1820
grating	rotating cylindrical grater with blades	–	1820
extraction	two-roller horizontal grape presses	maceration	1832
defecation	use of lime and sulfuric acid	use of whitewash and sulfuric acid	1820
clarification	beef blood (albumin) or skimmed milk	medicinal charcoal Dumont filters	1820 1825
filtration	screw press to compress cotton bags filled with juice	Dumont filters Peyron filters	1825 1840
evaporation	boiler over an open fire	vacuum evaporator	1815
crystallisation	evaporating oven	centrifuge	1850

Table 13: Old and new methods along with the year when these changes were introduced (by author).

<sup>352</sup> Around 1840, Peyron’s permanent charge filters facilitated filtration by raising the pressure in the filter. **Brançon**, “Le sucre”, p. 242, **Dombasle**, *Faits*, pp. 130–141, **Figuiet**, “Industrie du sucre”, p. 26, **Neumann**, *Nástin dějin*, p. 7, **Nomblot**, “1812–1914”, pp. 67–70 and **Sandford**, *The Popular Encyclopedia*, pp. 809–810.

<sup>353</sup> **Brançon**, “Le sucre”, p. 242.

<sup>354</sup> **Nomblot**, “1812–1914”, p. 74.

<sup>355</sup> Table 13: *Ibid*, pp. 63–75.



Along with more efficient machines and technologies, higher sugar yields also came into play. Although content never exceeded double digits, experiments with morphological characters conducted by Philippe André Lévêque de Vilmorin (1776–1862) were nonetheless of significant benefit to the industry. Another step towards systematic sugar beet breeding was taken by his son Pierre Louis François Lévêque de Vilmorin (1816–1860), who postulated that “a beet root with a high density would normally also have a high sugar content”.<sup>356</sup> Through this breeding system and new laboratory techniques, the Vilmorins laid the foundation for individual selection of single beets<sup>357</sup> and made rapid progress<sup>358</sup> in improving beet quality.

YEAR	1825	1827	1828	1830	1832	1833	1835	1838
<b>FACTORIES</b>	30	89	101	200	–	120	400	581
<b>SUGAR</b>	1,000	1,500	2,200	4,380	9,600	12,000	40,000	50,000

Table 14: French sugar factories and beet sugar produced (1825–1838) (by author).

### Unification of Bohemian methods and their disengagement

The decline of the Bohemian sugar factories in 1813 again strengthened animosity and mistrust among farmers towards beet cultivation. Although the causes of failure were discussed on the floor of the PES in December 1814, Emanuel Count Michna proposed no improvements.<sup>359</sup> After 1815, beet sugar factories virtually disappeared from Bohemia because they could not withstand the onrush of the cheap and high-quality overseas commodity that was flooding the European market.<sup>360</sup> The influx of cane sugar proliferated and drove growing consumption and yet the insufficient supply of sugar instigated manufacturers to “understand the benefits of growing beets on their farms and processing it into sugar in their own facilities”.<sup>361</sup>

<sup>356</sup> Improvements led to roots with sucrose content of 17% compared to the original 8 or 9%. **Brançon**, “Le sucre”, p. 242, **Cooke**, *The Sugar Beet Crop*, p. 13, **COONS**, George H., “The Sugar Beet: Product of Science”, *The Scientific Monthly*, vol. 68, no. 3, 1949, pp. 149–164, p. 153 and **Smith**, *Sugar*, p. 41

<sup>357</sup> In 1836, one-third of the sugar refined in France came from beets. **Prinsen-Geerligs**, *The World's Cane*, p. 17.

<sup>358</sup> Table 14: **Brançon**, “Le sucre”, p. 243, **Contour**, “Le Val-d’Oise”, pp. 273–274, **Diviš**, *Příspěvky*, p. 2, **Dudek**, *Vývoj*, p. 28, **Figuiér**, “Industrie du sucre”, p. 26, **Hitier**, *Plantes*, p. 12, **Laloux**, „La bataille“, p. 56, **Macinnis**, *Bittersweet*, p. 136, **McMurtrie**, *Report on the Culture*, p. 28 and 30, **Neumann**, *Nástin dějin*, p. 7, **Nomblot**, “1812–1914”, p. 42, **Říha**, *Počátky*, p. 88, **Snodgrass**, *World food*, p. 187, **TOMICH**, Dale W., *Slavery in the Circuit of Sugar*, New York, State University of New York, 2016, p. 115 and **WALKHOFF**, Louis, *Traité complet de fabrication et raffinage du sucre de betteraves*, t. 1, translated by E. Mérijot, Paris, F. Savy, 1870, p. 7.

<sup>359</sup> **Neumann**, *Nástin dějin*, pp. 61–63.

<sup>360</sup> **Dudek**, *Počátky*, p. 7.

<sup>361</sup> The production of sugar syrup was preferred because it could be monetised better than raw sugar. **Neumann**, *Nástin dějin*, p. 62 and **Novák**, “Pohled do vývoje”, p. 6.

In April 1831, there was a re-evaluation of what had caused the failure of the sugar industry, citing too meagre sugar production in comparison to other countries and factories operating without the necessary technical knowledge. The PES officer, Matyáš Kalina, therefore proposed the awarding of bonuses by the state to new factories that were capable of producing sugar for three years in a row and to lend suitable space to manufacturers at no charge or for a moderate compensation. Scientific institutes would also contribute toward promotion of the industry in their journals, where practical experiments would be published. Finally, PES would itself grow beets for seeds and then sell them.<sup>362</sup>

The government initially took the step of enhancing internal and external innovations that were to form a comprehensive manual intended to avoid outdated methods and to arrive at a richer production of beet sugar by applying new procedures.<sup>363</sup> In the first phase, oversight would come mainly from the progressive nobility, moving in the second phase to patronage from the new estates of industrialists and farmer's cooperatives, which would take the lead in the third wave.<sup>364</sup> To encourage more manufacturers to produce sugar, the state stepped in with a concession.<sup>365</sup>

“His Imperial Royal Grace [Emperor of Austria and King of Bohemia Francis II], on 11 January 1831, was most graciously pleased to grant an exemption that the industrial enterprises, which tend to the extraction of sugar from domestic crops, shall be exempted from income tax for ten years.”<sup>366</sup>

Most Bohemian sugar manufactures were open to economic innovations and investments which would compensate for the losses caused by the drop in prices of agricultural products during the crisis of 1820–1840.<sup>367</sup> In the late 1820s, they decided both to send their officials to France and to accept French or German experts to set up sugar factories on Bohemian estates, letting them teach the growing and processing of beets. However, the production was misunderstood and the factories were established with little capital, insufficient equipment and no steam.<sup>368</sup>

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<sup>362</sup> **Diviš**, *Příspěvky*, pp. 4–6.

<sup>363</sup> Bohemian producers mixed techniques developed by Fischer, Deyeux, Barruel, Isnard, Drappiez, Hermbstaedt and Achard. **Národní technické muzeum**, *Cukrovarnictví*, p. 20 and **Neumann**, *Nástin dějin*, p. 54.

<sup>364</sup> **Futtera**, „140 let”, p. 12.

<sup>365</sup> **Faltusová**, “Cukrovarnický průmysl”, p. 31, **Fexová**, „Nymburský cukrovar”, p. 18, **Jadlovský**, “Vývoj cukrovarů”, p. 36, **Nezdarová**, “Proměny cukrovarnictví”, p. 16 and **Novák**, “Pohled do vývoje”, p. 6.

<sup>366</sup> **Diviš**, *Příspěvky*, p. 4.

<sup>367</sup> **Dudek**, *Vývoj*, p. 28.

<sup>368</sup> **Dudek**, *Počátky*, p. 7, **Národní technické muzeum**, *Cukrovarnictví*, p. 20 and **Neumann**, *Nástin dějin*, pp. 7–8.

Even with such drawbacks, the 1830s saw sugar factories were erected on a large scale as the fever to establish them rose, although they were of minor importance and only produced raw sugar for subsequent sale to refineries. It was Antonín Richter, the director of the former Zbraslav factory in 1812–1813 and of the future facility that would stand at the same site between 1834 and 1837<sup>369</sup> who was purchasing and reselling the commodity, thus circulating capital and contributing to the establishment of new sugar factories, a remarkable act in itself.

But Richter was not the only enlightened man at the time. In addition to him, the Germans Zier, Hanewald, Karl Weinrich and Friedrich Kodweiss worked with Schubarth, the Gräbner brothers and Ludwig Krause of Prussia<sup>370</sup> were behind the development of the sugar beet factory, too. While Zier and Hanewald would set up a trial sugar factory in Quedlinburg in 1833 that became one of the foremost teaching institutes in the German Confederation,<sup>371</sup> Krause was invited by the Austrian Economic Society to take an instructive trip and prepare an expert opinion on the benefits of beet sugar production. He visited several facilities and ended his journey at Crespel-Delisse. Upon returning, Krause produced a special report for the Society and in 1834 published an extensive work.<sup>372</sup>

With Franz and Thomas Gräbner, the trend of establishing new factories gained momentum. The first industrial sugar factory in Moravia and the Austrian Empire was founded in 1829 at Baron Karl Dalberg's estate in the southern town of Kirchwiedern (today Kostelní Vydří). Franz was the inspector of the facility, while his brother, having returned from France and Bavaria, became its director.<sup>373</sup> In Bohemia, more sugar factories followed in 1831 in Chotzomischl (now Chocomyšl), and the following year in Schelesen (now Želízy) and further east in Obersuchau (now Horní Suchá), where new industrial forms of production and division of labour were used.<sup>374</sup> In 1833, another refinery was established in the south at Datschitz (now

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<sup>369</sup> **Diviš**, *Příspěvky*, p. 41, **Faltusová**, “Cukrovarnický průmysl”, p. 32, **FRONĚK**, Daniel, “Výroba cukru na Zbraslavi – kolébka českého cukrovarnictví”, *Listy cukrovarnické a řepářské*, vol. 124, no. 7–8, 2008, pp. 232–236, p. 234, **Jadlovský**, “Vývoj cukrovarů”, p. 37 and **Říha**, *Počátky*, p. 31.

<sup>370</sup> **Diviš**, *Příspěvky*, p. 2 and 40, **McMurtrie**, *Report on the Culture*, p. 28, **Říha**, *Počátky*, p. 88 and **Walkhoff**, *Traité complet*, p. 8.

<sup>371</sup> In 1834, one hundred people were trained here for a modest fee, after which a manual *Die Bereitung des Zuckers aus Runkelrüben von Zier und Hanewald* was created. **Diviš**, *Příspěvky*, p. 2.

<sup>372</sup> The report was titled *Neue Folge der Verhandlungen der k. k. Landwirtschafts-Gesellschaft* and his work *Darstellung der Fabrikation des Zuckers aus Runkelrüben, in ihrem gesammten Umfange*. **Diviš**, *Příspěvky*, p. 3.

<sup>373</sup> The factory produced 20 t of beet sugar annually. **Drábek**, “K vývoji”, pp. 1–2, **Faltusová**, “Cukrovarnický průmysl”, p. 31, **Fexová**, “Nymburský cukrovar”, p. 18, **Jadlovský**, “Vývoj cukrovarů”, p. 36, **Národní technické muzeum**, *Cukrovarnictví*, p. 24, **Neumann**, *Nástin dějin*, p. 4, **Nezdarová**, “Proměny cukrovarnictví”, p. 16, **Novák**, “Pohled do vývoje”, p. 6 and **Říha**, *Počátky*, pp. 88–89.

<sup>374</sup> **Froněk**, “200 let”, p. 358, **Jadlovský**, “Vývoj cukrovarů”, p. 36 and **Maděra**, “Výroba cukru”, p. 19.

Dačice).<sup>375</sup> While these new facilities differed from each other, the equipment and processes in these factories were about to be unified.

Karl Weinrich<sup>376</sup> was another director worth mentioning because of his sugar factory in Dobrovice (then called Dobrowitz),<sup>377</sup> north of Prague would be a model example for future refineries in Bohemia. Weinrich had travelled across France to observe all the innovative methods there and his knowledge of them was now prodigiously valuable. His reflections on the benefits of French beet sugar production heralded a new wave of factories:

“I offer to convey to all my compatriots detailed knowledge about this subject, to describe this production in detail according to the latest improvements and to answer as thoroughly as possible all questions regarding the costs of equipment and operation in various local conditions, the necessary buildings, the possible use of existing rooms and the acquisition of the necessary machines and devices.”<sup>378</sup>

In 1831, Weinrich was invited by Prince Karel Anselm Thurn-Taxis to his Dobrovice estate to “set up a sugar factory, manage production and train workers”.<sup>379</sup> The PES commission’s assessment was of a factory furnished in a very primitive manner, as screw presses had been built instead of hydraulic presses, and all the work with the juice was done over an open fire, not steam. The typical mechanical work was carried out by the workers on four screw presses and on a rotary wheel driven by horses. Control of the chemical reactions on copper pans and in wooden tuns had to be entrusted to “a supervisor who masters at least such chemical knowledge as is needed”.<sup>380</sup>

Between sixty to eighty people of different ages crystallised the sugar in lump-shaped vessels, with samples sent to the government for review. Although the sugar factory processed only 1,008 tonnes of beets, its 50 tonnes of raw sugar went to the warehouse in Prague where it

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<sup>375</sup> **Boušková**, “Změny v pěstování”, p. 12, **Jadlovský**, “Vývoj cukrovarů”, p. 36, **Maděra**, “Výroba cukru”, p. 19, **Marek**, “Čtvrt tisíciletí”, p. 240 and **Nezdarová**, “Proměny cukrovarnictví”, p. 16.

<sup>376</sup> Bedřich Justus Karel Weinrich (1800–1860) studied technical chemistry at the University of Göttingen, where he was educated as a technologist and economist. As early as 1826, he published a manual on the cultivation of beet sugar, and in 1837 he built his own sugar factory. **Diviš**, *Příspěvky*, pp. 12–15.

<sup>377</sup> **Fexová**, “Nymburský cukrovar”, p. 18, **Jadlovský**, “Vývoj cukrovarů”, p. 36, **Národní technické muzeum**, *Cukrovarnictví*, p. 24, **Novák**, “Pohled do vývoje”, p. 6, **Pokorná**, “Cukrovarnictví”, p. 14 and Státní oblastní archiv v Praze, Rodinný archiv Thurn-Taxisů, Loučeň, NAD 475.

<sup>378</sup> In the winter of 1828–1829, Weinrich travelled through France and acquired a recommendation from J. Liebig to Hallett and Crespel (Arras), Kuhlmann (Lille) and Lahaut (Sailly-Labourse). He returned in the spring of 1829 and set up a small factory on his father’s farm before returning to France in 1830 and later publishing *Fortschritte der Zuckerfabrikation aus Runkelrüben*. **Diviš**, *Příspěvky*, p. 9 and p. 12–13 and **Nezdarová**, “Proměny cukrovarnictví”, p. 17

<sup>379</sup> **Fexová**, „Nymburský cukrovar“, p. 18.

<sup>380</sup> For the whole description of the Dobrovice sugar factory see **Diviš**, *Příspěvky*, pp. 10–11.

enjoyed copious interest.<sup>381</sup> Common features could be found with the refineries in France. On one hand, the PES appointed their own commission to evaluate the state and functioning of the sugar factory, and on the other hand, the resulting sugar loaves were sent to the government to approve production. Thus, western methods were evidently taking root in Bohemia.

