

How the development of coal tar dyes in the late 1800's sparked a proliferation of food additives in the 1890's and early 1900's.

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Summary

This article outlines the development of curing technology against the backdrop of the advances in science that gave rise to the coal tar dye industry after an accidental discovery of synthetic mauve (a pale purple color, named after the mallow flower) by the young English scientist, William Perkin. It outlines the explosion of chemical synthesis and the accompanied synthesis of colourants and preservatives for the food industry. Along with the direct introduction of nitrites, these made its way into curing brines starting from the mid 1850's. It sets out the response in Germany and the USA by legislating against adulteration in foods.

The wholesale use of synthetic colourants and preservatives by the German Government during World War One is discussed, including the direct use of sodium nitrite as curing agent due to the food shortages during the Great War and due to restrictions placed on the use of saltpeter (nitrate). Sodium nitrite was being produced at this time as an important chemical for the coal tar dye industry.

It is widely held that Polenski was the first to identify nitrite as the curing ingredient and not nitrate. Evidence is presented that nitrite's central role in curing was understood some time before Polenski published in 1891.

Introduction

Through the ages, meat curing has reflected the prevailing scientific knowledge. (1) Initially meat preservation was accomplished simply by reduced water activity through the action of salt and sugar on meat juices and the drying and preserving action of smoke and heat. Over time humans realised that something in saltpetre was causing the reddening effect upon meat and the distinct cured taste. Much later, in the 1920's, we started to realise that it also have antimicrobial properties. (2)

For a comprehensive treatment of the history of saltpeter and nitrite, see "[Concerning the direct addition of nitrite to curing brine.](#)"

Coal Tar Dye

It is the development of chemical synthesis from the coal tar dye industry of the late 1800's that profoundly advanced the science of pharmaceutical drugs, colourants for the textile and food industry and the synthesis of preservatives. It captivated the imagination of the meat industry where the preservation of foods and a good, wholesome presentation was still a challenge in a time when the average household did not have refrigeration.

It all began in 1856 when the 18 year old William Henry Perkin (1838 – 1907), during the Easter vacation from London's Royal College of Chemistry, synthesized mauve, or aniline purple (a pale purple). This was the first synthetic dyestuff from chemicals derived from coal tar. (Chemical Heritage Foundation)

In "[A Letter from Denmark](#)" we looked at the importance of Friedrich Wöhler's accidental synthesis of urea. In many respect, the concept of synthesised chemicals remained largely unexplored until Perkin, trying to produce the antimalarial drug quinine, produced the colour mauve. For us living in the 2000's this does not seem like an important accomplishment, but in the late 1800's, dyes were big business and at the cutting edge of chemical investigation. (Chemical Heritage Foundation)

Scientific rigour

By the 1820's, France was the world-leader in chemical technology where scientists started to advocate a rigorous, quantitative, experimental approach to chemistry, unlike anything that was found in Germany and Britain at this time. (Paterson, G. R; 1983: 4) Laboratory work was not a standard part of chemistry training, not even in France, but a set of fortunate circumstances enabled the German scientist, Justus von Liebig (1803 – 1873), to get access to Gay-Lussac's laboratory. He was in Paris, courtesy of a grant awarded him by Grand Duke Louis I of Besse in 1822. (Paterson, G. R., 1983: 4)

Von Liebig returned to Germany not only with a more rigorous approach to chemistry, which he learned from people like Gay-Lussac, but with the benefits of laboratory work firmly entrenched in his mind. He took the model of laboratory work back to Germany and applied it at his university. This model was later adopted by many of the great German universities. Under Von Liebig, students "learned qualitative and quantitative analysis, prepared organic compounds and each performed a special laboratory work." (Paterson, G. R., 1983 4)

This resulted in a new generation of better trained chemists. In 1847 Von Liebig published *Research on the Chemistry of Food* what is probably the first book on food chemistry. (Fenneman, O. R. et al., 2007: 3)

