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Spinach in Blunderland: How the myth that spinach is rich in iron became an urban academic legend

Michael Mielewczik & Janine Moll

Abstract: The claim that spinach contains a lot of iron is one of the longest standing myths in science. In recent decades, this early error though has become widely known to the public and several theories were proclaimed, how this misconception was born. The most famous one, known in many varieties and reported in numerous books and scientific journals, is that a simple decimal error occurred. More recently it was claimed that the story of the decimal error is itself a myth and that Popeye against popular belief originally did not eat spinach for its iron content.

Unfortunately, not much is known on how urban academic legends and popular misbeliefs in medicine and natural sciences develop and how both facts and errors are popularized. Following an in-depth literature search, the article reports how spinach in the historical and publishing context became popularized as a healthy vegetable rich in iron and how and when this myth was debunked. Briefly, all previous analyses on the origin of the myth only told part of the story.

Popularization of spinach as an iron rich vegetable fist occurred in the 1850s. The following propagation of the myth, however, was based on a complex interaction involving scientists, journalists and popular culture, which emphasizes that the impact of science and propagation of ideas is inadequately covered by classic citation links and networks.

"In between the lines, there's a lot of obscurity.
….
I know you know, that I'm not telling the truth.
I know you know, they just don't have any proof.
Embrace the deception, learn how to bend
Your worst inhibitions tend to psych you out in the end."

(Steve Franks 2006)

Scientists are human and as such we relish humour, irony and satire as much as everybody else. Above all we seem to cherish a good story telling. The scientific narrative we form in every one of our articles is essentially proof of this. Yet like every other human we as scientists can err – "*Errare humanum est*"[1] – and, most likely, errors and discrepancies in science are much more prevalent and common, than we as a scientific community are commonly willing to acknowledge.[2] Sometimes such errors can have devastating effects and in some cases errors can even self-propagate into future research.[3] Occasionally it simply takes time, new approaches and novel methods until common knowledge and previous experiments can be challenged by new generations of researchers. Nonetheless errors in the scientific literature are an inherent risk, especially if they are not properly addressed and published by the scientific community when they are discovered.

One very prominent and easy to swallow example is the claim that spinach is healthy because it is a rich source of iron.[4] Originating sometime in the 19th century this claim became a well-known popular legend and one of the longest standing myths in science. Even until today, food companies sometimes use this claim in their marketing and advertisement strategy for their frozen products.[5] In recent decades, this early error though has become widely known to the public, especially because the mass media and textbooks love to recount an urban academic legend, according to which this misconception originated from a simple decimal error:[6]

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[1] **To err is human:** The English version of this aphorism is best known from Alexander Pope's "An Essay on Criticism" (Anonymous 1711). The Latin origin of the aphorism is typically attributed ancient roots.

[2] See for example: Baigant et al. 2008; Cole et al. 2015a; Cole et al 2015b; Francis et al. 2013; Horbach & Halffman 2017; Ioannidis 2005; Nowbar et al. 2014; Ziemann et al. 2016. Even though errata have been much more common in recent years, known discrepancies and errors are likely to be not be resolved or even collated in the scientific literature. For a notable exception of cumulative self-reporting of errors see Knuth 1989.

[3] See Horbach & Halffman 2017; Huang et al. 2017.

[4] Hamblin 1981; Thachil 2007; Sutton 2010a.

[5] E.g. Anonymous 2012, 2013.

[6] See for example: Harvey et al. 1987; Anonymous 1988 p.264; Mould 1996 p.33; Drösser 1997; Beck-Bornholdt & Dubben 2001 p.221; Kruszelnicki 2001; Röhlig 2005; Wolke 2005 p.122; Barham 2006 p.44; Baldi & Moore 2009 p.51; Hecht 2010; Prang 2010 p.111; Panteleit 2013; Schwarcz 2015; Anonymous 2016.

However, there is much confusion in the literature on why and when all those stories started.