The following processes in Dobrovice were used at most sugar factories at the time:

“The cellars stored the beets, which were washed in the building in front of the main gate, next to which was also a warehouse for 760 metres of wood. Inside the sugar factory, there was a gin with horses that turned the grater for the beets, the pieces of which were then processed in four presses. Unnecessary cuttings fell into the cellar, from where they were thrown out and distributed around the yards. The pressed juice was poured into a funnel and flowed through pipes to six clarifying boilers in a heated room and later through canvas bags into six large evaporation boilers, the vapours of which were led through pipes into two steam chimneys. Next to these boilers were three thickening boilers and three filtering boilers. Above this room were two lofts with sixty tuns for crystallisation of the thickened syrup which flowed down the channels into the tuns in the lower room.”<sup>382</sup>

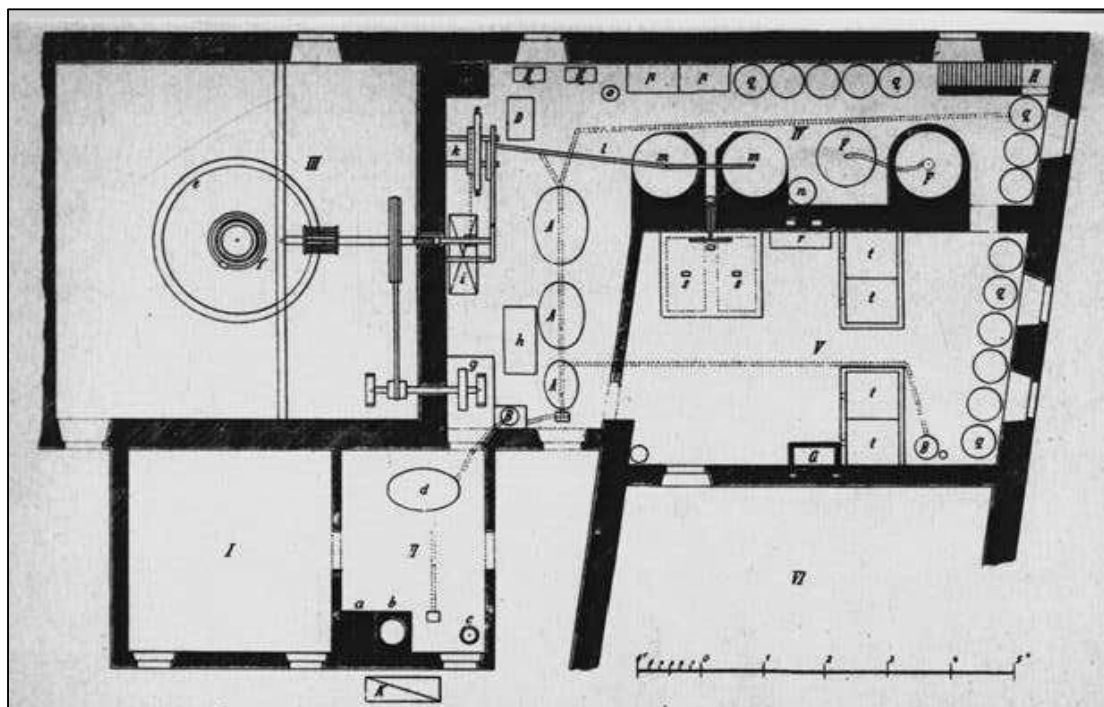


Figure 27: The Svinaře sugar factory resembled other Bohemian facilities. **Diviš**, *Příspěvky*, p. 36.

Following the example of Dobrovice, Weinrich founded many other factories, such as the one in today’s Malá Chuchle neighbourhood in Prague.<sup>383</sup> From 1831, Friedrich Kodweiss<sup>384</sup>

<sup>381</sup> In 1835, the number of employees reached 220 people, half worked during the day, half at night. **Diviš**, *Příspěvky*, pp. 10–12 and **Pokorná**, “Cukrovarnictví”, p. 14.

<sup>382</sup> **Diviš**, *Příspěvky*, pp. 15–17, **Dudek**, *Vývoj*, pp. 31–32 and **Říha**, *Počátky*, p. 114.

<sup>383</sup> About 2,240 t of beet sugar were produced. **Nezdarová**, “Proměny cukrovarnictví”, p. 17.

<sup>384</sup> Bedřich Kodweiss (1803–1866) devoted himself to pharmacy, physics and experimental chemistry. In 1830, he was awarded a Doctor of Philosophy degree and a year later was appointed the director of the sugar factory in

directed the factory on the estate of the Prince of Oettingen-Wallerstein. He was not only visited by people from far afield of Prague to learn the art of sugar making, but Kodweiss himself was often called to inspect various factories. His friendship with Weinrich led to “about three-fifths of the sugar factories [being] supervised by them and that most of the Bohemian sugar producers were their apprentices”.<sup>385</sup> At the Malá Chuchle sugar factory,

“washing was done in washtubs and tuns using blunt but strong brooms, or with a washing machine. Beets were cleaned with short, sharp knives; after being cut, they were pressed in bags made of fine twine. The juice was clarified with sulfuric acid and lime, evaporated in cauldrons over a fire, filtered with medicinal charcoal and thickened with egg white or whitewash. The sugar was then processed in the attic: it was mixed in lump-shaped containers with a narrow, long knife, and after three weeks, a loaf of sugar was knocked out by tapping the mould on the floor.”<sup>386</sup>

The factory in the Central Bohemian town of Svinaře, together with Dobrovice and Malá Chuchle, represented a training ground for future sugar producers.<sup>387</sup> The workers operated a disk spinning machine with iron teeth driven by a gin drawn by two pairs of oxen, and a hydraulic or manual press to obtain the juice. In Bezděkov, apart from hydraulic presses, steam machines for purifying and evaporating juice were used, but they seemed to be defective, so they were often replaced with pans. Between 1830 and 1834, Weinrich and Kodweiss built or supervised factories in Chudenice, Horní Stromka, Rtišovice and Zbraslav, that led to the establishment of other facilities in 1836.<sup>388</sup>

	1830	1831	1832	1834	1836		
<b>PLACE</b>	Bezděkov	Dobrovice	Svinaře	Zbraslav	Zlonice	Bílina	Slané
<b>USED</b>	840 t	1,008 t	840 t	2,240 t	2,240 t	1,680 t	2,800 t
<b>PLACE</b>	Chudenice	Malá Chuchle	Horní Stromka	Rtišovice	Smidary	Svinná	Stranov
<b>USED</b>	672 t	2,240 t	2,240 t	672 t	3,360 t	1,120 t	1,680 t

Table 15: Factories with the expected processing of a certain number of tonnes of beets (by author).

Malá Chuchle. Toward the end of his life, he travelled to France, Italy, Poland and Russia to bring back new knowledge about the sugar industry. **Diviš**, *Příspěvky*, pp. 18–21.

<sup>385</sup> While Kodweiss was the director at Malá Chuchle, Weinrich was the inspector. **Diviš**, *Příspěvky*, p. 20 and 22 and **Fexová**, „Nymburský cukrovar“, p. 18.

<sup>386</sup> More in *Kurzgefasste Beschreibung der Darstellung des Runkelrüben-Zuckers in der Hochfürstlich Oettingen-Wallerstein'schen Fabrik zu Kuchle*. **Diviš**, *Příspěvky*, pp. 22–34.

<sup>387</sup> *Ibid*, p. 21.

<sup>388</sup> Table 15: **Diviš**, *Příspěvky*, p. 7, 21 and 34–41, **Říha**, *Počátky*, p. 113 and **STRÁNSKÝ**, Josef B. (ed.), *Z vývoje české technické tvorby*, Praha, Spolek českých inženýrů, 1940, pp. 134–135.

A simple screw press, inspired by Achard, had two strong iron screws with brass nuts, a box filled with copper sheet, a solid base and an upper frame. The press was tightened by two men who diligently turned the lever until the juice had been completely squeezed out and then it was further processed by known methods. Its use even thirty years after the beet industry was born means that Bohemia was still not ready to use modern tools. There were simply no skilled personnel to both make and use them, so it took several years before the required tools could be properly used.

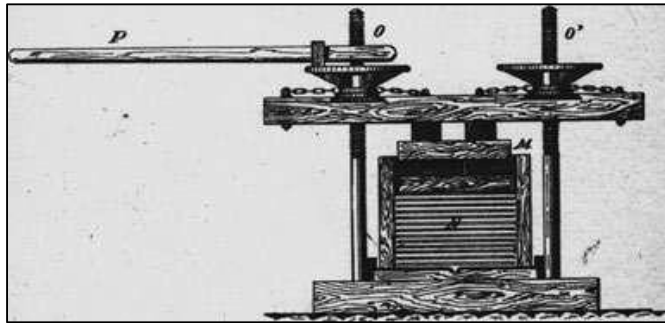


Figure 28: Primitive screw press. **Diviš**, *Příspěvky*, p. 38.

Other equipment in the Bohemian factories had changed little since 1812 and the technology remained primitive and time-consuming. Preserved illustrations show the cutters used in Bohemian sugar factories in the 1830s (right, below) are strikingly similar to what Achard and Kopp used (left), not taking into account its simplification and enhancement. The inspiration from Prussia and Bohemia, respectively, is apparent.

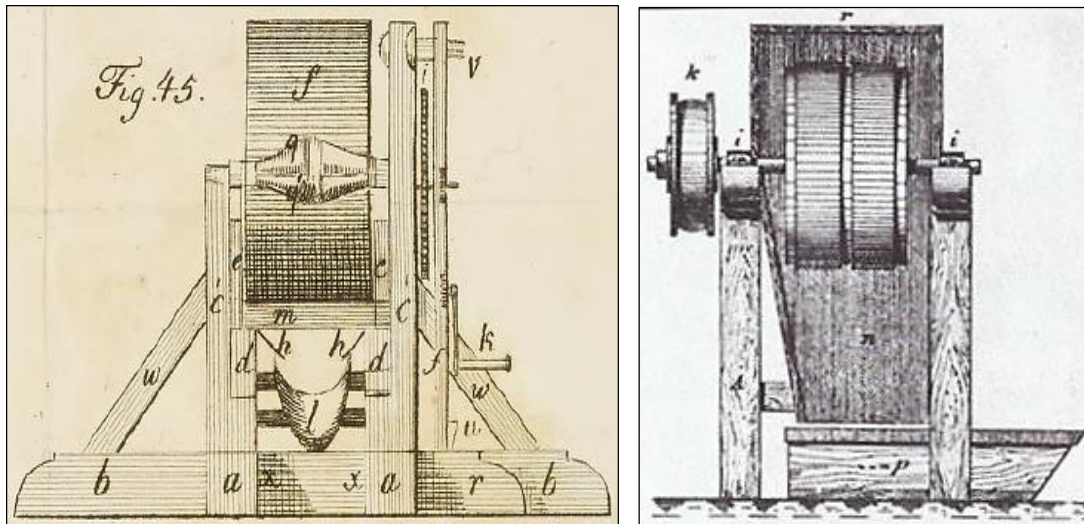


Figure 29: Achard's (left) and Bohemian (right) beet cutters. **Achard**, *Die europäische Zuckerfabrikation*, tab. V and **Dudek**, *Vývoj*, p. 193-15.

The learned societies of the time did not stand aside either. Considerable credit goes to the PES, which was responsible for awakening and strengthening the industry. In addition to appointing its own commissions, the regional government ordered it in February 1831 to “promote the production of sugar from domestic crops, mainly from beets, to look for suitable means to fund

this industry and to recommend them to the government.”<sup>389</sup> The PES also propagated the industry to larger producers in a treatise called *On the price of beets mainly for sugar production and for ordinary peasants with Instructions for growing beets*.<sup>390</sup>

Introducing the art of sugar production to society led to the development of industry in both agriculture and technology. Sugar factories were only established by those who had learned that the surrounding land was suitable enough for growing beets and obtaining a high yield and it would suffice for the operation of their facilities.<sup>391</sup> It did not take long for the obsolete cleaning of beet juice with acid and lime to be replaced by Weinrich’s modern method,<sup>392</sup> and when steam was finally incorporated into the factories, “initiating an almost continuous series of annual, increasingly costly mechanical changes”.<sup>393</sup>

However, Bohemia ceased to be dependent on the import of Western knowledge thanks to its own sugar research institute, which started testing new methods for processing sugar in 1836.<sup>394</sup> Experiments were conducted by knowledgeable figures from the factories aiming to make the region independent of foreign influences, which foreshadowed an unprecedented boom<sup>395</sup> in the sugar industry in the middle of the nineteenth century that put Bohemia’s factories among the most profitable among Europe when it had to face new, unexpected competition.

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<sup>389</sup> **Diviš**, *Příspěvky*, p. 4.

<sup>390</sup> **Boušková**, “Změny v pěstování”, p. 12, **Diviš**, *Příspěvky*, p. 7 and **Říha**, *Počátky*, pp. 97–98.

<sup>391</sup> **Fexová**, “Nymburský cukrovar”, p. 18.

<sup>392</sup> Weinrich is credited with making important enhancements of French methods concerning stirring, evaporating and saturating sugar juices. RECHCIGL, Miloslav (ed.), *Czechoslovakia past and present*, vol. II: Essays on the Arts and Sciences, Mouton, The Hague, 1968, p. 1266.

<sup>393</sup> This happened around 1835. Archiv Národního technického muzea, Karel Cyril Neumann, 10 III. f), ‘Inventarium strojového zařízení cukrovaru v Martinovsi z let 1835–1848’, **Neumann**, *Nástin dějin*, p. 8, 46, 54, 61 and 63 and **Říha**, *Počátky*, pp. 119–120.

<sup>394</sup> **Faltusová**, “Cukrovarnický průmysl”, p. 32 and **Jadlovský**, “Vývoj cukrovarů”, p. 37.

<sup>395</sup> **Table 16**: The gradual rise of sugar factories stopped between 1836 and 1843, when several facilities were closed, and after 1840 the number of new factories opening slowed. Nevertheless, fifty new Bohemian and Moravian sugar factories were established in one decade. ČIŽMÁŘ, Zeno, “160 let výroby cukru v Hrušovanech nad Jevišovkou”, *Listy cukrovarnické a řepařské*, vol. 127, no. 7–8, 2011, pp. 236–242, p. 236, **Dudek**, *Počátky*, pp. 8–12, **Fexová**, “Nymburský cukrovar”, p. 18, HOŘÍNEK, Vojtěch, *Statistické příspěvky ku dějinám průmyslu řepového cukru v Čechách*, Praha, Komitét pro kolektivní výstavu cukrovarníků Čech 1891 v Praze, 1891, p. 24, **Jadlovský**, “Vývoj cukrovarů”, p. 37 and **Říha**, *Počátky*, p. 95.



<b>YEAR</b>	<b>1819</b>	<b>1822</b>	<b>1825</b>	<b>1830</b>	<b>1832</b>	<b>1834</b>	<b>1836</b>	<b>1838</b>	<b>1840</b>
<b>WAS</b>	–	1	1	2	6	9	22	50	53
<b>NEW</b>	1	–	1	3	2	4	10	7	–
<b>FAILED</b>	–	1	–	–	–	2	1	4	2
<b>TOTAL</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>5</b>	<b>8</b>	<b>11</b>	<b>31</b>	<b>53</b>	<b>51</b>

Table 16: Existing, new and defunct Bohemian beet sugar factories (by author).