One of Von Liebig's students at University of Giessen was August W. Hofmann. Hofmann became the conduit for disseminating Von Liebig's ideas (3) and methods in England where Prince Albert, Sir Robert Peele (the British Prime Minister) and other influential people asked Von Liebig to recommend someone as the Director for the new Royal College of Chemistry that was established in 1845. (Paterson, G. R, 1983: 5)

Among the English students who studied under him was the young Perkin. (Paterson, G. R; 1983: 5)

The discovery of a purple dye changed history

Let us go back for a moment to Wöhler's accidental synthesis of urea in 1828 which is hailed as the first synthesis of an organic compound. Since those days, synthesizing organic compounds gained much favour with chemists. Quinine, the only important medicine for the treatment of malaria, was both scarce and a priority for Hofmann as a synthetic target. The medicine is obtained from the bark of cinchona tree which grows mainly in South America. Hofmann had suggested that it would be nice if someone could synthesize quinine. In 1856 Perkin took up the challenge and he started the work on quinine in the laboratory he set up at home. (4) (Nagendrappa, G, 2010: 781)

Perkin set out to accomplish this with a large amount of enthusiasm and not quite the required skill set. In the process he failed to create quinine, but instead created a purple colour that intrigued him and the rest is history. (4)

He was eager to commercialize the discovery of his light purple dye. Hofmann was against this, suggesting that he should remain focused on an academic career. With the financial support of his father, a construction contractor, Perkin forged ahead with his plans and developed the processes for the production and use of the new dye. In 1857 he opened his factory at Greenford Green, not far from London. (Chemical Heritage Foundation)

Germany's rise to dominance

Scientists in England, France, Germany and Switzerland followed this discovery with many new synthesized dyes but their period of dominance was short-lived, largely because of the following events.

First there was the discovery by Johann Peter Greiss (1829-1888) in 1858 in Kolbe's laboratory, of the diazotization reaction. (Paterson, G. R., 1983: 8) As an important side-note, it was an improvement of this production process initially used by Greiss for the production of Diazo compounds that *sodium nitrite* became important. In the improved process, *sodium nitrite* was used to produce nitrous acid. (Cain, J.C., 1908: 6) Sodium nitrite that later became the curing agent of choice thus emerged onto the scene, initially as part of the production process of coal tar dye's in the mid 1800's.

"The second important event was the synthesis by Carl Graebe (1841-1927) and Carl Theodor Liebermann (1842-1914) in Baeyer's laboratory of alizarin (the dye of natural madder) from anthraquinone." This is an important event since it caused the demise of a natural dye industry, with the synthetic product overtaking for the first time a natural dye. "Although British patents to Heinrich Caro (1834-1911), Graebe and Liebermann on the one hand, and to Perkin on the other, were granted on successive days in June, 1869 for the commercial manufacturing methods of alizarin, the effects in Germany and Britain proved to be quite opposite." (Paterson, G. R., 1983: 8)

Haber writes: "*the synthesis was being investigated in Britain and Germany: the invention was made simultaneously in both countries. In the former country it marked the end of nearly fifteen years of brilliant inventiveness, in the latter it was the first of a long line of important discoveries*". Harber quotes Otto Nikolaus Witt (1853-1915) as saying that the discovery of synthetic alizarin "*was the first fruit of a new trend in chemical research, that of purposive chemistry*." (Paterson, G. R., 1983: 8)

The creation of BASF in 1865 became a further propellant for establishing German dominance in the synthesized coal tar dye industry. (It is the biggest producer of dyes in the world today). (Nagendrappa, G, 2010: 787, 788)

BASF was more resourceful, rapidly increased its capacity and from 1872 steadily exceeded that of Perkin & Sons. They were also able to sell the dyes at a cheaper rate. A low cost price strategy is key to their market dominance to this day. Perkin found it difficult to compete. Declining profits pushed up the production rate required and they found it increasingly difficult to finance growth. Faced with the realities of the German competition, the brothers decided to sell while they still had a company worth something. (Nagendrappa, G, 2010: 787, 788)