In the Christmas issue of the British Medical Journal of 1981 an editorial article[7] reviewed then contemporary instances of fraudulent science. As a cliff-hanger cancer researcher Terence J. Hamblin (1943–2012) used a short introduction reflecting on the myth of high iron content of spinach originating from a decimal error[8], which had occurred nearly a century before and linked it humorously to be the reason why Popeye ate spinach to gain his super-powers.[9]

Nearly 30 years later this short introduction was light-heartedly, but heavily criticized[10], because Hamblin had given no original references for his claims related to spinach, iron and Popeye. The criminologist Mike Sutton took up the idea, tried to follow the chain of evidence, and concluded that Hamblin might have made up the story of the decimal error[11]. Hamblin himself could not remember the source of his claims 29 years later, and courteously acknowledged this to be an oversight.[12] Sutton later[13] found earlier sources[14] from the 1970s, pre-dating Hamblin's article, which mentioned the decimal error, and acknowledged Hamblin was

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[7] Hamblin 1981.

[8] **Decimal and numerical errors** are quite common, and especially widely discussed in the computer programming and engineering literature. Legends tell that they have caused several havocs in science. For example, it has been elaborated that the Mars Climate Orbiter mission of NASA failed due to such a metric conversion error, which would eventually lead the $125 million satellite of track (Kirkpatrick & Francis 2010 p.9; Oberg 1999; Sauser et al. 2009; see also Kerr 1999). A misplaced decimal point was responsible in a failed Titan IV mission (Lewis & Swanson 2009 p.203). Decimal errors are also widely known to occur in clinical practise for example in form of dose prescribing errors (see for example Lesar 2002; Doherty & Mc Donnell 2012).
Numerical errors in the order of magnitudes do not have to be exact integer movement of decimals points. Sometimes they can be subtler and originate for example between metrics and the imperial system or refer to error in the order of magnitude. Sometimes they can be simply originating from transcript errors from other sources, or by misreading scientific meters and displays. However, it is known for a long time, which mischiefs a misplaced comma might cause in other lingual contexts (Anonymous 1956a p.436; Truss 2004; Lewis 2015).

[9] Hamblin 1981: "*In the year that Popeye became once again a major movie star it is salutary to recall that his claims for spinach are spurious. Popeye's superhuman strength for deeds of deering-do comes from consuming a can of the stuff. The discovery that spinach was as valuable a source of iron as red meat was made in the 1890s, and it proved a useful propaganda weapon for the meatless days of the second world war. […] America was strong to the finish 'cos they ate their spinach and duly defeated the Hun. Unfortunately, the propaganda was fraudulent; German Chemists reinvestigating the iron content of spinach had shown in the 1930s that the original workers had put the decimal point in the wrong place and made a tenfold overestimate of its value.* […] *For a source of iron Popeye would have been better chewing the cans.*" Note: In German, the moved decimal point would have been a decimal comma in the original texts.

[10] Sutton 2010a.

[11] Sutton 2010a: "…*Hamblin (1981) invented the decimal error part of the SPIDES* [Spinach, Popeye, Iron, Decimal Error Story] *and invented therefore the mysterious German scientists who he tells us discovered the invented error.*"

[12] Hamblin 2010.

[13] Sutton 2010b, 2016.

[14] Bender 1972, 1977.

not the originator.[15] However, he stuck to his analysis in so far that story was made up earlier. He was unable to locate a decimal error and he proposed that the inflation of the iron amount was instead caused by measurement problems.[16] Furthermore, Sutton found out that in early Popeye comic strips spinach consumption was not related to the iron content of spinach.[17] In fact, Popeye became "*strong to the finish 'cos he eats his spinach*" as he knew: spinach is a food source rich in vitamins.[18] Sutton's investigation went viral and has received a wide circulation on the internet and was also covered on international scale in many newspapers, student books, radio programs and websites.[19] More recently his findings, which were originally published in an internet journal, were also taken up in several scientific essays on general questions related to correct academic citation practices, the half-life of knowledge, how to find literature, how to separate fact from fiction and how academic urban legends develop.[20]

Variants of a myth

Sutton's analysis[21] is a rich study on spinach and iron and it follows the criminologists' tradition to establish motive, opportunity, and physical and circumstantial chains of evidence. Even more, it is one of the few attempts trying to understand how academic urban legends in medicine and science in general evolve.

