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**Introducing Scientific Reasoning and Methods
into Agriculture
A Late 19th-Century Danish-English Case
on Butter**

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Introducing Scientific Reasoning and Methods into Agriculture: A Late 19th-Century Danish-English Case on Butter

Anita Kildebæk Nielsen

Introduction

Both Danish and English agriculture underwent fundamental restructuring in the second part of the 19th century, and in both cases did dairying become a very important sector.¹ However, the two agricultures developed in almost opposite directions and differed from each other in respect to production methods, main product and main market. To put it more generally, they differed in aim, strategies and not least – as I will focus on today – to the degree of how much new technology and scientific methods that were implemented. One of the main reasons for these decisive differences was that the Danish agriculture primarily was an export agriculture whereas the English farmers almost exclusively sold their products on the home market, often regionally. In this paper I will highlight the most important aspects of the comparison, focusing on the production of butter. I aim to show that not only economic historical but also scientific historical theories and methods must be applied if one wants to fully understand the different patterns of development of the Danish and English dairy agricultures and second, why Danish butter became a success on the very competitive English market – I will in the latter case demonstrate that science matters.²

Agricultural Chemistry

As F.M.L. Thompson has pointed out England, underwent a second agricultural revolution between 1815 and 1880.³ The revolution showed physical-technological as well as economical marks, among them the establishment of field drainage, and the introduction of new feeding stuffs and fertilizers. The agriculture increasingly became dependent on the developments and practical application of the natural sciences. “[I]t was in the second agricultural revolution that farming became properly commercialised”⁴, i.e. the idea of self-sufficiency was abandoned in favour of a conception of farming as a manufacturing industry. Likewise did the objective of the farmer come to resemble that of a factory owner, namely to intensify the production and increase profits. The rhetoric was clearly borrowed from the classical liberal ideas of the industrialisation. Denmark too underwent a second agricultural revolution in the 19th century even though it arrived later here than in England.⁵

The new and emergent type of agriculture was referred to as the rational agriculture, where ‘rational’ meant modern, based on market economy and on science. The establishment of an agricultural science was vital for obtaining a better understanding of questions concerning i.e. plant growths and diseases and animal epidemics. Much improvement was of course possible without a scientific understanding, in England most noticeably in such areas as cultivation of plants and stockbreeding. In the case of fertilizers, however, knowledge of the

chemical and physiological parameters involved in plant growth was necessary in order to develop efficient fertilizers. Modern, rational farming was thus closely connected to the new discipline of agricultural chemistry.

Agricultural chemistry was not just another branch of chemistry, even though it is often associated with the German chemist Justus von Liebig, who published an influential book on the topic in 1840.⁶ Agricultural chemistry was more than another scientific discipline - it was a social and cultural necessity – or so its adherents claimed. As the Swedish historian Erland Mårald has documented in his analysis of the discipline, the social and economic problems of mid 1800 was believed to be solvable with the aid of agricultural chemistry.⁷ Thus apart from enabling a successful production of fertilizers and the development of better cereals, the agricultural chemists wanted to lay the foundation for social reforms and guarantee improved standards of living. The discipline was marketed by its adherents as morally educational to the farmers.⁸ It would stabilize the country and help create a better society. It was stressed that agricultural chemistry was both academic and applied science. As Margaret Rossiter has pointed out “Spokesmen for the field [agricultural chemistry] could respond to the changing moods and demands of society and of its own practitioners by shrewdly stressing its practical applications at one moment and then its contributions to pure science at the next”.⁹

A Danish agrochemical network

It must be recalled that the development of the new agriculture not only coincided with the speedy developments within the natural sciences but also with the great depression, which affected the economy of the European countries from about 1875 to the end of the century.¹⁰ I will not go into details on the causes of the depression - instead I want to stress the impact the depression had on the restructuring of the Danish as well as the English agriculture. Surely, the agricultural revolution in both countries was well on its way before the monetary restraints of the depression, but the need to find alternative ways of farming, new products and markets was furthered by the partial collapse of the economy. Not least so in Denmark where the crisis speeded up the restructuring process of the agriculture - resulting in a Danish agriculture at the end of the century, which was quite distinct from the agriculture in the middle of the century. It increasingly became difficult to export cereals and livestock, and in both countries farmers turned to dairying. Denmark had already in the mid 1800s an export of fine butter to England, but the position of Danish butter on the English market was greatly enhanced from the 1880s onwards.¹¹ Its share of the market rose considerably at the expense of in particular domestic and Dutch butter. One of the main reasons for this success was the structure and influence of the Danish agricultural network and its institutional affiliations.