Another series of events that propelled Germany to its dominance in synthesised coal tar dye industry was “the flourishing of structural studies of organic molecules by Friedrich August Kekule (1829-1896), Archibald Scott Couper (1831-1892) and others. (Paterson, G. R., 1983: 8)

“Biology provided a further impetus in this evolution of the coal tar colour industry into a fine chemicals industry in which both dyes and drug entities were of prime importance.” (Paterson, G. R., 1983: 8)

These factors are all part of the multi-faceted reasons behind the almost complete transfer of the synthetic dye industry from England to Germany. This transfer mostly took place during the 1870's. (Paterson, G. R., 1983: 8)

Other reasons for the German take-over are the achievement of German national unity in 1871 with the establishment of the Prussian-dominated German Empire and the role of the banks. Germany had state banks which financed Germany's fine chemical manufacturers to construct modern factories, thoroughly equipped and scientifically and economically well-staffed. In Britain, the private manufacturer had, on the other hand, to provide the capital, and that from decreasing profits. (Paterson, G. R., 1983: 10)

An important factor in the rise of Germany's scientific dominance was their preeminence in its education system. For more than 20 years prior to Perkin's 1856 discovery, soon after Liebig took up his position in Giessen, Germany led the world in producing well-trained chemists. German chemical research was focused on practical goals, principally from Liebig's research.(Paterson, G. R., 1983: 10)

Another reason for Germany's dominance was their use of patent laws. (Paterson, G. R., 1983: 10)

Spawning multiple functional ingredients

A direct result of the enormous German chemical dye industry at the end of the 1800's is the proliferation of functional ingredients for the meat industry such as colourants and preservatives. (Young J. H. 1989: 111) “The commercialization of these dyes marked the demise of the German agriculture production and the birth of a science-based, predominantly German, industry.” (Tao, J. et al, 2010: 3)

Public laboratories were founded throughout the country for testing foods in Bonn (1855), Munster (1871), Leipzig (1875) and Hamburg (1878). A private laboratory was founded in 1848 of C. R. Fresenius (his doctoral advisor was none other than Justus von Liebig). At this time many food adulterations were known: heavy metals in flour, copper acetate in cucumbers; the colouring of sausages with cochineal, fuchsine or carmine; the preserving of minced meat by means of sulphur dioxide or nitrite. One the one hand was the adulteration of food through a wholesale use of colourants and preservatives and on the other hand was the toxins from disease causing food-born microorganisms. Many people died as a result of trichinosis during this time. (Morton, I. D. and Lenges. J.,1992: 142)

Some years before Polenske, Kisskalt or Lehmann published their research findings on nitrite and its role in meat curing, scientists and butchers knew the importance of nitrite. The work of C. R. Fresenius points to this. At this time (until the 1950's), nitrite was in the class of a food colourant. Its main function in food was to produce the reddening effect that make cured meat look appetising.



German food laws and food chemistry

The first food laws in Germany were established in 1879 prescribing the chemicals and technological examinations and assessments of among other, food stuffs. The task of examining foods was placed in the hands of a newly established occupational group who were regulated by law in terms of the scope of their work and their required academic qualifications. Their occupation was that of "*Food Chemists*" and their title was protected by law. (Morton, I. D. and Lenges. J.,1992: 142)

The state was responsible for their education. From 1894 mandatory requirements for their admission to the government education programs were a full education in pharmacy or chemistry or a successful study of 2 years in chemistry and the pre-diploma (corresponding to a B. Sc degree in England and South Africa). (Morton, I. D. and Lenges. J.,1992: 142)

For this reason, with techniques available to test for nitrite and with a thorough understanding of the role of bacteria in the reduction process from nitrate to nitrite, it is hard to imagine that the role of nitrite in meat curing was not well known, long before any scientist published on the subject.