His analysis, however, has some limitations. His original literature search was restricted in regard of not including many important sources that were originally published in German and French. A more severe issue, however, is that his article dances around the elephant in the room. His chain of events alone can hardly explain how the myth of spinach being rich in iron was initially established and became a global phenomenon. Unfortunately, even though mathematical models on the spread of misinformation and the dissemination of rumours exist[22], not much is known on how urban academic legends and popular misbeliefs in medicine and natural sciences develop and how both facts and errors are popularized. While there are practically endless numbers of examples of urban academic leg-

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[15] See Sutton 2010a and Hamblin 2010.

[16] Sutton 2016: "[…] *earlier erroneously high measures* […] *were explained in the USA by Professor Sherman in 1907 as resulting from iron contamination from heating dishes and other bad science.*" See also Sherman 1907.

[17] Sutton 2010a.

[18] **A vitamin super-hero:** According to Sutton 2010a Popeye started to eat spinach solely for his Vitamin A content and none of the comics from the early Popeye era mentioned iron in spinach.

[19] See for example: Anonymous 2010; Arbesman 2012, 2013; Engber 2016; Kovács et al. 2014 p.69-71; Rost 2017 p.150-151; Winkler 2010.

[20] Arbesman 2013; Rekdal 2014a; Rekdal 2014b; Rost 2017; Schwarcz 2015.

[21] Sutton 2010a, 2010b, 2016.

[22] See for example: Rapoport & Rebhuhn 1952; Daley & Kendall 1965; Dietz 1967; Nekovee et al. 2007; Kandhway & Kuri 2014; Acemoglu et al. 2010. Those models typically do not consider to differentiate between malicious and useful information (Kandhway & Kuri 2014).

ends and their potential origins – there is practically not a single example that has ever been analysed in detail in regard of how such academic legends evolve and in which way they might feed back into the halls of science.

Therefore, an intensive literature search was performed that covered all scientific, magazine and newspaper articles, textbooks, encyclopaedias and grey literature that were related to the topic and which could be located.[23] Based on new found sources the attempt was made to verify the different versions of the legend how spinach became rich in iron and to set them in the historical context in which they have been produced and propagated in. The following short list gives an overview of the trilogy of the most common variants of the legend:

- **Variant 1:** Gustav von Bunge (1844–1920), a Swiss scientist at the end of the 19th century made a decimal error, which led to a tenfold overestimation of the iron content.
- **Variant 2:** Emil von Wolff (1818–1896), a German scientist, made a decimal error in his compilation of mineral contents of vegetables and plants, which led to a tenfold overestimation of iron in spinach.
- **Variant 3:** In early biochemistry at some point the iron content presented as per dry weight was confused with the plants' fresh weight.

The findings of this literature search unfolded a citation puzzle of a complex story on how the myth of spinach being rich in iron originated much earlier than previously thought and how it was reported and popularized in the literature. It started as a simple side-note in one of the most viciously fought scientific, cultural, philosophical and religious disputes of the 19th century. It also revealed a multifaceted series of mistakes and a rollercoaster of multi-layered interactions between scientists from different disciplines and journalists, which eventually led to promoting spinach as iron rich after it was already discovered to be exaggerated, and later to debunk this myth, while simultaneously introducing new layers to the legend. It soon became clear that the ironic story of how spinach became rich in iron and