Of major importance in Denmark was the presence of an enthusiastic group of farmers, landowners and agricultural scientists, which in spite of a limited size formed an agrochemical network which had great impact – practically and ideologically.¹² There was within the network the interest and willingness to take up the ideas of the new, rational agriculture and to implement it in spite of economic burdens and without direct support from the state. The agrochemical network had specific institutional anchoring at the Royal Veterinary and Agricultural College, which was founded in 1858 after German inspiration, and at the private Royal Danish Agricultural Society. A number of key-persons involved in the management of the latter were of particular importance. The Society recruited its presidents among both innovative landowners and graduates in agriculture, most of them in part trained abroad.¹³ Some of the presidents were simultaneously employed at the Royal Veterinary and Agricultural College, for instance Niels J. Fjord, who was one of Denmark’s most influential

agricultural chemists from the 1860s.¹⁴ In 1882 Fjord managed to have an Agricultural Research Laboratory established, attached to the College and paid for by the state.¹⁵

The aim of the laboratory was to provide the farmers with science-based assistance, and the establishment was a consequence of the Danish farmer's new focus on refined husbandry products – first and foremost butter and bacon. The laboratory focussed on solving science related agricultural problems in close connection to the farmers. But in spite of this obvious focus on *applied* mechanics, chemistry, physiology, and bacteriology, the research of the laboratory had the epistemological mark of academic research. This is distinctly seen in the frequent research publications of the laboratory. They were on the one side – in accordance with the aim of the laboratory – written for agriculturists and they did include some paragraphs that were directly applicable to the farmer. But on the other side they had the argumentative style, language and structure of a scientific paper. In this respect they expected much science of their readers, and I believe this is one of the marks of the Danish agricultural research tradition: the scientists and the farmers were intimately related and this had two implications. First, it added credibility to the research results in the sense that the results were believed to be of direct value and were quickly implemented. They were generally not seen as work done in seclusion in an ivory tower. And second, the standards of how scientific results can be presented to its appliers were set high. They were set by the academics but accepted by the farmers.¹⁶

Research at the Agricultural Research Laboratory

A good example of the research done at the Agricultural Research Laboratory in close connection to the practical problems of the Danish dairy agriculture is the development of what became the lure-branded Danish butter. It is obvious that not one but many parameters played parts in the success of the product on the English market. From an economic historical point of view focus is usually on the increased efficiency obtained by the establishment of co-operative creameries, on the price developments, and on the effectiveness of the butter traders' networks.¹⁷ I by all means agree that these factors are important in understanding the success. I will, however, like to add the research dimension. I claim that the image of lure-branded butter as germ-free and of superior, uniform quality could not have been obtained without the research done at the Agricultural Research Laboratory. And it is very much the combination of new research results *and* the other factors mentioned that gave Danish butter the advantage in comparison to butter from other countries.

It was researchers at the Agricultural Research Laboratory who introduced two of the most important pieces of apparatus and the most important theoretical insights to the creameries. The first apparatus was the continuous cream separator, which was marketed by Danish and Swedish manufactures from 1878 and which was standard equipment in the co-operative dairies from their establishment in the 1880s. The separator significantly speeded up the curdling in comparison to the old-fashioned method of prolonged standing of the milk in open containers where the cream was separated from the first milk only by the aid of gravity. Denmark in 1898 as the first country passed a legislation that prescribed the dairies to guarantee that skimmed milk returned to the farmers for cattle feeding had been heated to at least 80 °C.¹⁸ As a consequence, a second piece of equipment was introduced at most dairies – the steam pasteurizer, which was invented by Fjord, whom I mentioned a minute ago.¹⁹

At the Agricultural Research Laboratory the head chemist, Vilhelm Storch, worked on obtaining a better understanding of the chemistry of milk and butter, and in 1890 he published a report documenting the flavour additive in butter. He showed that a given butter sample's

flavour traditionally had been the result of a mixture of lactic bacteria and similarly that bad taste owed to the presence of undesirable cultures of bacteria. Following this new knowledge, Storch succeeded in separating a number of lactic bacteria and to grow pure strains with specific flavouring properties. Storch concluded that production of butter with a given, good taste could be obtained by adding specific agreeable lactic bacteria during souring while at the same time suppressing other cultures of bacteria. In practice, this resulted in a new practice for producing butter at the creameries where the first milk was first separated, then pasteurised in order to limit the number of germs and finally added a locally made or commercial starter to sour the cream before the churning.²⁰ The starters contained one or a few lactic bacteria with documented flavouring effects. The application of pasteurizers and standardised starters in the butter production were thus indispensable factors in the obtainment of a product with uniform flavour and texture, prolonged keeping quality - which was an added benefit of the pasteurisation - and without pathogenic germs.