Nitrite - the principal curing ingredient

Formally, German scientists were publishing experimental evidence on the reddening effect of meat that is cured with saltpeter (potassium nitrate) and salt. In 1891, Dr Ed Polenske, working for the Imperial Health Office concluded that nitrite found in cured meats and curing pickle arose from bacterial reduction of nitrate. (Pegg, R. B. and Shahidi, F. 2000: 12)

The German scientists, Kisskalt and Lehmann confirmed that the reddish/ pinkish cured meat colour is due to nitrite and not nitrate. (Pegg, R. B. and Shahidi, F. 2000: 12)

Ersatz food

World War One (1914 – 1918) broke out in Europe. By 1915 German food supplies were critical. Germany deployed its full scientific might in every aspect of the war, including the effort to create “replacement food” and to colour this with the technology from its impressive synthetic dyes industry in order to make it more appetizing. This food was called Ersatz food (replacement food).

In Jan 1915 the German Government ordered potato flour to be added to wheat in the production of so called “k” (for war or potato) bread. Barley, oat and rice quickly entered bread production – as did ground bean, pea, and corn meal later in the war. (Herwig, H. H. 2014: 285)

Butter was replaced with coconut and curdled milk, sugar and food colouring. Cooking oil by a mixture of red beets, carrots, turnips and spices. Salad oil by 99% mucilage. Meat soup, cubes of flavoured brine. Eggs by yellow coloured corn or potato flour. Wheat flour was stretched by adding powdered hay. Ground European beetles and linden wood replaced fats. Sausage was formed by mixtures of water, plant fibres and animal scraps. More than 11 000 ersatz products reached German stores during the war. Patents on ersatz were granted for 837 types of sausages. (Herwig, H. H. 2014: 285)

“Evelyn Princess Blucher, and English observer in Berlin, suffering from influenza in March 1916, jokingly suggested that she had succumbed to ‘Ersatz illnesses’. ‘Everyone is feeling ill from too many chemicals in the hotel food. I don’t believe that Germany will ever be starved out, but she will be poisoned out first with these substitutes.’” (Herwig, H. H. 2014: 285)

By 1916/ 1917, German meat production had fallen by 31%. The weekly entitlement of meat for a German adult was restricted to 100 – 250g. Even this was not readily available and could be bought mainly on the black market through a barter trade system. As much as one third of rations reached the consumers through the back market. (Herwig, H. H. 2014: 285)

Probably based on the work of Polenske, Haldene and Kisskalt, the German Government authorised the use of nitrite in food sometime after 1916. This was in all likelihood done in an effort to speed up curing time of meat, even though this may have been used by the German population well before 1916 due to the increased production and availability of sodium nitrite as part of the war effort. The main motivation for the legalising of an alternative curing agent was probably that all saltpeter (potassium nitrate) was claimed for the war-effort to produce munitions and as such its use in foods was illegal in this time. ([Concerning the direct addition of Nitrite](#))

The meat curers initially used sodium nitrite directly (i.e. not mixed with sodium chloride). Several cases of poisoning were reported including the mass poisoning of 34 people including a child who died in Leipzig. The Government promptly banned its use (Hans Marquardt , et al, 1999: 21), but in the prevailing war conditions, and with the Government's inability to stamp out the massive black market in foods, there can be no doubt that this practice persisted throughout the war.

The practice of colouring curing salt containing sodium nitrite pink probably stems from this incident of incidents like this, in order to prevent people from confusing sodium nitrite with table salt. The practice became law in most countries in subsequent years and remains to this day.