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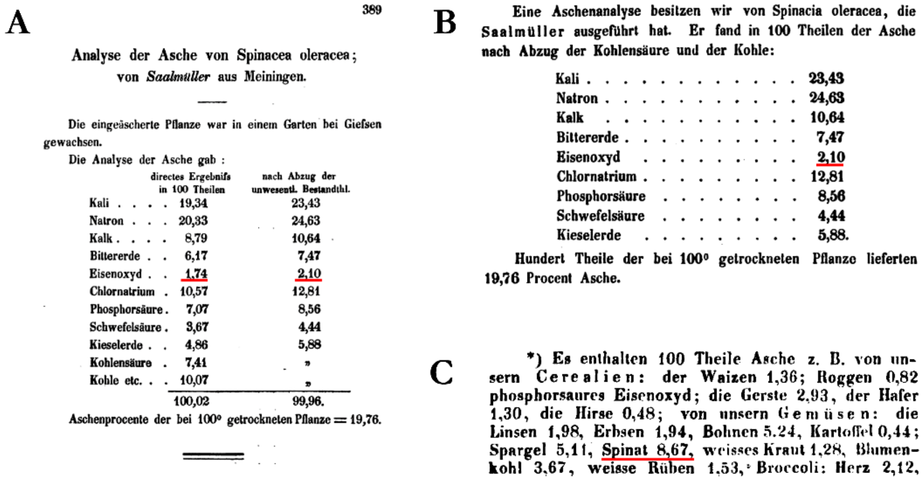
[23] **Methods:** To locate relevant literature a multitude of Search Engines and literature databases were consulted in a fuzzy search approach. Literature databases consulted included beside others: ANNO (AustriaN Newspapers Online), Bibliothèque National de France (Gallica Digital), Biodiversity Heritage Library, British Library Main Catalogue, British Newspaper Archive, California Digital Newspaper Collection, DIFMOE (Digitales Forum Mittel- und Osteuropa), Google Books, Google Scholar, Google Historical News Archive, HathiTrust, Imperial College Library Search, Internet Archive (archive.org), JSTOR, Landesbibliothek Dr. Friedrich Tessmann (Tessmann Digital), New York States Historic Newspapers, New York Times Archive, newspapers.com, Papers Past (National Library of New Zealand), Pubmed, The European Library, The Spectator Archive, Trove Digitized Newspapers, Web of Science, Wellcome Library – Digital Collection, Zeno.org.
Further the Digital collections of the "Staats- und Universitätsbibliothek Bremen", UrMEL Thüringer Universitäts- und Landesbibliothek Jena (ThULB), Swiss Press Online (Swiss National Library and partners).

how it was debunked is one of burlesque character and provides more potential twists than Rubik's cube.

Early origins of when spinach became rich in iron

Surprisingly enough it is possible to trace place and date relatively precisely when spinach first appeared as a vegetable rich in iron. In the oldest accounts on the composition of spinach authors already noticed, as they had for other plant species, traces of mineral contents.[24] They had, however, not found (and not looked for) iron in spinach, which was already known to be present in several plant species.

The earliest article, in which the content of iron in spinach was analysed, appeared as a small table published in 1846 by Saalmüller (see Fig. 1A).[25] No expressed claim was made there that spinach contains much iron, but it was implicated by the provided content of iron-oxide.[26] Saalmüller's findings, as well as another report by Richardson were reprinted over the years several times either together or alone (see also Fig. 1B,C, Fig. 2,3,4).[27] Reviewers of the original papers, however,



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Analyse der Asche von Spinacea oleracea;
von *Saalmüller* aus Meiningen.

Die eingeäscherte Pflanze war in einem Garten bei Gieſsen gewachsen.

Die Analyse der Asche gab :

	directes Ergebniſs in 100 Theilen	nach Abzug der unwesentl. Bestandthl.
Kali	19,34	23,43
Natron . . .	20,33	24,63
Kalk	8,79	10,64
Bittererde . .	6,17	7,47
Eisenoxyd . .	1,74	2,10
Chlornatrium .	10,57	12,81
Phosphorsäure .	7,07	8,56
Schwefelsäure .	3,67	4,44
Kieselerde . .	4,86	5,88
Kohlensäure .	7,41	»
Kohle etc. . .	10,07	»
	100,02	99,96.