Deep-rooted methods in France for extracting beet sugar made it the epicentre of a novel wave that definitively gave birth to a new industry. Crespel-Delisse, de Dombasle and Dubrunfaut refined old methods with new techniques and machines, such as maceration and introducing beet washing machines. Bohemia's sugar industry did not stand aside this time. Its PES convened a commission to evaluate the state of the industry in the kingdom and proposed significant adjustments. In addition, it financed Weinrich's trip to factories in France to observe methods, which he would later promote in the new Bohemian factories he was inspecting. Other manufacturers followed his example to later direct beet sugar factories that would become examples of a new industry, an important future component of the Bohemian economy.

## 6. Conclusion

Sugarcane processing technology has undergone significant modifications over the course of several millennia, making sugar a widespread, but expensive and rare commodity. The unfavourable political situation at the end of the 18<sup>th</sup> century limited the supply of raw material to mainland Europe, leading to a blockade completely depriving continental Europeans of the supply of cane sugar. In order to avoid the dissatisfaction and to answer the needs of a part of the population, finding a replacement for the halted imports had to be found.

The sugar market crisis hit the Old Continent when the Enlightenment and science had been coming to the forefront of society. The Enlightenment sparked the formation of learned societies and the propagation of reason, while new discoveries were recorded in chemistry, so the timing could not have been more fortuitous. Since some countries had had their own experiences with the refining of cane sugar, they were aware of all the requirements for producing and preparing the final product. Because sugar processing technology was so widespread and versatile, forced self-sufficiency drove some people to reach for any available crops that could yield sugar.

The first experiments with corn, chestnuts and potatoes were partly successful, but they could not fully satisfy the growing demand for quality raw materials. As knowledge about chemistry improved, disseminated by learned societies among others, so did chemical experiments, eliminating those foods in which the manufactured sugar could neither be purified to the level of cane sugar, nor resemble cane sugar's chemical properties. In the search for substitutes, maple sap, preferred in German-speaking Central Europe, and grapes, grown on a large scale in France, emerged victorious. The tradition of grapes and wine in France and of tree cultivation east of it was initially fruitful, but it did not last long. There was not enough maple sap to meet demand and the grapes rotted due to the content of perishable glucose. Neither there were sufficient sales to make these crops profitable.

The approach each country had to the processing of grapes and maple sap differed. The Austrian Empire and its Bohemian Patriotic Economic Society (PES) took a passive stance during the sugar shortage crisis, so the noble estates bottled sap. On the other hand, in France, fighting broke out over the primacy of the technology for obtaining grape sugar, in response to which the government began awarding medals and giving financial rewards that were supposed to motivate citizens to achieve even better results.

Meanwhile, there was a revolutionary discovery made in Prussia, where a satisfactory amount of sugar could be obtained from the cultivation of sugar beets. Experiments with this crop had already begun in the middle of the 18<sup>th</sup> century, but it was not until the end of the century that significant success was achieved from Achard's experiments (1800) in Silesia. Summarised his own experiences, he explained the tools and machines in detail and used his own drawings, which were translated into several European languages. He even approached the French Academy of Sciences to start processing beets, but its learned commission had a different opinion. Based on Achard's notes, Baron de Koppy built in Prussia the first modern European sugar factory in 1805, and it became a model example for future factories in Russia and especially in Central Europe, making Achard a pioneer of the highly successful and still functioning beet sugar industry.

Exhausted sap stocks and poor grape harvests led desperate governments in both the French Empire and the Kingdom of Bohemia to look for a new sugar-yielding crop. When Achard's report reached the French press in 1808, sugar beet methods were reviewed once more. One member of the commission assessing them even reported on Prussian technology developed by a French military apothecary, putting a key document in the hands of the government that unlocked the door to the new industry. The auspicious existence of chemists and apothecaries able to move the industry in a significant direction forward allowed France to seize upon Prussian methods, although it went in its own direction by gradually introducing innovations.

Numerous experiments have shown the technology to obtain sugar from cane, maple sap and grapes to be applicable to beets, too. Further efforts were stimulated by two decrees, which set aside a certain number of hectares for the cultivation of beets, granted significant financial incentives and established experimental schools where the new art could be taught. Since a French delegation had previously gone in 1810 to Achard's school for the same purpose, this method seemed to be socially beneficial at the time. Learned societies also joined, whose foreign correspondents published findings from their countries in magazines that led to an unprecedented spread and development of sugar-making techniques. In this manner France took over knowledge of hydraulic presses, a technology earlier developed in Great Britain, and Russia cleaned beet juice with animal charcoal.

News of successful trials and positive results, spread by French newspapers, periodicals, societies' reports and military representatives, turned the attention of Bohemian society to sugar beets. However, production continued on locally remote and secluded noble estates. In addition, the passivity of the Kingdom of Bohemia stemming from the ideological belief that beets were

considered unpatriotic in the Austrian Empire, itself caused by Napoleon's promotion of them, and the technological lack of education among Bohemian sugar producers led to early decline, further exacerbated by outdated Prussian methods and the failure of the new French discoveries to catch on in the factories.

The artificial support of industry by the French Empire, whose regime controlled almost all of Continental Europe, ended with the fall of Bonaparte. The original sugar factories in Prussia, Silesia and Bohemia disappeared, while in France only a few persisted. Yet the survival of the beet industry was due to a generous economic policy, favouring of domestic production over colonial sugar, which had begun again to flow to Europe in large quantities, and the continuity in the use of original methods. The new wave was represented by Crespel-Delisse, Chaptal and de Dombasle, whose businesses had disappeared in the previous regime, and yet they were able to restore them in the new era.

Although France became the second cradle of industry, Bohemia got its second wind. While in the 1820s France improved methods and produced new, more efficient equipment, this time the Bohemian PES began to actively support the reborn industry. In 1829 it sent Karel Weinrich on a tour of French factories and, after his return in 1834, it issued a report summarising the new findings, including drawings of the machines used abroad. Other men also visited Western European factories and used their experience to manage the sugar factories in Bohemia, which only very slowly applied the new methods and installed more modern equipment.

Sugar-making methods combined mechanical and chemical processes that required cooperation between manually skilled workers and knowledgeable factory owners. Although not asserted in the first wave, the later return perfected it, evidenced by the growth in the number of sugar factories and the reports issued from inspections of them. Even though mostly primitive tools continued to be used, efficiency and division of labour improved along with chemical extraction and purification of sugar. Only a few factories used hydraulic presses and steam power, but stronger support from state institutions and deeper cooperation among producers from the unification of production processes led to Bohemia soon becoming an indispensable producer and exporter of beet sugar.

Future research should focus on the social aspect from the adoption of improved methods and the use of new machines, as new techniques led to a deeper study of the chemical sciences and, in the case of machines, to better and greater mathematical and physical knowledge. A study of urban, territorial, and social changes emanating from the founding of sugar factories would be

worthwhile, too. Employment naturally had to rise in towns where the sugar factories were established, whether working there, producing chemicals for the factory, or producing the necessary equipment like boilers and pipes. The social status of residents changed as well, not to mention the transformation of the local sugar markets. All of this was the consequence of the transnational transfer of knowledge, which deserves a thorough linguistic and graphic analysis of the content in published translated foreign works and how these led to structural changes in the local population, industry and economy.

## 7. Sources and bibliography

### 7.1. Sources

#### 7.1.1. Archives

##### 7.1.1.1. France

1. Archives nationales (Pierrefitte-sur-Seine), Subsistances F/11 294–295, ‘Documents divers’: ‘Renseignemens résultant de la Correspondance relative à la fabrication du Syrop et du Sucre de Raisin, an 1810’.
2. Archives nationales (Pierrefitte-sur-Seine), Statistique F/20 560, ‘Tableau de l’étendue de la culture des betteraves, en 1812, indiquant le nombre de sucreries établies à cette époque et la quantité approximative de leurs produits’, statistiques gouvernementales, 1813.
3. Archives nationales, (Pierrefitte-sur-Seine), Maison de l’Empereur (Premier Empire) O/2 969, ‘Manufacture impériale de sucre de betteraves de Rambouiller’.

##### 7.1.1.2. Czech Republic

4. Archiv Národního technického muzea, Karel Cyril Neumann, 10 III. f), ‘Inventarium strojového zařízení cukrovaru v Martinovsi z let 1835–1848’.
5. Státní oblastní archiv v Praze, Rodinný archiv Thurn-Taxisů, Loučeň, NAD 475.
6. Státní oblastní archiv v Praze, Velkostatek Zbraslav, NAD 213.

#### 7.1.2. Articles, journals and newspapers

7. ACHARD, F. K., “Procédé d’extraction du sucre de betterave”, *Annales de chimie*, t. 32, 1799, pp. 163–168.
8. *Bulletin de la Société d’encouragement pour l’industrie nationale*, t. 9–18, Paris, Imprimerie de M<sup>me</sup> Huzard, 1810–1819.
9. BOUDET, J. P., “Extrait d’un Mémoire de M. Boudet, Pharmacien en chef à l’armée du Rhin, sur une fabrique de sucre de Betteraves, établie en Silésie”, *Bulletin de Pharmacie*, t. 1, no. II, Paris, D. Colas, février 1809, pp. 76–85.
10. CHAPTAL, Jean-Antoine, “Rapport fait à l’Institut National par la Commission chargée de répéter les expériences de M. Achard, sur le Sucre contenu dans la Betterave”, *Annales des arts et manufactures*, Thermidor 1800, pp. 181–224.
11. CHAPTAL, Jean-Antoine, “Suite du Mémoire sur la Manière d’extraire le Sucre contenu dans la Betterave”, *Annales des arts et manufactures*, Fructidor 1800, pp. 321–332.
12. CHAPTAL, Jean-Antoine, “Sur les Vins”, *Annales de chimie*, t. 36, 1800, pp. 3–49.
13. DELAMÉTHÉRIE, Jean-Claude (dir.), *Journal de physique, de chimie, d’histoire naturelle et des arts*, t. 50, Paris, H. L. Perronneau, 1800.

14. DELAMÉTHÉRIE, Jean-Claude (dir.), *Journal de physique, de chimie, d'histoire naturelle et des arts*, t. 51, Paris, J.-J. Fuchs, 1800.
15. DEYEUX, Nicolas, “Mémoire sur l'extraction du sucre de betterave”, *Annales de chimie*, t. 77, 1811, pp. 42–62.
16. GUYTON-MORVEAU, L.-B., “Expériences et observations sur le Sucre”, *Annales de chimie*, t. 25, 1798, pp. 37–50.
17. *Le Moniteur universel*, no. 159, 7 June 1808.
18. *Le Moniteur universel*, no. 276, 2 October 1808.
19. *Le Moniteur universel*, no. 61, 2 March 1811.
20. *Le Moniteur universel*, no. 256, 13 September 1811.
21. *Le Moniteur universel*, no. 3, 3 January 1812.
22. *Le Moniteur universel*, no. 8, 8 January 1812.
23. *Le Moniteur westphalien*, no. 302, 18 December 1812.
24. LONDET, M. and L. BOUCHARD (dir.), *Annales de l'agriculture française ou Recueil encyclopédique d'agriculture*, t. 5, no. 26, 1865.
25. “Mémoire sur la culture des betteraves à sucre en France”, *Annales de chimie*, t. 38, 1801, pp. 329–332.
26. PARMENTIER, Antoine-Augustin, “Extrait d'un traité sur le vinaigre”, *Annales de chimie*, t. 37, 1801, pp. 113–131.
27. SCHERER, A. N., “Note sur l'extraction du sucre de la betterave”, *Annales de chimie*, t. 30, 1799, pp. 299–302.
28. VAN MONS, J.-B., “Sur la culture de la betterave, destinées à la fabrication du sucre d'Europe. Extrait de l'ouvrage de M. Achard sur cette matière”, *Annales de chimie*, t. 33, pp. 67–73.

### 7.1.3. Others

29. Académie des sciences, *Procès-verbaux*, vol. 96, Paris, Académie des sciences, 1777.
30. ACHARD, Franz-Karl and DEROSNE, Charles (dir.), *Traité complet sur le sucre européen de betteraves; culture de cette plante considérée sous le rapport agronomique et manufacturier: traduction abrégée de M. Achard*, translated by M. D. ANGAR, Paris, M. Derosne et D. Colas, 1812.
31. ACHARD, Charles-François and HEURTELOUP, N. (dir.), *Instruction sur la culture et la récolte des betteraves, sur la manière d'en extraire économiquement le sucre et le sirop*, translated by M. COPIN, Paris, Testu, 1811.
32. ACHARD, Franz Karl and THEILE, Drey (ed.), *Die europäische Zuckerfabrikation aus Runkelrüben, in Verbindung mit der Bereitung des Branntweins, des Rums, des Essigs und eines Caffee-Surrogats aus ihren Abfällen*, Leipzig, J. C. Hinrichs, 1809.

33. *Archives des découvertes et des inventions nouvelles, faites dans les Sciences, les Arts et les Manufactures, tant en France que dans les Pays étrangers*, Paris, Treuttel et Würtz, 1812.
34. BARRUEL, Jean-Pierre and ISNARD, Maximin, *Mémoire sur l'extraction en grand du sucre des betteraves, et quelques considérations sur leur culture*, Paris, Madame Huzard, 1811.
35. BASSE, Detmar, *Instruction pour cultiver et pour exploiter la betterave à sucre*, Paris, L'imprimerie de Ch. Fr. Cramer, 1799.
36. CHAPTAL, Jean-Antoine, *Chimie appliquée aux arts*, t. 2, Paris, Crapelet, 1807.
37. CHAPTAL, Jean-Antoine, *De l'industrie française*, t. 2, Paris, Antoine-Augustin Renouard, 1819.
38. CHAPTAL, Jean-Antoine, *Mémoire sur le sucre de betteraves*, Paris, Madame Huzard, 1818.
39. CHAPTAL, Jean-Antoine and CHAPTAL, Antoine (dir.), *Mes souvenirs sur Napoléon par le C<sup>e</sup> Chaptal*, Paris, Librairie Plon, 1893.
40. COMMERELL, Abbé de, *Instruction sur la culture, l'usage, et les avantages de la betterave champêtre*, Paris, L'imprimerie royale, 1786.
41. DOMBASLE, Christophe-Joseph-Alexandre Mathieu de, *Faits et observations sur la fabrication du sucre de betteraves et sur la distillation des mélasses*, 2<sup>ème</sup> édition, Paris, Madame Huzard, 1822.
42. DUBRUNFAUT, Auguste-Pierre, *Art de fabriquer le sucre de betteraves*, Paris, Bachelier, 1825.
43. Institut de France, Académie des sciences, *Procès-verbaux des séances de l'Académie*, t. I, Hendaye, L'Observatoire d'Abbadia, 1910.
44. Institut de France, Académie des sciences, *Procès-verbaux des séances de l'Académie*, t. II, Hendaye, L'Observatoire d'Abbadia, 1912.
45. *Instruction pour la culture des betteraves*, Aix, Gaspard Mouret, 1812.
46. MARGGRAF, Andreas Sigismund, „Expériences chimiques faites dans le dessein de tirer un véritable sucre de diverses plantes, qui croissent dans nos contrées“, in *Histoire de l'Académie royale des sciences et belles lettres*, année 1747, Berlin, Haude et Spener, 1749, pp. 79–90.
47. MONCEAU, Duhamel Du and BERTRAND, J.-E. (dir.), *Art de raffiner le sucre*, Paris, Moronval, 1812.
48. SUSSY, Jean-Baptiste Collin de, *Description des moyens et procédés employés à Paris par le sieur Bonmatin pour extraire le sucre de la betterave*, Paris, L'imprimerie impériale, 1812.
49. THIBAudeau, Antoine Claire, *Décret impérial au Palais des Tuileries, le 25 Mars 1811*, Paris, L'imprimerie de Mossy, 1811.
50. VALÉE, Antoine, *Traité élémentaire sur le sucre de raisin, sa fabrication, ses propriétés et ses usages dans l'économie domestique et commerciale*, Paris, D. Colas, 1808.