During the war the German Government suggested the use of jam on bread. Today it is customary to have jam on bread, but in pre-war Germany, bread was eaten with butter and/or meat fat. "So when the government advocated jam as a substitute for this" it brought about resistance. "In 1916, a crowd of food rioters had as their chant, "Bread! Bacon! Fat! Potatoes! Away with jam!" (hogsalt)

By 1917 nitrite was not only used for curing meat in Germany, but proprietary meat cures containing nitrites were being marketed in Europe. (Pegg, R. B. and Shahidi, F. 2000: 13)



The USA's "Pure Food" Act (5)

In the USA, the "Pure Food and Drug Act and Meat Inspection Act" of 1906 is a direct result of the proliferation of synthetic dyes used as food colourants and the use as preservatives.

Opposed to these moves were the powerful meat packing industry in Chicago and spice and ingredient suppliers such as Heller & Co.. They put the same choice that was faced by the authorities in Germany before consumers namely the choice between the deadly bugs that could be in the food or the chemicals with questionable health status. They wrote in 1906 in one of their publications, '*Shall we eat the germs, or make the germs' existence impossible.*' (Heller Brothers, 1906: 6)

There was a growing awareness by the general public about food hygiene and with the rise of consumerism, pressure on meat packers and bacon curers emerged to improve the brines used.

Many of the curing mixes with nitrite and other ingredients added made their way from Europe to the USA in this time. Functional ingredients were sold under various trade names. In a time when no legislation existed about ingredient declarations, it makes a proper evaluation of curing mixes from this time challenging. Producers of the functional ingredients and bacon curers alike were very secretive about the ingredients used. (Fenneman, O. R. et al, 2007: 111) Authorities in the US were cracking down on the use of these ingredients by 1906. (Heller Brothers, 1906: 6)

R. C. Yeoman, Dean of Civil Engineering, Valparaiso University, published ***The Rural Efficiency Guide*** in 1918. He lists the following functional ingredients used as preservatives at this time, “borax, boracic acid, formalin, salicylic acid, and other chemicals are sometimes used in preserving meats”. He suggests that they should not be used on account of them being “*considered by so many authorities to be harmful to the health of the consumer that their use should be avoided.*” He refers to “*the proprietary preparations put on the market*” that are “*also dangerous to health*”. The reason why they were popular in curing brines is given as that “*they are more active than salt, and the chief reason for their use is to hasten the curing process.*” It was his opinion that only salt was required to cure good quality bacon. (Yeoman R. C. 1918: 280)

He adds an interesting note on saltpeter. He writes that “*Saltpeter is used to preserve the natural color of the flesh or to give a reddish color, but it is harmful to the health. It is even more astringent (cause tissue to shrink) than salt.*” He is in favour of the use of sugar and a little bit of baking soda. “*Sugar is not an astringent and its presence in the pickle softens the muscle fibres and improves the flavor of the meat. Saleratus(baking soda) is used in small quantities to sweeten the brine. In warm weather a small quantity will aid in preventing the brine from spoiling.*” (Yeoman R. C. 1918: 280)

Publications from the US firm, Heller and Co, from 1906 to 1922 address this issue of banning harmful functional ingredients.

Adolph Heller, the father of Benjamin, Albert, Joe, Edward and Harry, the members of the firm, is described as a scientific and practical butcher and packer and a practical sausage manufacturer. (Heller Brothers, 1922: 18) It is said that he studied the causes of failure in handling of meat with the aim of always producing the best and most uniform product that could be made. In light of the enactment of the national Pure Food Law, the National Meat Inspection Law and various state Pure Food Laws, they have set out to compile guidelines for the manufacturing of various meat products without the use of ingredients that have been banned by these various laws. (Heller Brothers, 1922: 18, 19)

Heller & Co gives the following list of proprietary preparations in 1906 that is targeted by the US government for banning due to questions about its safety, “Preservaline , Freeze-Em, KonservirungsSalze, Freeze-Em-Pickle, Zanzibar Carbon, Zanzibar Ham Smoke and other such well known articles. (Heller Brothers, 1906: 6)

Preservaline, was mostly salicylic acid used as a preservative. (Young J. H. 1989: 111); Freeze-Em, sodium sulfite. (Young J. H. 1989: 111). Zanzibar Carbon, a combination of celery and other condiments.