Aschenprocente der bei 100° getrockneten Pflanze = 19,76.

Eine Aschenanalyse besitzen wir von Spinacia oleracea, die **Saalmüller** ausgeführt hat. Er fand in 100 Theilen der Asche nach Abzug der Kohlensäure und der Kohle:

Kali	23,43
Natron	24,63
Kalk	10,64
Bittererde	7,47
Eisenoxyd	2,10
Chlornatrium	12,81
Phosphorsäure	8,56
Schwefelsäure	4,44
Kieselerde	5,88.

Hundert Theile der bei 100° getrockneten Pflanze lieferten 19,76 Procent Asche.

*) Es enthalten 100 Theile Asche z. B. von unsern Cerealien: der Waizen 1,36; Roggen 0,82 phosphorsaures Eisenoxyd; die Gerste 2,93, der Hafer 1,30, die Hirse 0,48; von unsern Gemüsen: die Linsen 1,98, Erbsen 1,94, Bohnen 5.24, Kartoffel 0,44; Spargel 5,11, Spinat 8,67, weisses Kraut 1,28, Blumenkohl 3,67, weisse Rüben 1,53, Broccoli: Herz 2,12,

Fig. 1 *Values presented for the iron-oxide content of spinach as presented by (A) Louis Saalmüller 1846, (B) Jacob Moleschott[1] in 1850 and (C) Hessling 1852 referring to Richardson (values as iron phosphate). Relevant values are highlighted.*

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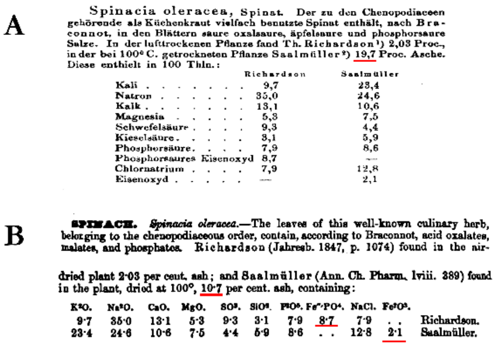
[24] Braconnot 1808, 1810 p.47; John 1814 p.4.

[25] Saalmüller 1846, p.389.

[26] Note that the presentation of iron-oxide in the original tables is a potential problem for reading and comparing the originally presented values, which is often not noticed by later publications that directly refer to the iron content. Sometimes later authors did not differ between iron, iron oxide and phosphorous iron oxide.

[27] Buchheim 1847, Ritter 1859 p.42-44, Anonymous 1861 p.95, Liebig & Kopp 1849 p.1074, Tiedemann & Moleschott 1850 p.369, Watts 1868, Moser 1870 p.369, Wolff 1871, König 1893 p.662).



A

Spinacia oleracea, Spinat. Der zu den Chenopodiaceen gehörende als Küchenkraut vielfach benutzte Spinat enthält, nach Braconnot, in den Blättern saure oxalsaure, äpfelsaure und phosphorsaure Salze. In der lufttrockenen Pflanze fand Th. Richardson[1]) 2,03 Proc., in der bei 100° C. getrockneten Pflanze Saalmüller[2]) 19,7 Proc. Asche. Diese enthielt in 100 Thln.:

	Richardson	Saalmüller
Kali	9,7	23,4
Natron	35,0	24,6
Kalk	13,1	10,6
Magnesia	5,3	7,5
Schwefelsäure	9,3	4,4
Kieselsäure	3,1	5,9
Phosphorsäure	7,9	8,6
Phosphorsaures Eisenoxyd	8,7	—
Chlornatrium	7,9	12,8
Eisenoxyd	—	2,1