## 7.2. Bibliography

### 7.2.1. Monographies

51. AASLESTAD, Katherine B. and JOOR, Johan (eds.), *Revisiting Napoleon's Continental System. Local, Regional and European Experiences*, Palgrave Macmillan, Basingstoke, 2015.
52. ABBOTT, Elizabeth, *Le sucre, une histoire douce-amère*, translated by Benoît PATAR and Richard DUBOIS, Montréal, Fides, 2008.
53. BEARD, John Rely, *The Life of Toussaint L'Ouverture, the Negro Patriot of Hayti*, Chapel Hill, DocSouth Books Edition, 2012.
54. COOKE, D. A., *The Sugar Beet Crop. Science into practice*, Wallington, Chapman & Hall, 1993.
55. DIVIŠ, Jan Vincenc, *Cukrovarnictví*, Praha, I. L. Kober, 1897.
56. DIVIŠ, Jan Vincenc, *Příspěvky k dějinám průmyslu cukrovarnického v Čechách, období druhé 1830–1860*, Kolín, Komitét pro uspořádání kolektivně výstavy cukrovarnické, 1891.
57. DUDEK, František, *Monopolizace cukrovarnictví v českých zemích do roku 1938*, Praha, Academia, 1985.
58. DUDEK, František, *Počátky řepného cukrovarnictví v Čechách. Příspěvek k hospodářským dějinám 30. a 40. let 19. století*, Poděbrady, Oblastní muzeum v Poděbradech, 1973.
59. DUDEK, František, *Vývoj cukrovarnického průmyslu v českých zemích do roku 1872*, Praha, Academia, 1979.
60. DUMAS, Jean-Baptiste, *Traité de chimie appliqué aux arts. Atlas*, Paris, 1828.
61. FINDLAY, Ronald and O'ROURKE, Kevin H., *Power and Plenty. Trade, War, and the World Economy in the Second Millenium*, Princeton, Princeton University Press, 2009.
62. GILLISPIE, Charles Coulston, *Science and polity in France: The Revolutionary and Napoleonic Years*, Princeton, Princeton University Press, 2004.
63. GIRARD, Philippe R., *The Slaves Who Defeated Napoléon. Toussaint Louverture and the Haitian War of Independence, 1801–1804*, Tuscaloosa, The University of Alabama Press, 2011.
64. GUDOSHNIKOV, Sergey, JOLLY, Lindsay and SPENCE, Donald, *The World Sugar Market*, Boca Raton, CRC Press, 2004.
65. HECKSCHER, Eli F. and WESTERGAARD, Haral (ed.), *The Continental System. An Economic Interpretation*, Oxford, Clarendon Press, 1922.
66. HITIER, Henri, *Plantes industrielles*, Paris, B. Baillière et fils, 1905.
67. HOBHOUSE, Henry, *Seeds of Change. Six Plants That Transformed Mankind*, Berkeley, Counterpoint, 2005.
68. HOŘÍNEK, Vojtěch, *Statistické příspěvky ku dějinám průmyslu řepového cukru v Čechách*, Praha, Komitét pro kolektivní výstavu cukrovarníků Čech 1891 v Praze, 1891.
69. HORN, Jeff, *The Path Not Taken: French Industrialization in the Age of Revolution, 1750–1830*, Cambridge, The MIT Press, 2006.

70. JÍLEK, František et al., *Studie o technice v českých zemích 1800–1918*, t. 1, Praha, Národní technické museum, 1983.
71. KLEIN, Ursula, *Technoscience in History: Prussia, 1750–1850*, Cambridge, The MIT Press, 2020.
72. KULKARNI, D. P., *Cane Sugar Manufacture in India*, New Delhi, The Sugar Technologist's Association of India, 1996.
73. MACINNIS, Peter, *Bittersweet. The Story of Sugar*, Crows Nest, Allen & Unwin, 2002.
74. MAUMENÉ, Edme-Jules, *Traité théorique et pratique de la fabrication du sucre*, tome 1, Paris, Dunod, 1876.
75. MCMURTRIE, William, *Report on the Culture of the Sugar Beet and the Manufacture of Sugar Therefrom in France and the United States*, Washington, Government Printing Office, 1880.
76. Národní technické muzeum, *Cukrovarnictví, cukrovary a cukrovarníci. Fenomén českého hospodářství v 19. a 20. století*, Praha: NTM, 2011, Prameny a studie 47.
77. NEUMANN, Karel Cyril, *Nástin dějin průmyslu cukrovarnického v Čechách. Období první. 1787–1830*, Praha, Komitét pro uspořádání kolektivní výstavy cukrovarnické, 1891.
78. OUERFELLI, Mohamed, *Le sucre. Production, commercialisation et usages dans la Méditerranée médiévale*, Leiden, Koninklijke Brill NV, 2008.
79. PÁNEK, Jaroslav, TŮMA, Oldřich et al., *A History of the Czech Lands*, Praha, Karolinum Press, 2018.
80. PERRIER-ROBERT, Annie and BERNARDIN, Marie-Paule, *Le grand livre du sucre*, Paris, Solar, 1999.
81. PRINSEN-GEERLIGS, H. C., *The World's Cane Sugar Industry*, Altrincham, Norman Rodger, 1912.
82. REHCIGL, Miloslav (ed.), *Czechoslovakia past and present*, vol. II: Essays on the Arts and Sciences, Mouton, The Hague, 1968.
83. REISER, Philippe, *Avec ou sans sucre?*, Versailles, Éditions Quae, 2015.
84. ŘÍHA, Oldřich, *Počátky českého cukrovarnictví*, Praha, Univerzita Karlova, 1976.
85. SANDFORD, Daniel Keyte, *The Popular Encyclopedia*, vol. II, part II, Glasgow, Blackie & Son, 1841.
86. SMITH, Andrew F. (ed.), *Sugar. A Global History*, London, Reaktion Books, 2015.
87. SNODGRASS, Mary Ellen, *World food: an encyclopedia of history, culture, and social influence from hunter-gatherers to the age of globalization*, t. 1, Armonk, Sharpe Reference, 2013.
88. STINCHCOMBE, Arthur L., *Sugar Island Slavery in the Age of Enlightenment. The Political Economy of the Caribbean World*, Princeton, Princeton University Press, 1995.
89. STRÁNSKÝ, Josef B. (ed.), *Z vývoje české technické tvorby*, Praha, Spolek českých inženýrů, 1940.
90. *The Repertory of Arts, Manufactures, and Agriculture*, 2<sup>nd</sup> series, vol. 24, London, 1814.
91. OMICH, Dale W., *Slavery in the Circuit of Sugar*, New York, State University of New York, 2016.

92. VILMORIN, Jacques Lévêque de, *L'hérédité chez la betterave cultivée*, Paris, Gauthier-Villars et Cie, 1923.
93. WALKHOFF, Louis, *Traité complet de fabrication et raffinage du sucre de betteraves*, t. 1, translated by E. Mérijot, Paris, F. Savy, 1870.

### 7.2.2. Articles and chapters

94. ARRINGTON, Leonard J., “Science, Government, and Enterprise in Economic Development: The Western Beet Sugar Industry”, *Agricultural History*, vol. 41, no. 1, 1967, pp. 1–18.
95. BRANÇON, Denis and VIEL, Claude, “L’approvisionnement en sucre sous le Blocus continental. II – Jean-Antoine Chaptal et le sucre de betterave”, *L’actualité chimique*, vol. 7, no. 205, 1997, pp. 34–38.
96. BRANÇON, Denis and VIEL, Claude, “Le sucre de betterave et l’essor de son industrie: Des premiers travaux jusqu’à la fin de la guerre de 1914–1918”, *Revue d’histoire de la pharmacie*, vol. 87, no. 322, 1999, pp. 235–246.
97. CHAST, François, JULIEN, Pierre and MURATORI-PHILIP, Anne, “Parmentier et le sucre de raisin”, *Revue d’histoire de la pharmacie*, vol. 89, no. 330, 2001, pp. 149–168.
98. CLOUT, H. D. and PHILIPS, A. D. M., “Sugar-Beet Production in the Nord Département of France during the Nineteenth Century”, *Erdkunde*, vol. 27, no. 2, 1973, pp. 105–119.
99. CONTOUR, Solange, “Le Val-d’Oise betteravier au XIXe siècle et dans la première moitié du XXe siècle”, *Mémoires de la Société historique et archéologique de Pontoise, du Val d’Oise et du Vexin*, vol. 98, 2016, pp. 271–372.
100. COONS, George H., “The Sugar Beet: Product of Science”, *The Scientific Monthly*, vol. 68, no. 3, 1949, pp. 149–164.
101. CROWLEY, John E., “Sugar Machines: Picturing Industrialized Slavery”, *The American Historical Review*, vol. 121, no. 2, 2016, pp. 403–436.
102. ČIŽMÁŘ, Zeno, “160 let výroby cukru v Hrušovanech nad Jevišovkou”, *Listy cukrovarnické a řepářské*, vol. 127, no. 7–8, 2011, pp. 236–242.
103. DANIELS, John and DANIELS, Christian, “The Origin of the Sugarcane Roller Mill”, *Technology and Culture*, vol. 29, no. 3, 1988, pp. 493–535.
104. FIGUIER, Louis, “Industrie du sucre”, in *Les merveilles de l’industrie ou Description des principales industries modernes*, tome 2, Paris, Jouvot et Cie, 1877, pp. 1–148.
105. FOURNIER, Josette, “L’approvisionnement en sucre sous le Blocus continental. I – Louis-Joseph Proust et le sucre de raisin”, *L’Actualité chimique*, vol. 6, no. 204, 1997, pp. 31–37.
106. FRONĚK, Daniel, “200 let řepného cukrovarnictví v České republice”, *Listy cukrovarnické a řepářské*, vol. 126, no. 11, 2010, pp. 358–359.

107. FRONĚK, Daniel, “Výroba cukru na Zbraslavi – kolébka českého cukrovarnictví”, *Listy cukrovarnické a řepářské*, vol. 124, no. 7–8, 2008, pp. 232–236.
108. GALLOWAY, Jock H., “The Mediterranean Sugar Industry”, *Geographical Review*, vol. 67, no. 2, 1977, pp. 177–194.
109. LALOUX, Ludovic. “La bataille du sucre ou la défaite méconnue de Napoléon I<sup>er</sup>”, *Artefact*, vol. 9, 2018, pp. 35–56.
110. MACHKOVÁ, Hana, “Cukrovarnický průmysl ve Francii”, *Listy cukrovarnické a řepářské*, vol. 129, no. 11, 2013, pp. 356–358, p. 356.
111. MÁLEK, Vlastimil, “České cukrovary v 50. letech 19. století”, *Listy cukrovarnické a řepářské*, vol. 126, no. 9–10, 2010, pp. 280–283.
112. MAREK, Blahoslav, “Čtvrt tisíciletí od narození Jakuba Veitha”, *Listy cukrovarnické a řepářské*, vol. 124, no. 7–8, 2008, p. 240.
113. NYPLOVÁ, Zdenka, “Kapitalistické začátky a krise zbraslavského cukrovaru”, *Český lid*, vol. 37, no. 7/8, 1950, pp. 164–168.
114. SMITH-PETER, Susan, „Sweet development: The sugar beet industry, agricultural societies and agrarian transformations in the Russian empire 1818–1913”, *Cahiers du Monde russe*, vol. 57, no. 1, 2016, pp. 101–124.
115. SMRČEK, Otto, “Výroba strojů a technologického zařízení pro cukrovary v českých zemích v době průmyslové revoluce”, *Listy cukrovarnické a řepářské*, vol. 126, no. 9–10, 2010, pp. 296–299.
116. VIGREUX, Pierre, “Aux origines du savoir agro-alimentaire : la création de l’École Nationale des Industries Agricoles (Douai, 1893)”, *Revue du Nord*, vol. 72, no. 285, 1990, pp. 255–289.

### 7.2.3. University theses

117. BOUŠKOVÁ, Michaela, “Změny v pěstování a zpracování cukrovky”, bachelor’s thesis, Jihočeská univerzita v Českých Budějovicích, Zemědělská fakulta, 2011.
118. DELAUNAY, Bernard, *La pensée technique de l’Académie royale des sciences (1699–1750), Volume 2: annexes*, Paris, 2013, dissertation, Université Paris 1 Panthéon-Sorbonne, Centre d’histoire des sciences et des techniques.
119. DRÁBEK, Jakub, “K vývoji československého cukrovarnictví a řepářství od roku 1918 do konce druhé světové války,” dissertation, Vysoká škola ekonomická v Praze, Národohospodářská fakulta, 2020.
120. FALTUSOVÁ, Simona, “Cukrovarnický průmysl v České republice – geografická analýza”, master’s thesis, Jihočeská univerzita v Českých Budějovicích, Pedagogická fakulta, 2010.
121. FEXO VÁ, Lucie, “Nymburský cukrovar pod vedením Hanuše Karlíka”, master’s thesis, Univerzita Karlova v Praze, Katolická teologická fakulta, 2017.

122. FUTTERA, Ladislav, „140 let vlečkové dopravy do cukrovaru Dobrovice (1870–2010)“, seminar paper, Gymnázium Dr. Josefa Pekaře, 2010.
123. HŮLOVÁ, Vanda, “Vliv pěstování cukrové řepy a výroby cukru na krajinu mikroregionu Hrušovanska”, master’s thesis, Masarykova univerzita, Pedagogická fakulta, 2013.
124. JADLOVSKÝ, Filip, “Vývoj cukrovarů v České republice, jejich historický vývoj a současný stav”, master’s thesis, Masarykova univerzita, Přírodovědecká fakulta, 2020.
125. MADĚRA, Lukáš, “Výroba cukru v českých zemích dříve a nyní”, bachelor’s thesis, Západočeská univerzita v Plzni, Fakulta pedagogická, 2016.
126. NEZDAROVÁ, Michaela, “Proměny cukrovarnictví ve východních Čechách z hlediska historického vývoje vybraných cukrovarů,” bachelor’s thesis, Univerzita Pardubice, Fakulta filozofická, 2014.
127. NOMBLLOT, Matthieu, “1812–1914: un siècle d’histoire et d’utilisation du sucre de betterave”, dissertation, Université de Caen Normandie, Sciences pharmaceutiques, 2019.
128. NOVÁK, M., “Pohled do vývoje cukrovarnictví”, seminar paper, Vysoká škola chemicko-technologická, Katedra učitelství a humanitních věd, 2011.
129. POKORNÁ, Bohdana, “Cukrovarnictví a vznik železniční sítě na Novobydžovsku”, bachelor’s thesis, Univerzita Hradec Králové, Filozofická fakulta, 2015.

## 7.2.4. Websites

### 7.2.4.1. Biographies

130. “Andreas Caesalpinus.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/andreas-caesalpinus>.
131. “Carolus Linnaeus.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/history/news-wires-white-papers-and-books/carolus-linnaeus>.
132. “Daléchamps, Jacques.” *Encyclopedia.com*. Accessed on 10.03.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/dalechamps-jacques-or-jacobus-dale-champius>.
133. “Derosne, Charles.” *Encyclopedia.com*. Accessed on 03.05.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/derosne-louis-charles>.
134. “Duhamel Du Monceau, Henry-Louis.” *Encyclopedia.com*. Accessed on 13.03.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/duhamel-du-monceau-henri-louis>.