Moreover, the establishment in 1900 of "The Danish Butter Brand Association" furthered the standardization of Danish butter. It soon embraced the far majority of Danish creameries and in 1901 the lure icon was registered as a butter trademark in Denmark and England. The meaning was to better enable the consumer to distinguish between Danish butter and butter from other countries which did not have the same quality control. The brand was given national status only five years later when the Danish Ministry of Commerce made the lure-brand compulsory for all export of Danish butter and bacon.²¹

English butter and liquid milk production

So the principal Danish dairy product was the export butter. Just to give you a few numbers, the Danish butter export to England rose from ca. 10,000 to 60,000 tons between 1870 and 1900.²² In fact both the English and the Danish dairies produced for the English market. However, as the large London butter market was lost to imported products by the mid-nineteenth century,²³ the English producers had to cultivate other markets. In this way, the English dairies to a certain degree avoided direct competition with the imported products and this signified the subsequent development. As emphasised by the historian David Taylor, "the potential of technical and organizational advances (exemplified by the co-operative creameries of Denmark) was never realized in England".²⁴ The Danish dairy expert Bernhard Bøggild noticed during a study tour of the British Isles in the 1890s, that much of the British butter was made in the old-fashioned way without mechanical separators, pasteurizers or starters and exclusively for the local markets.²⁵ Small producers sold their butter directly to the consumers, and for this reason I believe the focus on a uniform product was much less pronounced than it was judging the imported products. The personal acquaintance between producer and consumer was sufficient quality guarantee. Price differences between the products must also have been essential, but the prices varied from town to town and depended on many factors. Taylor states in his historical analysis that "in the late nineteenth century the average price of first quality imported butter was lower than that of second quality English",²⁶ but Bøggild points to the fact that he had difficulties determining the average net price of English butter as the price on the local market often was *lower* than the list price given by the producers and *lower* than the price of imported butter.²⁷

However, butter was not the principal product of the English dairies. From the latter decades of the 19th century, liquid milk production became the most important enterprise, accelerated by the extension of the railways and the growing foreign competition on other products.²⁸ Concurrently, the demand of liquid milk by the growing population of the cities

offered the producers an appealing prompt cash flow compared to many other kinds of agriculture. But in spite of high prices on milk in the big cities, the producer's profits were not above average, as the co-operatives or consortia, which bought the milk from the farmers and sold it in the cities, claimed the surplus. The argument was that in order to be able to promise the consumers fresh and healthy milk, the companies had the expenses of having a network of inspectors paying regular visits to the producers, where they examined the facilities and tested the milk. As far as I can see, these efforts were made voluntarily with the aim of making the customers trust the products of the companies – they were *not* taken as cause of legislation. Moreover, it appears that 'clean milk' as a concept with importance for the consumer only developed in the 1890s in England. Before then, the customers put greater emphasis on obtaining warm and yellow milk, as these qualities symbolised a fresh and rich product, than on the milk being germ-free.²⁹

But even after 1890, it is still to be further studied to which extent the same standards applied to domestic and imported products and how this influenced the customers' choice of products.³⁰ As I stressed earlier Danish butter gained market in England by emphasizing the cleanness of the product, while English butter at the same time was still being made in the old-fashioned way. This difference in product was most certainly a key-factor and therefore I do not hesitate to conclude that the introduction of scientific methods and reasoning into the Danish production of manufactured dairy products was central in establishing the success on the foreign markets and in England in particular. Still, I would like to see analysed in detail to which extent the success was based on a better marketing of the Danish butter, a wider distribution network, more competitive prices, longer preservation, a better taste, or on the argument of being bacteria-free. There seems to be a difference between the Danish ideals and the English in the role played by the concept of hygiene – and perhaps also in relation to the customers' expectations of the products.