This is then how the late 1800's and early 1900's became the period of the proliferation of food dyes and preservatives. A movement started where the world realised that harmful food ingredients can not be justified by the pathogens it is preventing and a move to reduced **E**-numbers or functional ingredients started.

Conclusion

Functional food ingredients and curing salt are closely linked to the prevailing level of science and technology. The quest is to present to consumers safe, affordable, quality food, free from harmful ingredients.

Developments in the coal tar dye industry brought about a proliferation of such functional ingredients, many of them harmful to human health.

Understanding its history helps us realise that everything we use in food has a history and a reason. These reasons can and must be continually re-evaluated, including the merits of using nitrite and the quest must remain for safer, better quality foods.



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Notes:

1. The development of chemistry and adding chemicals to food went hand in hand. During the 1700's, 1800's and much of the early 1900's, the chemical revolution generated as much excitement and yielded productive changes to our lives as information technology in the late 1900's and the beginning of the 2000's.

A number of important discoveries were made between 1780 and 1850 that directly impacted on our understanding of the chemistry of food. A few examples will suffice.

One of the greatest Chemists, who ever lived, Carl Wilhelm Scheele (1742 – 1786), a Swedish pharmacist, isolated and studied the properties of lactose (1780). He devised a means of preserving vinegar by the application of heat (1782). He discovered chlorine, glycerol, and oxygen (three years before Priestly, but unpublished). He isolated citric acid from lemon juice (1784) and gooseberries (1785) and isolated malic acid from apples (1785). (Fenneman, O. R. et al., 2007: 2) It was Carl who first made pure nitrite in 1777. (Scheele CW. 1777)

His work is considered the beginning of analytical research in agricultural and food chemistry. (Fenneman, O. R. et al., 2007: 2)

The brilliant French Chemist, Antoine Lavoisier (1743 – 1794) was instrumental in formulating the principals of modern chemistry. He established the fundamental principle of combustion organic analysis. He was the first to show that the process of fermentation could be expressed as a balanced equation. He was the first to attempt to determine the

elemental composition of alcohol (1784) and he presented one of the first papers on organic acids of various fruits (1786). It was Antoine who established that saltpetre is potassium nitrate. ([Bacon and the art of living 02. The saltpeter letter](#))

Nicolas Theodore Saussure (1767 – 1845) helped to formulise and clarify the principals of agriculture and Chemistry provided by Antoine. He studies CO₂ and O₂ changes during plant respiration (1804) and the mineral content of plants and made the first accurate elemental analysis of alcohol (1807). (Fenneman, O. R. et al., 2007: 2)

In 1847, Justice von Liebig (1803 – 1873) published what is probably the first book on food chemistry, *Research on the Chemistry of Food*. Included in this book is his research into the constituents of muscle (creatine, creatinine, sarcosine, inosinic acid, lactic acid, etc) (Fenneman, O. R. et al., 2007: 3)

As one can expect, the widespread occurrence of what is called the adulteration of foods parallels the developments in food chemistry. (Fenneman, O. R. et al., 2007: 3)

A particular case in point is our understanding of the working of curing brines particularly related to the action of nitrite's. The chemistry of nitrates, nitrites and bacterial reduction was well established by the end of the 1800's. ([The micro letter](#)) In 1891, Dr Ed Polenski published results of testes where he found nitrites present in brine after only nitrates were used in t6he initial mix. He correctly speculated tha this was due to bacterial reduction of the nitrate to nitrites. ([Concerning the direct addition of nitrite to curing brine](#)) This was followed by detailed analysis of the subject from around the world that in one form or the other continues to this day.