135. “Hermbstaedt, Sigismund Friedrich.” *Encyclopedia.com*. Accessed on 25.04.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/hermbstaedt-sigismund-friedrich>.
136. “Jean-Baptiste van Mons.” *Nature*. Accessed on 07.05.2022. <https://www.nature.com/articles/150286c0>.
137. “Joseph Louis Proust.” *Encyclopedia.com*. Accessed on 19.06.2022. <https://www.encyclopedia.com/people/science-and-technology/chemistry-biographies/joseph-louis-proust>.
138. “Koppy, Moritz von.” *Deutsche Biographie*. Accessed on 03.05.2022. <https://www.deutsche-biographie.de/sfz44533.html>.
139. “Lovits (Lowitz), Johann Tobias.” *Encyclopedia.com*. Accessed on 14.04.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/lovits-lowitz-johann-tobias>.
140. “Malabaila de Canal, Joseph Emanuel.” *BOTANY.cz*. Accessed on 24.05.2022. <https://botany.cz/cs/malabaila/>.
141. “Nicolas Deyeux.” *Napoléon & Empire*. Accessed on 17.06.2022. <https://www.napoleon-empire.net/personnages/deyeux.php>.
142. “Parmentier, Antoine-Augustin.” *Encyclopedia.com*. Accessed on 19.06.2022. <https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/parmentier-antoine-augustin>.
143. “Schmidt, Franz Willibald.” *BOTANY.cz*. Accessed on 16.06.2022. <https://botany.cz/cs/schmidt/>.

#### **7.2.4.2. Others**

144. Farm to Table: Sugar Beet Harvest. *The Sugar Association*. Accessed on 10.03.2022. <https://www.sugar.org/blog/farm-to-table-sugar-beet-harvest/>.
145. GANGI, Roberta. “Sugar cane in Sicily”. *Best of Sicily Magazine*. Accessed on 15.12.2021. <http://www.bestofsicily.com/mag/art143.htm>.
146. GANIÈRE, Paul. “La bataille du sucre”. *Napoleon.org*. Accessed on 28.05.2022. <https://www.napoleon.org/histoire-des-2-empires/articles/la-bataille-du-sucre/>.
147. Historical Currency Converter. *Historical Statistics*. Accessed on 13.03.2022. <https://www.historicalstatistics.org/Currencyconverter.html>.
148. History of Sugar. *Südzucker Group*. Accessed on 03.05.2022. <https://www.suedzucker.de/en/company/history/history-of-sugar>.
149. History of sugarbeets. *CropWatch*. Accessed on 15.05.2022. <https://cropwatch.unl.edu/history-sugarbeets>.
150. Jednotky, převody jednotek. *Jednotky*. Accessed on 05.04.2022. <https://www.jednotky.cz>.

151. Les débuts du sucre. *Association pour la Sauvegarde de la Sucrierie de Francières*. Accessed on 29.06.2022. <https://sucrierie-francieres.fr/les-debuts-du-sucre/>.
152. L'histoire du dimanche – Le sucre de betterave, une production imposée par Napoléon lors du blocus continental de 1806. *France 3 Régions*. Accessed on 28.06.2022. <https://france3-regions.francetvinfo.fr/hauts-de-france/l-histoire-du-dimanche-le-sucre-de-betterave-une-production-imposee-par-napoleon-lors-du-blocus-continental-de-1806-2074036.html>.
153. Measurements Converter. *Convert-me*. Accessed on 07.04.2022. <https://www.convert-me.com/en/>.
154. “Molasses.” *Encyclopedia.com*. Accessed on 16.06.2022. <https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/food-and-cooking/molasses>.
155. ROUET, Christian, “Une manufacture de sucre à Rambouillet”. *Le Pays d'Yveline*. Accessed on 26.06.2022. <https://yveline.org/une-manufacture-de-sucre-a-rambouillet/>.
156. SILBERMAN, Neil. „Crusaders, Venetians, and Sugar Cones”. Hanover, 1986. Accessed on 14.3.2022. <http://www.icwa.org/wp-content/uploads/2015/10/NAS-20.pdf>.
157. “Spodium.” *Leporelo.info*. Accessed on 03.07.2022. <https://leporelo.info/spodium>.
158. Sucre de betterave. *Hussardises*. Accessed on 21.04.2022. <https://les-apn-belgique.webnode.fr/news/sucre-de-bettrave/>.
159. ‘Sweet salt’: Sugar Production in Medieval Cyprus. *Fergus Murray*. Accessed on 15.12.2021. <https://www.fergusmurraysculpture.com/cyprus/history-notes-12-pages/viii-sweet-salt-the-medieval-sugar-industry/>.
160. TESTOT, Laurent. “Le prix du sucre”. *Histoire Globale*. Accessed on 15.12.2021. [http://blogs.histoireglobale.com/le-prix-du-sucre\\_844](http://blogs.histoireglobale.com/le-prix-du-sucre_844).
161. The French Republican calendar. *Napoléon & Empire*. Accessed on 04.05.2022. <https://www.napoleon-empire.com/republican-calendar.php>.
162. Vilmorin Clause et Cie. *Encyclopedia.com*. Accessed on 26.05.2022. <https://www.encyclopedia.com/books/politics-and-business-magazines/vilmorin-clause-et-cie>.

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## 8. Appendices

TYPE OF ROOM	USED FOR	SIZE (L x W)
covered shed	carts with beets + wood	19.5 x 7.1 m
corridor with 6 compartments	preserving the beets	48.7 x 5.8 m
room with a beet gin	crushing the beets	11.7 x 6.5 m
laundry room	drying and extracting juice	18.2 x 11.7 m
acidifying room	acidifying juice	5.8 x 4.8 m
laboratory	clarifying and evaporating	14.6 x 11.7 m
storeroom	storage of canvases and utensils	5.8 x 5.8 m
fuel room	storage of combustible	5.2 x 5.8 m
fermentation room	barrels with malt	18.2 x 6.5 m
distillation room	manufacture of spirits	11.7 x 8.1 m
vinegar room	manufacture of vinegar	11.7 x 9.7 m
cellar	storage of liquids	18.1 x 5.8 m
<b>Baron Moritz de Koppys factory in total</b>		<b>84.4 x 20.1 m</b>

The detail of Achard's manual can be seen in the indication of the dimensions of Baron de Koppys sugar factory, including the location of the rooms and the description of the processes that took place in them. The proportions then served as orientation for other European facilities.<sup>i</sup>

OFFER	VALUE IN GULDEN	VALUE IN €
<b>initial share capital</b>	150,000	911,300
<b>the whole refinery</b>	23,800	144,593
<b>machines &amp; equipment</b>	17,944.44	109,018
<b>office trifles</b>	300.31	1,824
<b>goods in Prague warehouse</b>	7,199.55	43,739
<b>goods in Zbraslav warehouse</b>	1,513.40	9,194
<b>cash &amp; stock</b>	17,623.57	107,069
Pricing of the Zbraslav refinery.	<b>TOTAL</b>	<b>1,326,737</b>

The pricing of the first Bohemian refinery at the auction indicated the amount of capital invested in the business, which was certainly not small, and only the most successful producers could afford to operate it.<sup>ii</sup>

FACTORY	FROM	TO	FACTORY	FROM	TO
<b>Žáky</b>	1810	1814	<b>Prague-Petynka</b>	1811	1813
<b>Liběchov</b>		1821	<b>Prague-Kanálka</b>		1814
<b>Semily</b>	1811	1812	<b>Blatná</b>	1812	1813
<b>Čáslav</b>		1813	<b>Bukovany</b>		1813
<b>Křesetice</b>		1813	<b>Mitrovce</b>		1816
<b>Kbely</b>		1814	<b>Troja</b>		1816
<b>Chlumec</b>		1813	<b>Zbraslav</b>		1813
List of Bohemian sugar factories.			<b>Žleby</b>		1816

Overview of established sugar factories in Bohemia. Similar to France, the year 1811 started a sugar fever, that, however, did not last long due to the political and economic situation.<sup>iii</sup>

# DÉCRET IMPÉRIAL.

Au Palais des Tuileries, le 25 Mars 1811.

NAPOLÉON, EMPEREUR DES FRANÇAIS, ROI D'ITALIE, Protecteur de la confédération du Rhin, Médiateur de la confédération Suisse, etc.

Sur le rapport de la commission nommée à l'effet d'examiner les moyens proposés pour naturaliser sur le continent de notre Empire, le sucre, l'indigo, les cotons, et diverses autres productions des deux Indes;

Sur la présentation qui nous a été faite d'une quantité considérable de sucre de betterave raffiné, cristallisé, et ayant toutes les qualités et propriétés du sucre de canne;

Sur la présentation qui nous a été également faite au conseil de commerce, d'une grande quantité d'indigo extrait de la plante du pastel, que produisent en abondance les départemens du Midi de notre Empire, lequel indigo a toutes les propriétés de l'indigo des deux Indes;

Ayant droit de compter qu'au moyen de ces deux précieuses découvertes, notre Empire ne tardera point à être affranchi d'une exportation de cent millions, nécessaire jusqu'à ce jour, pour fournir à sa consommation en sucre et en indigo,

NOUS AVONS DÉCRÉTÉ ET DÉCRÉTONS ce qui suit :

ART. 1<sup>er</sup>. Il sera mis dans notre Empire jusqu'à la concurrence de 32,000 hectares en culture de betteraves propres à la fabrication du sucre.

2. Notre ministre de l'intérieur fera la distribution de ces 32,000 hectares entre les départemens de notre Empire, en prenant en considération les départemens où la culture du tabac était établie, et dont les terres sont, par leur nature, plus favorables à la culture de la betterave.

3. Nos préfets prendront des mesures pour que les quantités d'hectares affectés à leurs départemens se trouvent en pleine culture cette année, et au plus tard l'année prochaine.

4. Il sera mis dans notre Empire, jusqu'à concurrence d'un nombre d'hectares déterminé, en culture de pastel propre à la fabrication de l'indigo, et dans la proportion de la quantité nécessaire à nos manufactures.

5. Notre ministre de l'intérieur en fera la distribution entre les départemens de notre Empire, en prenant particulièrement en considération les départemens au-delà des Alpes et ceux du Midi, où cette culture a fait autrefois de grands progrès.

6. Nos préfets prendront des mesures pour que les quantités d'hectares affectés à leurs départemens se trouvent en pleine culture au plus tard l'année prochaine.

7. La commission désignera, avant le 4 mai, les lieux les plus convenables pour l'établissement de six écoles expérimentales, où l'on enseignera la fabrication du sucre de betterave, conformément aux procédés des chimistes.

8. La commission désignera également, et à la même époque, les lieux les plus convenables pour l'établissement des quatre écoles expérimentales, où l'on enseignera l'extraction de la fécule du pastel et la fabrication de l'indigo, suivant les procédés approuvés par elle.

9. Notre ministre de l'intérieur fera connaître aux préfets les lieux où seront placés ces écoles et où devront être envoyés les élèves destinés à cette fabrication. Les propriétaires et cultivateurs qui voudront assister au cours desdites écoles expérimentales, y seront admis.

10. Les sieurs Barruel et Isnard, qui ont perfectionné les procédés de

l'extraction du sucre de betterave, seront spécialement chargés de la direction de deux des six écoles expérimentales.

11. Notre ministre de l'intérieur leur fera donner, en conséquence; en gratification, la somme nécessaire pour la formation desdits établissemens, laquelle somme sera prise sur le fonds d'un million que nous mettons à la disposition dudit ministre, au budget de la présente année 1811, pour l'encouragement de la fabrication du sucre de betterave et de l'indigo du pastel.

12. A compter du 1<sup>er</sup> janvier 1813, et sur le rapport que nous en fera notre ministre de l'intérieur, le sucre et l'indigo des deux Indes seront prohibés et considérés comme marchandises de fabrication anglaise, ou provenant du commerce de l'Angleterre.

13. Notre ministre de l'intérieur est chargé de l'exécution du présent décret.

Signé NAPOLÉON.

Par l'Empereur :

Le Ministre Secrétaire d'état. Signé H. B. DUC DE BASSANO.

NOUS COMTE DE L'EMPIRE, Conseiller d'État, Préfet du département des Bouches-du-Rhône, Commandant de la Légion-d'Honneur, Vu le Décret ci-dessus;

La Lettre de Son Exc. le Ministre de l'intérieur, du 28 mars 1811, portant que l'intention de SA MAJESTÉ est que le département des Bouches-du-Rhône ensemence au moins 200 hectares de terre en betteraves pour la fabrication du sucre,

ARRÊTONS :

ARTICLE PREMIER.

Le Décret du 25 mars dernier sera imprimé, publié et affiché dans toutes les Communes du Département.

2.

Les instructions relatives à la manière de cultiver la betterave, aux procédés à suivre pour la fabrication du sucre, et le mémoire contenant les résultats des expériences faites par le Gouvernement, sur cette fabrication, seront déposés aux Secrétariats des Sous-préfetures et des Mairies de Marseille, Aix, Saint-Remi, Arles et Tarascon, pour être communiqués aux personnes qui voudront se livrer à la culture de la betterave et à la fabrication du sucre.

3.

L'Académie de Marseille et la Société des Arts, Lettres et Agriculture d'Aix, seront invitées à répandre ces instructions et à donner des encouragemens.

4.

Les Sous-préfets sont chargés de l'exécution du présent Arrêté, qui sera imprimé, publié et affiché.

Fait à Marseille, en l'Hôtel de la Préfecture, le 5 Avril 1811.

A. C. THIBAudeau.

DE L'IMPRIMERIE DE MOSSY, RUE D'AUBAGNE, N° 45.

A ground-breaking decree of March 1811, which introduced the establishment of beet sugar mills with the help of reserved hectares for the cultivation of the crop, the establishment of experimental schools and the granting of high financial incentives.<sup>iv</sup>



SOUS - PREFECTURE D'AIX.

# INSTRUCTION POUR LA CULTURE DES BETTERAVES.

Tous les terrains qui ont un peu de profondeur, arrosables ou non, sont propres à la culture de la Betterave.

Les terres sablonneuses et légèrement humides sont les plus propres à cette culture.

Si la terre est légère et sablonneuse, il lui faut peu de labour et plus d'engrais; si elle est forte et compacte, il faut qu'elle soit défoncée et légèrement fumée.

Le mois de Mars et la première moitié d'Avril sont le tems propice à cette culture, et l'ensemencement peut être retardé sans inconvénient jusqu'au 15 ou 20 de ce dernier mois.

La terre préparée pour recevoir la semence doit être parallèlement sillonnée; les sillons doivent avoir, de l'un à l'autre, environ un demi-mètre de distance.

On peut, dans chaque sillon, semer la graine comme on sème les haricots, ou faire, avec le pouce, des trous peu profonds, à un demi-mètre l'un de l'autre, dans chacun desquels on dépose deux graines, que l'on recouvre ensuite.

La meilleure méthode est d'établir d'abord des planches dans un carré de terre à l'arrosage et à une bonne exposition; et après avoir fait lever la graine, de repiquer les plançons. Dans la terre préparée pour la culture en grand, on arrosera, dans le moment, cette plantation, et on n'aura plus besoin, jusqu'à la récolte, que de veiller au sarclage.

Les propriétaires et cultivateurs qui, adoptant cette dernière méthode, pourront continuer l'arrosage, sont assurés d'un succès plus complet et d'une récolte plus abondante.