When the English government in 1909 finally decided to fund scientific research for agricultural areas, the strategy was completely opposite to the Danish chosen some 30 years earlier. The way the money was distributed it "effectively separated research situated in major, national institutions from the specific problems which the farmers encountered on their farms and put greater emphasis on scientific principles than practical difficulties", as Keith Vernon pointed out in a study of how the Development and Road Improvement Act of 1909 was implemented.³¹ Vernon noticed that one of the consequences of this policy was that dairying was given low priority, even though the production of liquid milk was *the* growing agricultural sector.³²

Conclusions

Thus, to make a brief summary, the Danish and English farmers responded very different to the great depression of the 1870s managing in each their way to restructure the agriculture - The English farmers being under extra strains by the international competition on their home markets, the Danish by having close competition on their principal market. In England, the international competition, the lack of an agricultural scientific network, and the low general level of education amongst the farmers made them focus on the production of liquid milk - a market hardly accessible to foreign farmers. In the long run, the state's late intervention with educational programmes and research funds restrained a successful development of the English agriculture into the 20th century. In contrast, the development of a Danish model based on advanced training of the farmers and with close relations between farmers and scientists, who focussed directly on the needs of the farmers, resulted in the construction of a competitive

dairy industry which was very successful on foreign markets – at least until the late interwar period.

References

Holger Ærsøe (1981) *Husdyrbrugsforsøgsvirksomheden i Danmark. En Redegørelse for Landøkonomisk Forsøgslaboratoriums Oprettelse, Udvikling og Virksomhed i Tiden 1882-1942*, 2. ed. (Frederiksberg, Statens Husdyrbrugsudvalg).

Claus Bjørn (ed.) (1982) *Dansk mejeribrug 1882-2000* (Odense, De danske Mejeriers Fællesorganisation).

Claus Bjørn (1988), Det moderne landbrug grundlægges - 1840-1860, pp. 166-192 in Bjørn *et al.* (eds.), *Det danske landbrugs historie*, vol. 3 (Odense, Landbohistorisk Selskab).

Bernhard Bøggild (1897) *Mælkeribruget i fremmede Lande* (Kjøbenhavn, Det nordiske Forlag).

H. Hertel (1919-20) *Det kgl. danske Landhusholdningsselskabs Historie* (Kjøbenhavn, Det kgl. danske Landhusholdningsselskab).

Colin J. Holmes (1988) Science and the Farmer: the Development of the Agricultural Advisory Service in England and Wales, 1900-1939, *Agricultural History Review*, 36, 77-86.

Einar Jensen (1937) *Danish Agriculture. Its Economic Development* (Copenhagen, J. H. Schultz Forlag).

Wolfgang Krohn & Wolf Schäfer (1976) The Origins and Structure of Agricultural Chemistry, pp. 27-52 in Gerard Lemaine *et al.* (ed.), *Perspectives on the Emergence of Scientific Disciplines* (The Hague/Paris, Mouton).

Wolfgang Krohn & Wolf Schäfer (1982) Agricultural chemistry: a goal-oriented science, pp. 196-211 in Barry Barnes & David Edge (ed.), *Science in Context: readings in the sociology of science* (Milton Keynes, Open University Press).

Jørgen L. Leisner (2002), Mælk og bakterier. Den bakteriologiske sundheds- og forbrugermæssige standard af mælk og smør fremstillet i Danmark 1850-1914, *Erhvervshistorisk Årbog*, 50-118.

E. Patrick Munday (1990) *Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture* (Cornell).

Erland Mårald (2000) *Jordens kretslopp: Lantbruket, staden och den kemiska vetenskapen 1840-1910* (Umeå, Umeå Universitet).

Anita Kildebæk Nielsen (2002) Landøkonomisk forsøgslaboratorium og Vilhelm Storch i kemisk perspektiv, pp. 163-186 in Anita Kildebæk Nielsen (ed.), *Dansk landbrugskemi i historisk perspektiv, 1750-1930* (Dansk Selskab for Historisk Kemi, Kjøbenhavn).

Anita Kildebæk Nielsen (2003a) Mikrobiologi og lurmærket smør, *Aktuel Naturvidenskab*, 5, no. 2, 28-30.

Anita Kildebæk Nielsen (2003b) En videnskabshistorisk vinkel på den danske smørekseport. Landøkonomisk Forsøgslaboratoriums betydning, *Den jyske Historiker*, no. 102-3 (forthcoming).

Christabel S. Orwin & Edith H. Whetham (1964) *History of British Agriculture 1846-1914* (London, Longmans)

Margaret W. Rossiter (1975) *The emergence of agricultural science: Justus Liebig and the Americans, 1840-1880* (New Haven, Yale University Press).