2. The specific antimicrobial contribution of Nitrite (and indirectly nitrate) was only recognised in the late 1920's. Kerr et al. (1926) stated that nitrites and nitrates had no value to preserve, but two years later Lewis and Moran (1928) suggested that nitrite had anti-microbial effects. Steinke and Foster (1951) delivered definitive evidence of sodium nitrites antimicrobial efficacy in cured meats. During the 1970's, definitive evidence of the relative contribution of nitrite in controlling *c. botulinum* was only obtained for certain foods. (McCarthy, M. Chairman of the Committee of nitrite and alternative curing agents in food. Et al. 1981. Page 2-4)

3. "At the beginning of the nineteenth century, France led the world in organized chemical endeavours, although there were singular contributions from other Europeans, chiefly Germans and the British. After the end of the Napoleonic Wars, many aspiring chemists (most often pharmaceutically trained) sought experience and instruction in France; here Napoleon's education reforms had produced better training. It was in France too where innovative and gifted pharmacists (this tern replaced "apothecary" in 1777) gave rise to establishments, manufacturing the first drug entities, the alkaloids.

The Englishman Morson was an excellent example of an apothecary chemist who went to Paris for several years in order to learn the newer methodology. An important visitor to Paris was Justus Liebig (1803-1873); his stay in Paris was the foundation for all his subsequent work. Even in Paris, instruction in chemistry did not usually include laboratory work. However a set of fortunate circumstances enabled Liebig, who had in 1822 obtained from Grand Duke Louis I of Besse a grant to study in Paris, to gain access to Gay-Lussac's laboratory.' This was quite different from the small Darmstadt facility his father maintained in connection with the family drug and painting supplies business.

It was in his father's laboratory that the younger Liebig first performed experiments, including preparation of the explosive, silver fulminate. When he first went to Paris, it was to attend lectures. Holmes says "Liebig attended the lectures of Gay-Lussac, Thenard and Dulong, where he encountered a rigorous, quantitative, experimental chemistry unlike anything he had found in Germany and learned for the first time some of the general principles, connecting his knowledge of particular compounds and processes. Liebig, presenting a memoir on fulminates to the Academie des Sciences in 1823, impressed Humboldt who arranged for him to work in Gay-Lussac's private laboratory.

When Liebig returned to Germany to the University of Giessen, he was determined to institute laboratory instruction, such as he had experienced in Paris, for his students. Under Liebig, they learned qualitative and quantitative analysis, prepared organic compounds and each performed a special laboratory problem. Even though the first laboratory was a converted, and unventilated, barracks, it was the model for all future academic laboratory teaching. "It was the first institution deliberately designed to enable a number of students to progress systematically from elementary operations to independent research under the guidance of an established scientist".⁸ Here we have the keys to Liebig's importance for future developments rigorous laboratory teaching, numbers of procedures developed for and applied to many organic compounds. Other universities in Germany also adopted Liebig's methods and philosophy, and a new generation of chemists was produced, more thoroughly trained than ever before. (Paterson, G. R. p 3 – 5)

4. Dr. Nagendrappa explains Perkins discovery as follows: "The most basic requirement for synthesizing a compound is the knowledge of its molecular structure, i.e., how its atoms are connected. In 1856, knowledge of chemical structures was just then emerging, though fairly correct molecular formulae could be determined. The structures of only small molecules could be written. The ring structures were still unknown. Perkin was therefore completely ignorant of the quinine structure (Box 1). It was indeed presumptuous on the part of Perkin to have undertaken quinine synthesis, which must be attributed to his irrepressible enthusiasm and confidence. It seems that he had no doubt about the outcome.