Quelque méthode qu'ils adoptent, un kilogramme de graines suffit à l'ensemencement d'un hectare de terrain.

La méthode du repiquage en exige beaucoup moins.

La préparation des terres pour cette culture est un excellent assolement pour ces terres, à quelque culture qu'on les destine l'année suivante.

Les feuilles de la Betterave sont un très-bon fourrage pour le gros bétail. Sa racine aura des débouchés avantageux au cultivateur à l'époque de la récolte.

Outre les fabriques établies en vertu des licences accordées par S. M., pour l'extraction du sucre de Betteraves, il y aura des fabrications de syrop de Betteraves qui, d'après la décision de S. M., en date du 17 février dernier, pourront s'établir sur les lieux même, librement et sans besoin de licences, par les particuliers qui entreprendront cette spéculation avantageuse, qui augmentera le produit des fabriques de sucre, diminuera les frais de transport des matières premières, et multipliera les débouchés pour la vente de la récolte.

Il sera rendu un compte fidèle: par les Maires, au Sous-Préfet; par le Sous-Préfet, à M. le Comte, Préfet de ce Département; et par ce Magistrat, à S. E. le Ministre du Commerce et des Manufactures, du zèle que chaque particulier aura montré dans cette circonstance, des travaux auxquels il se sera livré, des succès qu'il aura obtenus, des obstacles même qu'il n'aura pu vaincre.

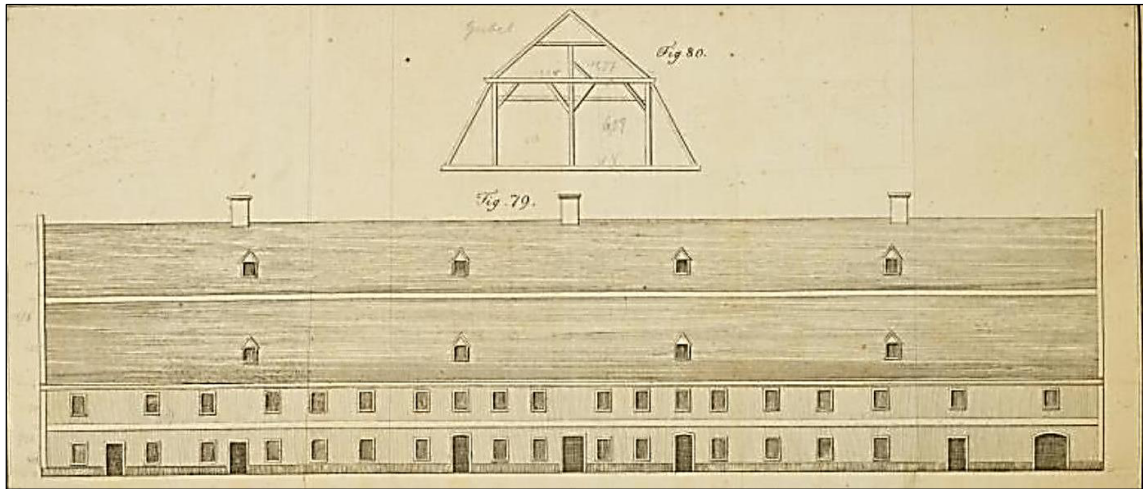
Des exemplaires de la présente Instruction resteront déposés au Secretariat de chaque Mairie de l'arrondissement, et affichés dans les lieux les plus apparents de chaque Commune.

A Aix, en Sous-Préfecture, le 16 Mars 1812.

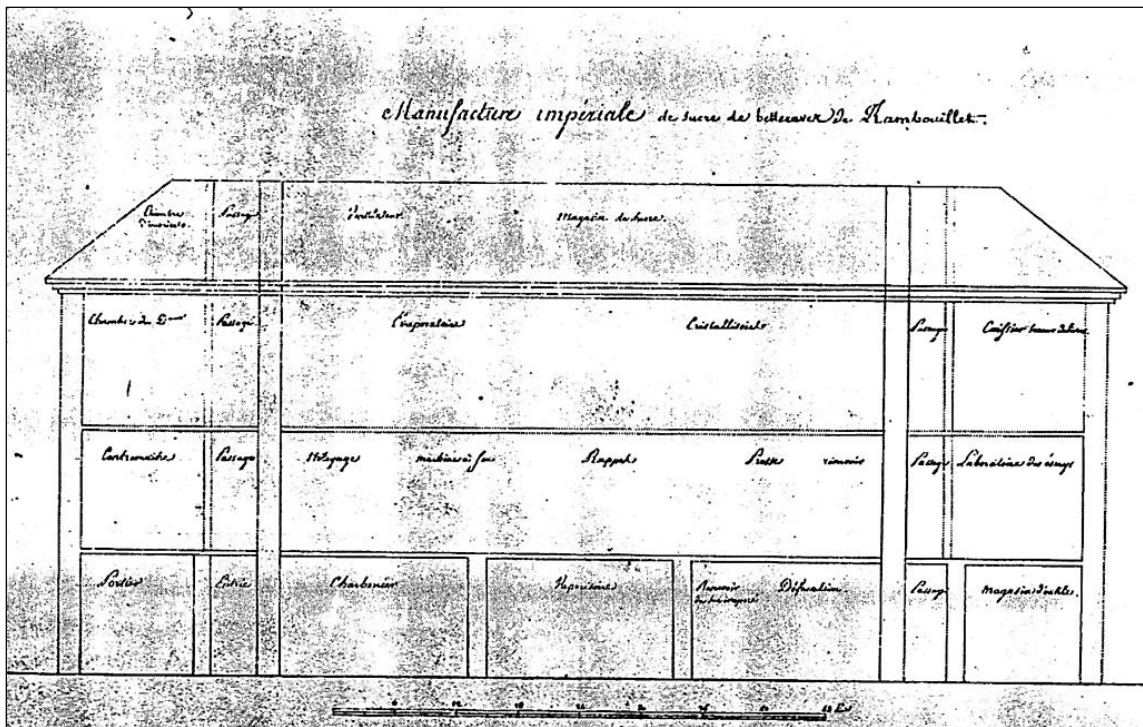
Le Baron de l'Empire, Sous-Préfet d'Aix,  
D'ARBAUD - JOUQUES.

A AIX, chez Gaspard MOURET, Imprimeur. 1812.

In direct response to the issuance of the imperial decree, the sub-prefecture of Aix<sup>v</sup> stated the exact procedure for beet cultivation, which was intended to stimulate farmers' interest in this crop.



A depiction of one of the first Prussian beet sugar factories (1805), in Achard's manual, serving as an example for the construction of other facilities. Below is the construction plan of one such factory in Rambouillet (1812), which was largely inspired by the Prussian plans.<sup>vi</sup>





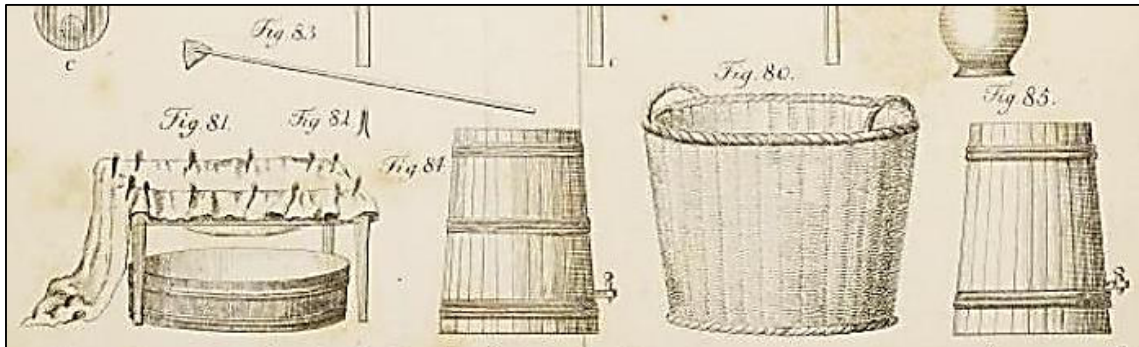
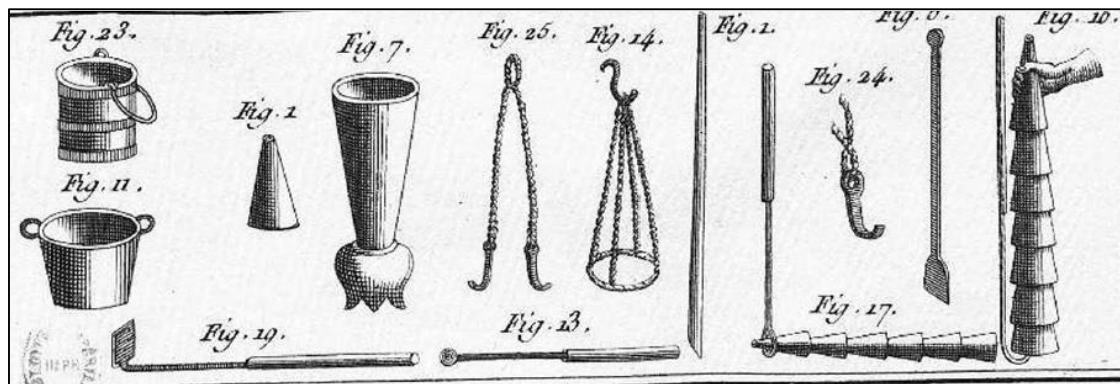


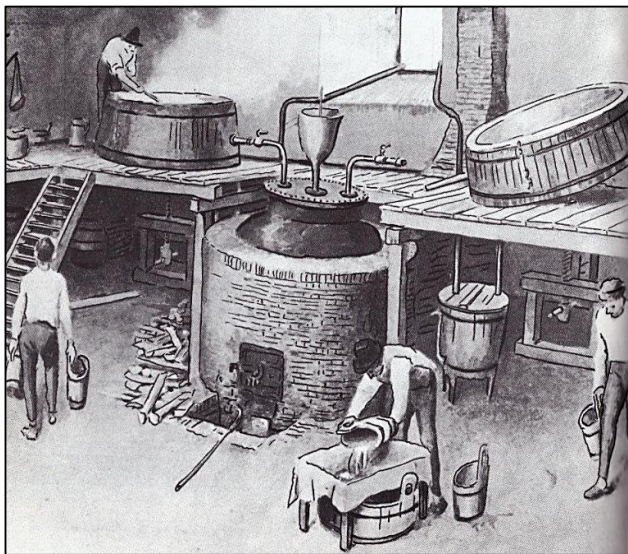
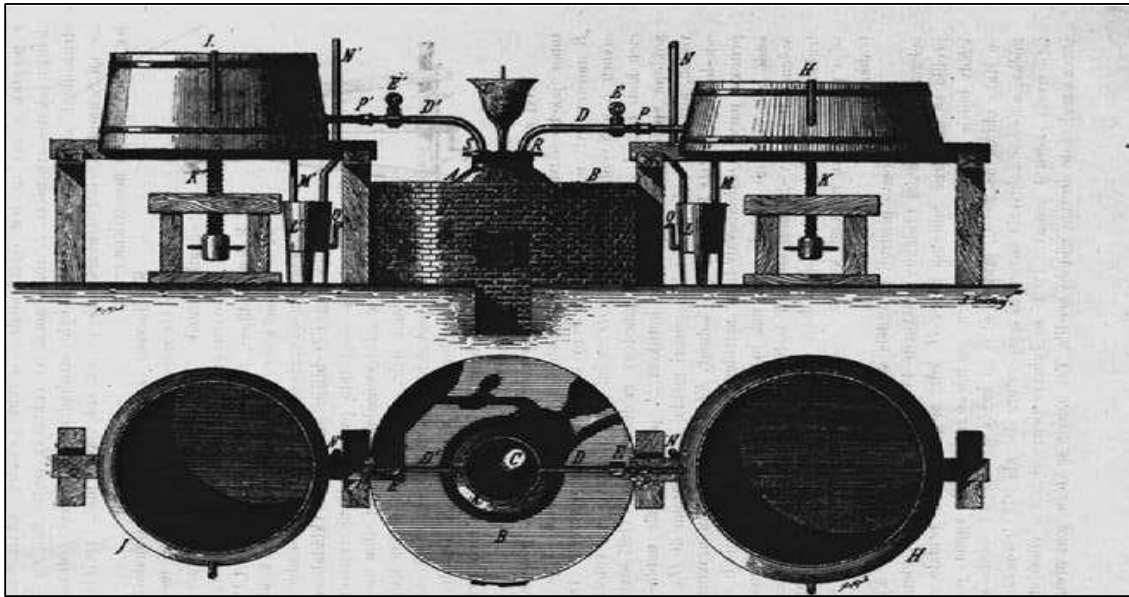
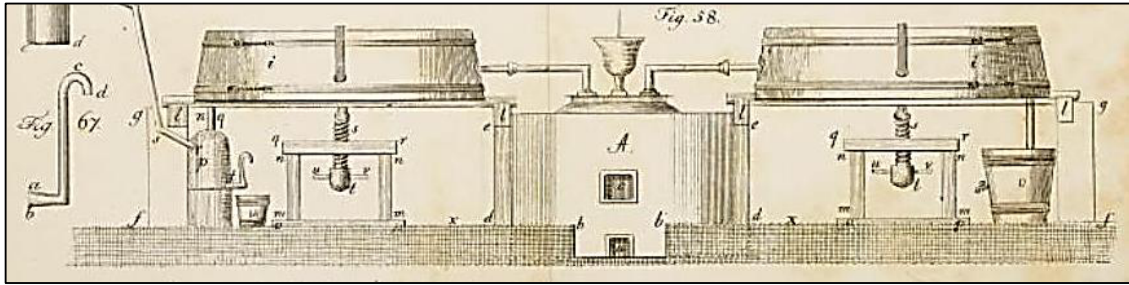
Illustration of the first tools for extracting beet sugar. Achard's manual (1805) describes and then graphically presents the tools needed for the individual processes: a cloth with a bucket into which impure juice was squeezed, wicker baskets for bringing beets and coal to the facility, or buckets for extinguishing fires and transferring juices at different stages. The re-edition of du Monceau's treatise on beet processing (1812) already offers an expanded range of tools, some of which have received improvements, such as hanging holders for lump-shaped moulds and special mould shapes.<sup>vii</sup>