Uschi Schling-Brodersen (1992) Liebig's Role in the Establishment of Agricultural Chemistry, *Ambix*, 39, 21-31.

V. Storch (1891) Docent N. J. Fjord, *Tidsskrift for Landøkonomi*, 5th series, 10, 425-497.

David Taylor (1987) Growth and Structural Change in the English Dairy Industry, c1860-1930, *The Agricultural History Review*, 35, 47-64.

F. M. L. Thompson (1968) The Second Agricultural Revolution, 1815-1880, *Economic History Review*, 38, 62-73.

Keith Vernon (1997) Science for the Farmer? Agricultural Research in England 1909-36, *Twentieth Century British History*, 8, 310-333.

¹ See Bjørn 1982 and 1988, and Taylor 1987, 47.

² For a more thorough discussion see Nielsen 2003b.

³ Thompson 1968. Orwin & Whetham 1964 date the second agricultural revolution later, especially the introduction of agricultural science, see page 28 ff. The authors state that medieval farming was still to be found in Britain in the middle of the century (p. 33).

⁴ Thompson 1968, 65.

⁵ Bjørn 1988.

⁶ On the background and reception of Liebig's book see Munday 1990. See also Schling-Brodersen 1992.

⁷ Mårald 2001, 5-6. For another view on the origin of agricultural chemistry as a discipline, see Krohn & Schäfer 1976 and 1982.

⁸ Mårald 2001, 83.

⁹ Rossiter 1975, xi.

¹⁰ For the background of the Great Depression and its influence on Danish agricultural history see Jensen 1937. The parallel English case is described in Orwin & Whetham 1964, chapter 10.

¹¹ According to Arla Foods, the international interest in Danish butter started in connection to the world trade exhibition in London in 1879, see www.arlafoods.dk/C1256A11003233CD/alldocs/Q544764C42066A03EC1256AEE00292B71!Open&HJ100D01Cat15&000&002.

¹² Orwin & Whetham 1964, 32, note that in England “[t]he prosecution of scientific research and the dissemination of its results was the affair of *individuals*, either singly or in co-operation”. Emphasis added.

¹³ On the history of the Royal Danish Agricultural Society see i.a. Hertel 1919-20, especially vol. 2.

¹⁴ Storch 1891.

¹⁵ Ærsøe 1943 and Nielsen 2002.

¹⁶ Holmes 1988, 83, has noted in relation to the English agricultural literature that it was a general problem the writers expected too much scientific knowledge of the readers and therefore the communication between scientists and farmers in part failed.

¹⁷ Taylor 1976, 56, argues that it was ”Co-operative farming supported by government credit facilities and co-operative export societies [that] led to a flourishing trade”. Again, I believe this pattern of explanation to be overly simplified.

¹⁸ Nielsen 2002, 176-177.

¹⁹ However, many creameries had by then already made use of the advantages of the technique for some years before passing of the law.

²⁰ Nielsen 2002, 175 ff.

²¹ The idea of branding specific foodstuffs quickly spread to other butter exporting countries and within years the Swedes were branding their butter with national icons. Nielsen 2003a, 30.

²² Bjørn 1982, 549. 86,000 tons were reached just ten years later in 1910.

²³ Taylor 1987, 55.

²⁴ Taylor 1987, 56.

²⁵ Bøggild 1897, 119 ff.

²⁶ Taylor 1987, 56.

²⁷ Bøggild 1897, 122 (“det er meget tvivlsomt, hvor stor Gjennemsnits-Nettoprisen paa Engelsk Smør i Virkeligheden er. – Som karakteristisk for Forholdet kan det nævnes, at taler man med Producenterne, hører man hyppigst ret høje Priser anførte; men færdes man paa Torvene, hvor den Del maa sælges, som Producenterne ikke have faste Kunder til, erfarer man, at meget engelsk Smør sælges billigere end Prisen paa indførte Varer”).

²⁸ Taylor 1987, 47.

²⁹ Bøggild 1897, 113.

³⁰ It did not become customary to pasteurise liquid milk in Denmark nor in England before the twentieth century - On the history of liquid milk production in Denmark see Leisner 2003.

³¹ Vernon 1997, 319.

³² Vernon 1997, 312. When the agricultural Provincial Advisory Service was established from 1912, dairying was given low priority here too. Not one of the sixteen provincial advisory officers appointed in 1914 were dairy bacteriologists. Holmes 1988, 79, table 2.