His reasoning was simple. The empirical formula of quinine was known to be $C_{20}H_{24}N_2O_2$. Therefore it is quite logical to assume that one can combine two molecules of a compound with molecular formula $C_{10}H_{13}N$ to get $C_{20}H_{26}N_2$, at the same time adding two oxygen atoms and removing two hydrogen atoms. And it would be perfectly understandable if one thought, in 1856, of oxidizing a compound with formula $C_{10}H_{13}N$ to get a compound of formula $C_{20}H_{24}N_2O_2$:

Perkin chose allyltoluidine, which has the formula $C_{10}H_{13}N$, as the reactant and heated it with potassium dichromate and sulphuric acid as oxidizing agent. Of course, only a miracle would have produced quinine from such a concoction, and indeed what Perkin got was a reddish brown precipitate. However, he did not give up, but decided to investigate the reaction with aniline, a simpler compound. He treated aniline sulphate with potassium dichromate. Now he obtained a black precipitate. When he added methanol, probably to wash it, he noticed that methanol became purple coloured. As the colour was attractive, young Perkin thought of using it as a dye. He dyed a silk fabric with the colour and sent it to a well-known dye house Pullar & Son who approved it with admiration for its much desired attractive purple colour and its fastness on the fabric. The dye was called Aniline Purple, Mauve or Mauveine. He applied for a patent¹ for it on 26th August 1856, with the intention of manufacturing it. The patent was granted on 20th February 1857. At 18, William Perkin was on his way to become one of the most celebrated figures of chemistry and chemical industry. Hofmann was unhappy that Perkin was leaving the Royal College of Chemistry to take up manufacturing, as it was considered not a desirable activity for people of refined social rank.

For Perkin, the situation to start an industry to manufacture Aniline Purple was not quite favourable. He had no industrial experience or business skill. He had to mobilize funds, get assured supply of raw materials, find buyers of the finished products, acquire land and take care of other related matters. **He could overcome every hurdle with his abundant enthusiasm, patience and resoluteness.**

Perkin's father, who had changed his stance by now, put all the required money, and his brother Thomas Dix Perkin provided building and business support. The modern dye industry was born with the establishment of Perkin & Sons at Greenford Green, England, to manufacture mauve in 1856."

When Perkin started the work on the oxidation of aniline, it was not his adroitness alone that led to mauve, but also a providential coincidence. The aniline sample that he was using was not pure; it contained toluidines in considerable quantities. Had there been no toluidine, there would still be some kind of a dye, but the result would not have been so spectacular. The purple shade of mauve was the most desired colour by the high society. The need for a purple dye was earlier met by the expensive Tyrian Purple extracted from mollusks. Discovery of mauve, which Perkin had initially called Tyrian Purple, changed the scenario as it was available to common people at affordable prices. Perkin inferred the presence of toluidine in mauve from its elemental analysis. Later he found that toluidines and other aniline derivatives (e.g., xylidines) also formed similar dyes. He made a dye from pure aniline and called it pseudo-mauveine, though its colour was not much attractive. Of all these new dyes the best was still the mauve. So Perkin's luck lay in impure aniline mixed with toluidines.

Mauve itself is not a pure compound. It is a mixture of two major components A and B, and small amounts of other purple dyes. The components A and B were isolated and their structural identity determined only in 19942 . They are phenazene derivatives. The component A contains two aniline, one o-toluidine and one p-toluidine molecules, while the component B contains one aniline, two o-toluidine and one p-toluidine molecules.

(Nagendrappa, G, 2010: 781 -783, 785)

5. **Adulterated food** is impure, unsafe, or unwholesome food. In the United States, the Food and Drug Administration (FDA), regulates and enforces laws on food safety and has technical definitions of adulterated food in various United States laws. "Adulteration" is a legal term meaning that a food product fails to meet federal or state standards. Adulteration is an addition of a non food item to increase the quantity of the food item in raw form or prepared form, which may result in the loss of actual quality of food item. Among meat and meat products one of the items used to adulterate are water.

The History is instructive as we have referred to some of these vents many times in this work and will continue to refer to them:

- 1906 (21 U.S.C. 601 et seq.)
- 1938 Federal Food, Drug, and Cosmetic Act (21 U.S.C. 321 et seq.)
- 1957 Poultry Products Inspection Act (21 U.S.C. 451 et seq.)

(http://en.wikipedia.org/wiki/Adulterated_food)

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