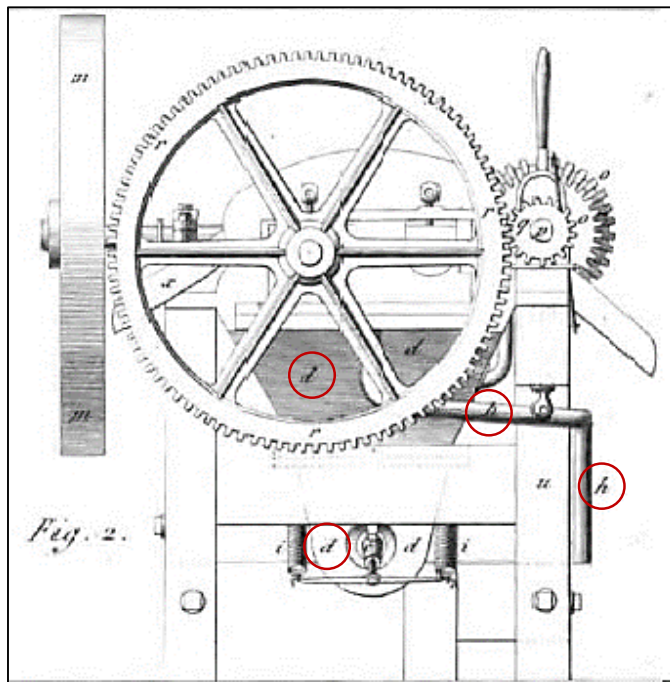
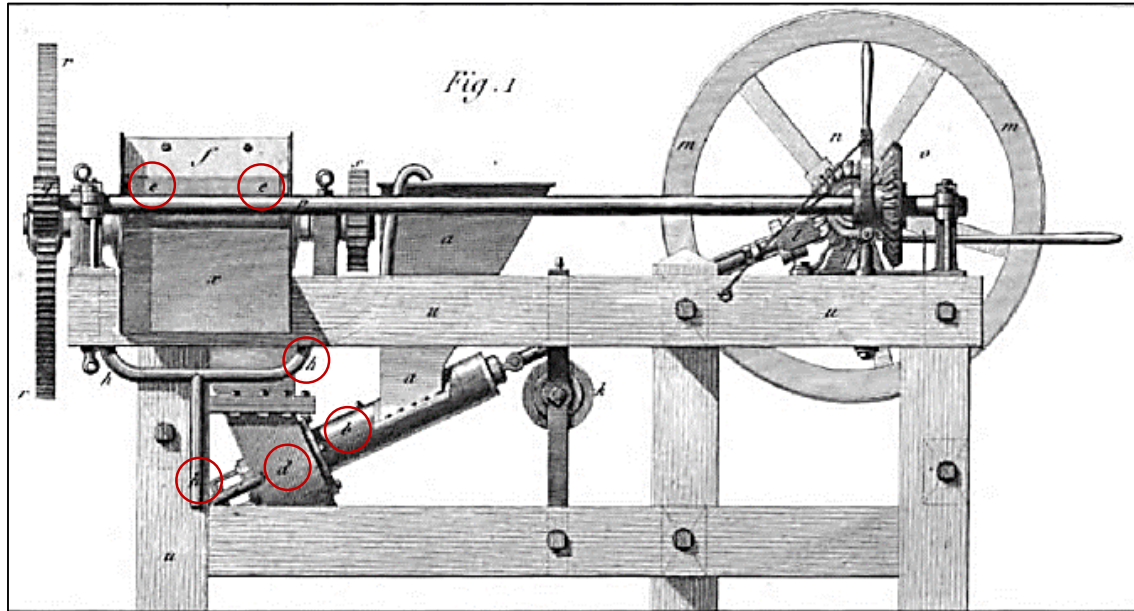


A depiction of a Bohemian “mobile laboratory” in the middle of maple groves. Several decades old maples were bored and the sap that leaked out was further processed in the same way as cane or beet juice. Due to the lack of old – and therefore fertile trees full of sap – this crop was abandoned.<sup>viii</sup>

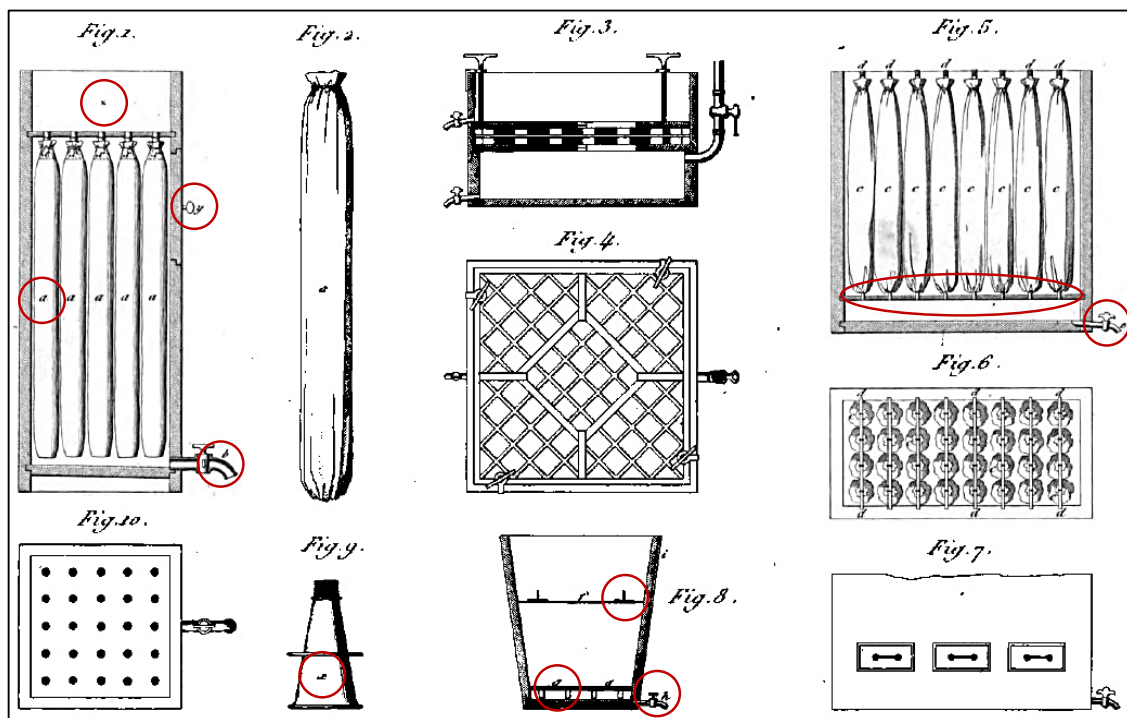




The importance of the transfer of not only machines, but also technology is demonstrated by the plans of Achard's equipment for thickening beet syrup. The image above (1805) is very similar to the image of the equipment in Canal's sugar factory, which began to be used after the return of the examination committee led by prof. Schmidt in 1811. The image on the left then demonstrates the use of the device in action.<sup>ix</sup>



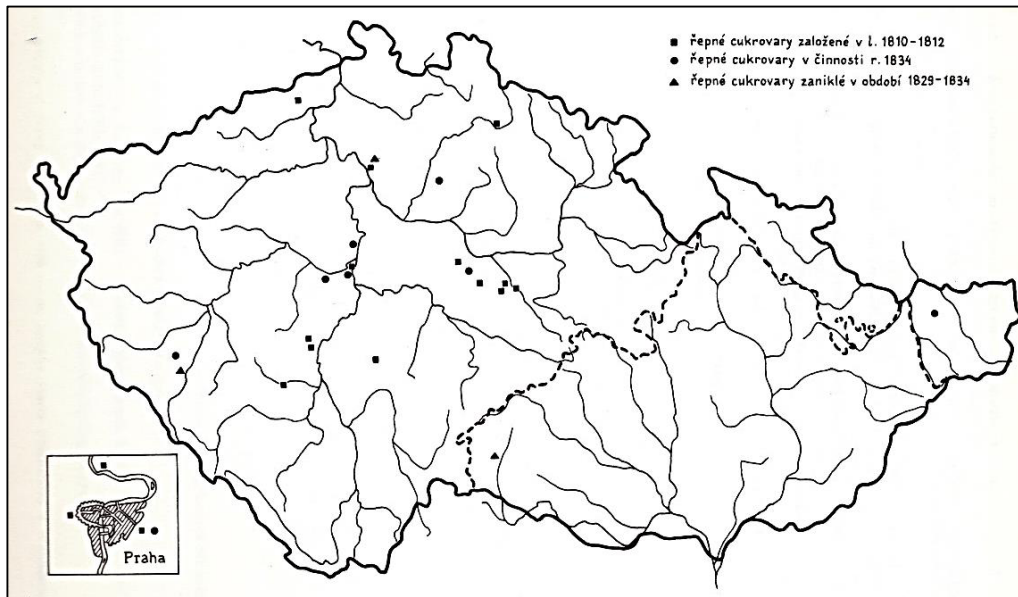
The prototype of Pecqueur's press<sup>x</sup> was used from the 1820s. Pieces of the washed beets were placed in the container *f*, where they were crushed by very thick copper cylinders *e*. The squeezed juice flowed through the tubes *h* into the prepared containers. The beet residues fell out through hole *d*, where the larger pieces were crushed by piston *b* to obtain as much of the remaining juice as possible.



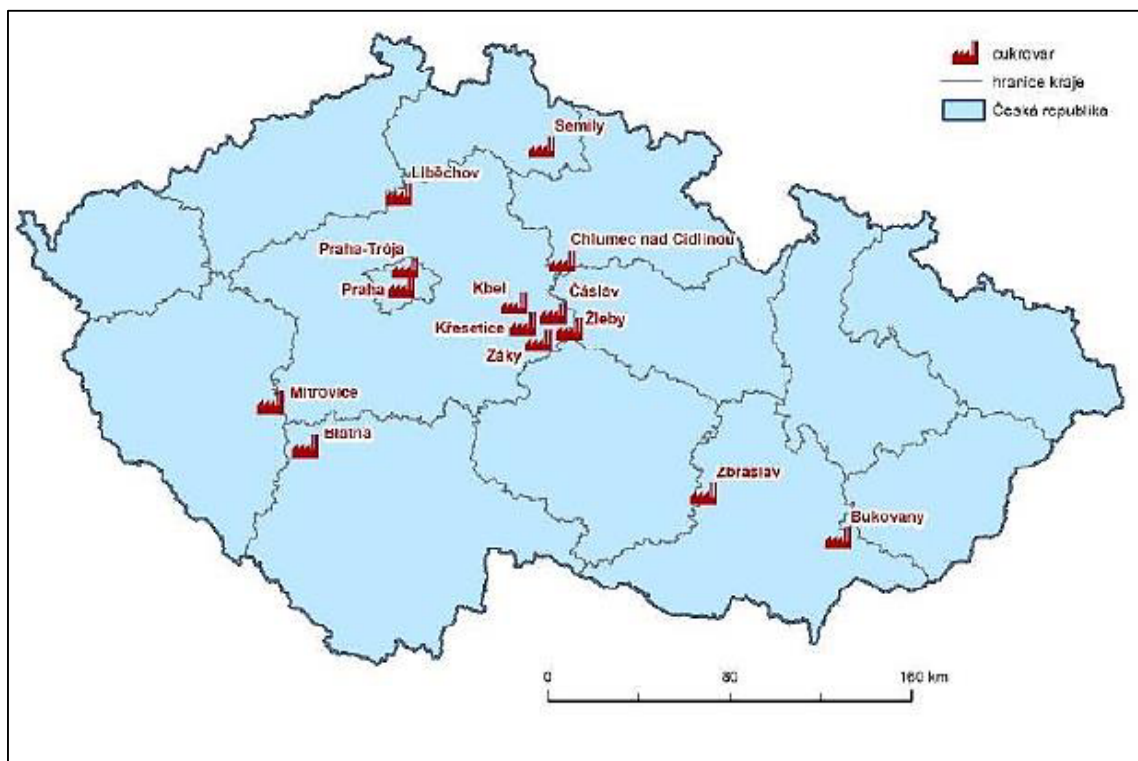
Use of innovative Taylor filters<sup>x1</sup> (1) serving for better cleaning of beet juices. The prepared beet juice was poured through the upper space *x*, which was absorbed into the bags *a* attached by rings on the horizontal tube. The purified juice was drained with the help of a tap *b*. The ends of unused clean bags (2) were adapted through the hole *y*. Another kind of filter (3) was made up of two grids (grand plan, 4) brought together by pressure screws, between which a porous substance, cotton, was placed. Detail of a tube with space *x* on which the bags *a* were hang (9), fastening of the slats (7) and a ground plan (10) are also represented.

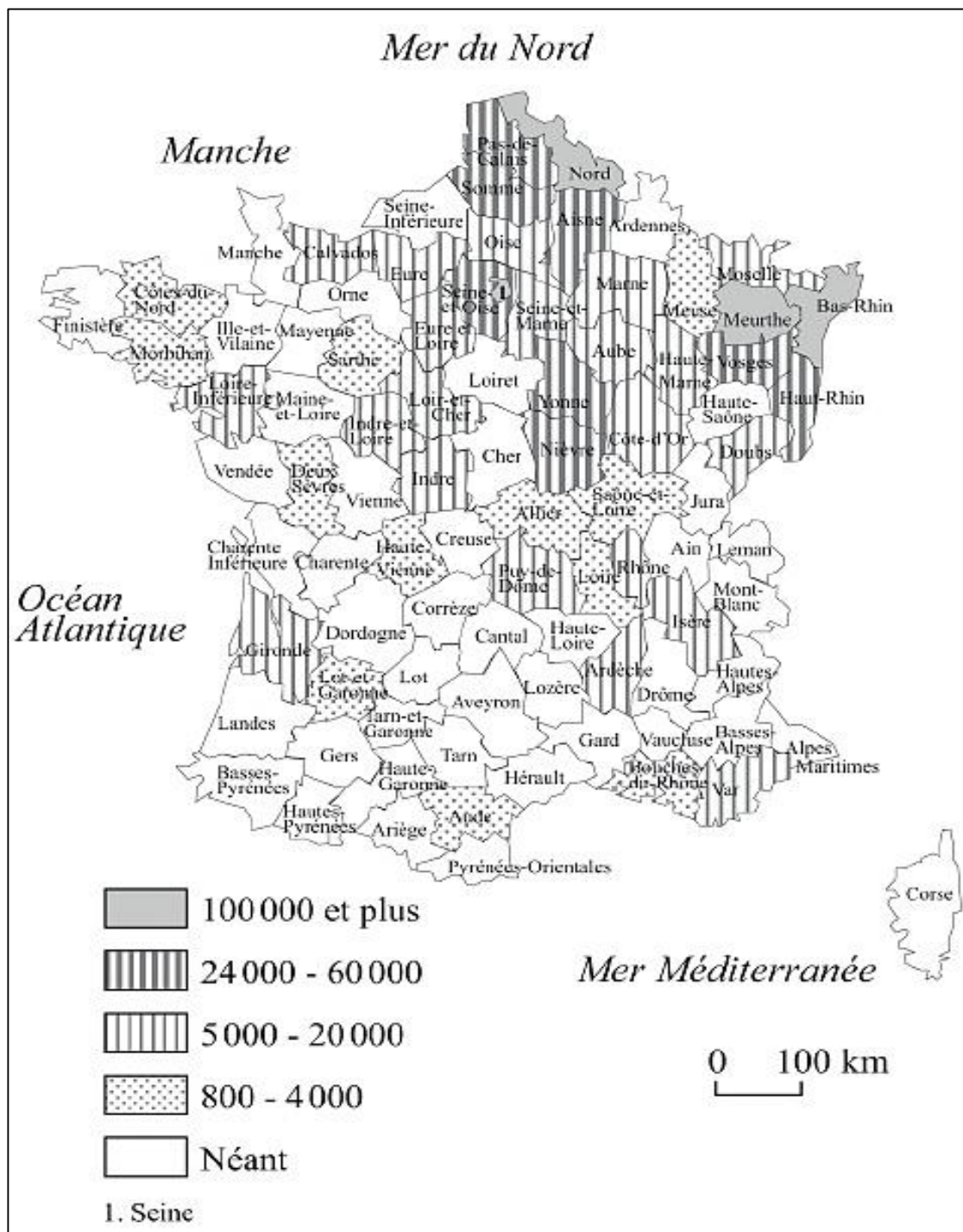
Modified Taylor filter (5) made the juice filtering from outside to inside (soaking in the bags and flowing through the pipes), instead of obsolete filtering from inside to outside (seeping from the bags); ground plan of the filter (6). The French version, a Dumont filter (8), consisted of a lower grid *g*, upper grid *i* and a tap *h*.



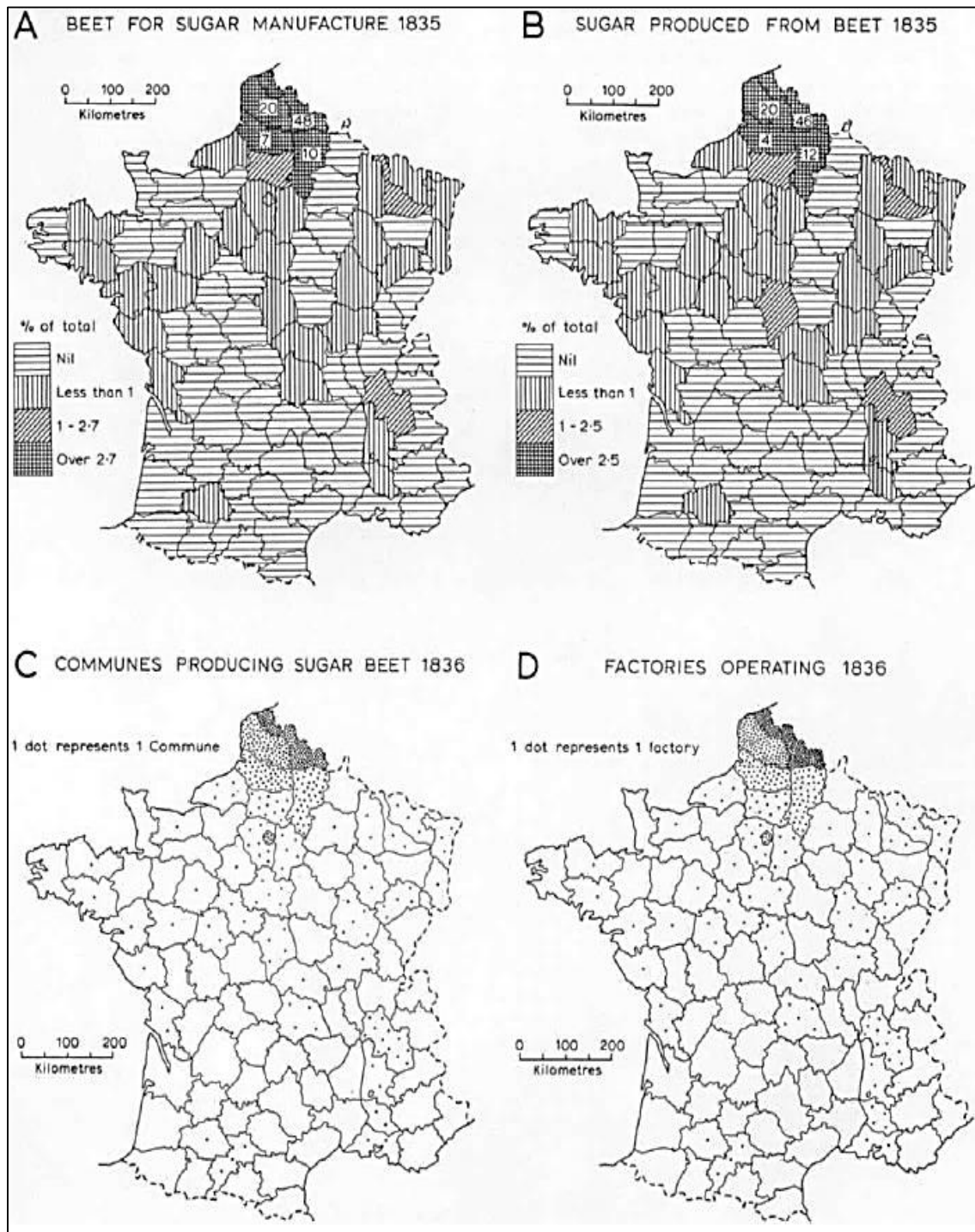


Distribution of the first sugar factories in the Czech lands. In the first period (1810–1812) it can be clearly seen that they were established mainly in Bohemia (separated from Moravia by a dashed line), from 1829 a few sugar factories were also established in eastern Moravia. However, all of them soon disappeared due to the lack of knowledge of their founders and due to considerable isolation from other facilities. The map below shows the distribution of sugar factories in 1812 in the regions of the current Czech Republic.<sup>xii</sup>





Variously coloured map according to the amount of sugar produced in the French departments in 1812. While the southern departments were profitable for grape harvests and grape sugar production, the northern departments were the most suitable for beet. They were adjacent to today's Belgium, where beet was cultivated for a long time, so it is easy that the tradition of its cultivation facilitated the subsequent production of beet sugar.<sup>xiii</sup>



The distribution of French beet sugar factories in the second wave in the 1830s. It is evident that the trend remained the same and new facilities were created again mainly in the northern and north-eastern departments.<sup>xiv</sup>

YEAR	1811	1812	1813	1814	1815				
<b>FACTORIES</b>	40	192	↑ 380%	300+	↑ 56%	213	↓ 29 %	200	↓ 6%
<b>SUGAR IN t</b>	271	1,615	↑ 496%	2,850	↑ 76.5%	4,000	↑ 40%	2,500	↓ 37%

French factories and produced beet sugar.

Comparison of the number of French<sup>xv</sup> and Czech<sup>xvi</sup> factories together with the amount of sugar produced. In the Czech lands, records on the amount of sugar produced are scarce, so the results of the most productive facilities are presented. The large number of factories in France was caused by the more benign economic policy of the government, which, in contrast to the Austrian or Czech approach, was responsible for the proper establishment of a new industry.

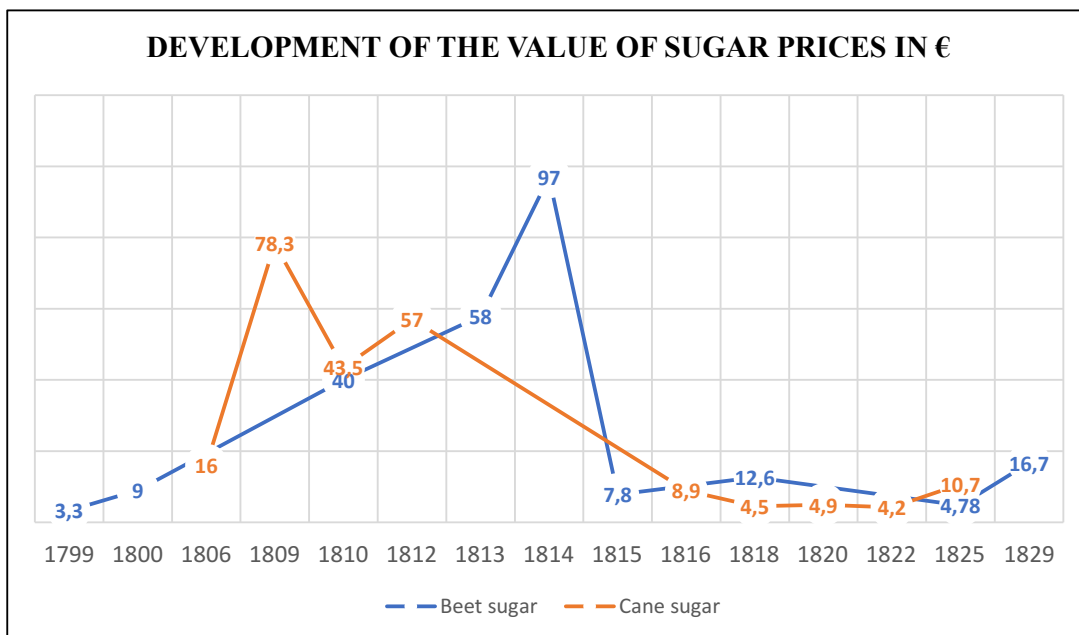
	ŽÁKY	KBELY	ČÁSLAV	LIBĚCHOV	CHLUM	TOTAL	
<b>PLANTED</b>	23 ha	9.6 ha	19.4 ha	22.8 ha	3.8 ha	<b>78.6 ha</b>	<b>1811</b>
<b>REAPED</b>	336 t	115.2 t	228.5 t	1,074 t	82.7 t	<b>1836.4 t</b>	
<b>PLANTED</b>	14.3 ha	8.4 ha	3.4 ha	11.5 ha	20.7 ha	<b>58.3 ha</b>	<b>1812</b>
<b>USED</b>	500 t	67.5 t	48 t	470 t	192 t	<b>1,364 t</b>	
<b>SUGAR</b>	10 t	1 t	–	2.5 t	100 kg	<b>13.6 t</b>	
<b>PLANTED</b>	11.5 ha	9.4 ha	failed	11.5 ha	20.1 ha	<b>52.5 ha</b>	<b>1813</b>
<b>USED</b>	329 t	62 t		226.1 t	381 t	<b>998.1</b>	
<b>SUGAR</b>	5.6 t	0.9 t		3.1 t	2.9 t	<b>12.5</b>	

The most prosperous Czech sugar factories and their yields (1811–1813).

ITEM	FRANCS	€	ITEM	FRANCS	€
factory expenses	6,800	48,536 €	machine repair	4,000	28,551 €
value of the roots	74,582.19	532,342 €	objects to renew	817	5,831 €
interest on a movable	6,000	42,826 €	<b>expenditure</b>	<b>136,081,79</b>	<b>971,305 €</b>
staff and salary	17,025	121,519 €	pulp profits	38,673.90	276,041 €
combustible costs	20,587.60	146,947 €	<b>final revenues</b>	<b>260,840.70</b>	<b>1,861,790 €</b>
miscellaneous	6,270	44,753 €	<b>final costs</b>	<b>97,407.89</b>	<b>695,264 €</b>
<b>TOTAL PROFIT</b>	<b>163,432.81 francs</b>		=	<b>1,166,526 €</b>	

Duhamel's accounting list of expenditures and revenues of his sugar factory.

Over time, the help manuals were also improved. An example is Duhamel's detailed and comprehensive treatise, in which he systematically proceeds from the planting of seeds through the various processes of beet juice processing to crystallization. From the accounting lists, it is possible to read how much the individual items needed to operate the beet sugar factory cost when processing around four thousand tons of beet (1825).<sup>xvii</sup>



Comparison of cane<sup>xviii</sup> and beet<sup>xix</sup> sugar prices per kg in euros (1799–1829).



- <sup>i</sup> **Achard**, *Le sucre européen*, pp. 94–98.
- <sup>ii</sup> **Neumann**, *Nástin dějin*, p. 9 and **Nyplová**, “Kapitalistické začátky“, p. 167.
- <sup>iii</sup> **Boušková**, “Změny v pěstování“, p. 11, **Dudek**, *Vývoj*, pp. 21–24, **Fexová**, “Nymburský cukrovar“, p. 17, **Froněk**, “200 let“, p. 358, **Hůlová**, “Vliv pěstování“, p. 20, **Jadlovský**, “Vývoj cukrovarů“, pp. 33–34 and **Neumann**, *Nástin dějin*, p. 15, 36–39 and 48–54.
- <sup>iv</sup> **Thibaudeau**, *Décret impérial au Palais des Tuileries, le 25 Mars 1811*.
- <sup>v</sup> *Instruction pour la culture des betteraves*, Aix, Gaspard Mouret, 1812.
- <sup>vi</sup> **Achard**, *Die europäische Zuckerfabrikation*, tab. X and Archives nationales, (Pierrefitte-sur-Seine), Maison de l’Empereur (Premier Empire) O/2 969, ‘Manufacture impériale de sucre de betteraves de Rambouiller’.
- <sup>vii</sup> **Achard**, *Die europäische Zuckerfabrikation*, tab. VII and **Monceau**, *Art de raffiner le sucre*, planche IV.
- <sup>viii</sup> **Diviš**, *Cukrovarnictví*, p. 27.
- <sup>ix</sup> **Achard**, *Die europäische Zuckerfabrikation*, tab. VI, **Dudek**, *Vývoj*, p. 193-8 and **Neumann**, *Nástin dějin*, p. 42.
- <sup>x</sup> DUMAS, Jean-Baptiste, *Traité de chimie appliqué aux arts. Atlas*, Paris, 1828, planche 96.
- <sup>xi</sup> *Ibid*, planche 98.
- <sup>xii</sup> **Dudek**, *Vývoj*, p. 180 and **Jadlovský**, “Vývoj cukrovarů“, p. 35.
- <sup>xiii</sup> Archives nationales (Pierrefitte-sur-Seine), F/20 560, ‘Tableau de l’étendue de la culture des betteraves, en 1812, indiquant le nombre de sucreries établies à cette époque et la quantité approximative de leurs produits’, statistiques gouvernementales, 1813.
- <sup>xiv</sup> **Clout**, “Sugar-Beet Production“, p. 109.
- <sup>xv</sup> ARRINGTON, Leonard J., “Science, Government, and Enterprise in Economic Development: The Western Beet Sugar Industry“, *Agricultural History*, vol. 41, no. 1, 1967, pp. 1–18, p. 2, **Abbott**, *Le sucre*, pp. 190–191, **Brançon**, “Le sucre“, p. 243, **Contour**, “Le Val-d’Oise“, p. 273, **Ganière**, “La bataille“, **Gudoshnikov**, *The World Sugar*, p. 6, Heckscher, *The Continental System*, p. 293, “History of sugarbeets“, **Laloux**, “La bataille“, p. 49, 53 and 56, *Le Moniteur universel*, no. 8, 8 January 1812, **McMurtrie**, *Report on the Culture*, p. 20 and 22, “Molasses“, **Prinsen-Geerligs**, *The World’s Cane*, p. 16 and **Snodgrass**, *World food*, p. 187.
- <sup>xvi</sup> **Neumann**, *Nástin dějin*, p. 39, 51 and 57.
- <sup>xvii</sup> **Dubrunfaut**, *Art de fabriquer*, pp. 480–498.
- <sup>xviii</sup> **Aaslestad**, *Revisiting*, p. 42 and 95, **Brançon**, “Le sucre“, p. 238, **Chaptal**, *Mes souvenirs*, p. 117, **Clout**, “Sugar-Beet Production“, p. 109, **Dudek**, *Vývoj*, p. 19, **Fournier**, “Essais de fabrication“, p. 227, **Heckscher**, *The Continental System*, p. 292, HOBHOUSE, Henry, *Seeds of Change. Six Plants That Transformed Mankind*, Berkeley, Counterpoint, 2005, p. 93, **McMurtrie**, *Report on the Culture*, p. 23, **Nomblot**, “1812–1914“, p. 41, **Novák**, “Pohled do vývoje“, p. 6 and SNODGRASS, Mary Ellen, *World food: an encyclopedia of history, culture, and social influence from hunter-gatherers to the age of globalization*, t. 1, Armonk, Sharpe Reference, 2013, p. 187.
- <sup>xix</sup> **Achard**, *Instruction sur la culture*, pp. 82–83, **Achard**, *Le sucre européen*, p. 160, **Barruel**, *Mémoire*, pp. 7–8 and 10, **Brançon**, “Jean-Antoine Chaptal“, p. 37, **Contour**, “Le Val-d’Oise“, p. 273, **Delamétherie**, *Journal de physique*, t. 51, p. 386, **Diviš**, *Příspěvky*, p. 8, **Dubrunfaut**, *Art de fabriquer*, p. 498, **Figuier**, “Industrie du sucre“, p. 24 and 26, **Ganière**, “La bataille“ and **Institut de France**, *Procès-verbaux*, t. II, p. 310.