B

SPINACH. *Spinacia oleracea.*—The leaves of this well-known culinary herb, belonging to the chenopodiaceous order, contain, according to Braconnot, acid oxalates, malates, and phosphates. Richardson (Jahresb. 1847, p. 1074) found in the air-dried plant 2·03 per cent. ash; and Saalmüller (Ann. Ch. Pharm. lviii. 389) found in the plant, dried at 100°, 10·7 per cent. ash, containing:

K^2O.	Na^2O.	CaO.	MgO.	SO^3.	SiO^2.	P^2O^5.	$Fe'''PO^4$.	NaCl.	Fe^2O^3.	
9·7	35·0	13·1	5·3	9·3	3·1	7·9	8·7	7·9	. .	Richardson.
23·4	24·6	10·6	7·5	4·4	5·9	8·6	. .	12·8	2·1	Saalmüller.

Fig. 2 *Values presented for the iron-oxide/iron-phosphate content of spinach as presented by (A) Anonymous 1861 p.95, and (B) Watts 1866 p.399 & p.400 joined. Relevant values are highlighted. Note that both reports noted different percentages of ash for Saalmüller 1846.*

did not always judge in favour of spinach. A sanitary state police report reviewing the spread of cholera for example concluded, supported by Saalmüller's table, that one should "*Savour as few vegetables as possible!*" and that "*Cabbage and spinach are not to be recommended under any circumstances.*"[28]

More generally a special interest in vegetable iron appears to have been sparked, when a new generation of iron therapies was introduced in the first half of the 19th century. Most famous was the introduction of Blaud's pills, which finally made iron a widely accepted element of the *Materia Medica*.[29] Until then doctors had used iron salts since ancient times[30], and during the renaissance and baroque periods, interest in iron treatments was revived:[31] A number of important discoveries on the physiological relevance of iron were made at that time – By 1713 Lémery and Geoffroy had demonstrated that blood and vegetables contain iron[32], in 1746 it was first reported that the amount of iron in the blood

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[28] Ritter 1859 p.42-44. Translations by the authors.

[29] **Iron remedies:** Blaud's pills were first introduced as remedies for chlorosis and anaemia in France in 1831 by Dr. Blaud the médecin-en-chef de l'hôpital de Beaucaire (Neurath & Lee 1941). Blaud's success is typically described on being based on using ferrous carbonate with the addition of sugar as oxidative protection (Römpp 1996 p.1098).

[30] **Iron tonics and remedies in ancient times**: The oldest example for the use of an iron tonic in ancient times is probably retold by the legend of Iphiclus (gr. Ἴφικλος) (Frazer 1921: *Apollodorus 1.9.12*): Iphiclus was infertile and cured by the seer Melampus. The latter had told him to take rust from the knife of his father, which stuck in a tree for years and to drink it solved in water or wine. This superstitious use of iron remained a medical tradition for a long time and was still advocated in the 17th century (Wallerstein & Mettier 1958 p.1).
Another well-known example is the "old-wives' tale" to spike apples with iron nails and to leave them overnight (McDowell 2017 p.256), which is often attributed to Herodot (482-429 B.C.) (see for example Schwedt p.16-17), however always without quoting the original source. This practice of creating a household iron remedy, however, seems to have originated in the 18th century especially in Eastern Europe and was revived by doctors throughout the 19th century (Kafka 1864 p.92, 1865 p.227), who used similar preparation practices to produce Ferrum pomatum, Extractum Ferri Pomatum and other similar remedies (Mitscherlich 1847 p.374).
For further antique examples on medical uses of iron see for example Christian 1903; McDowell 2017.

[31] Haden et al. 1938.

[32] Lémery 1713.

could be altered by feeding supplementary iron.[33,34] Eventually Justus Liebig popularized his famous "*Law of the Minimum*" in agricultural sciences, according to which "*the rate of growth of a plant, the size to which it grows, and its overall health depend on the amount of the scarcest of its essential nutrients that is available to it*".[35,36]

For the first time, ash analyses of spinach were presented to a wider audience in 1850. Jacob Moleschott, a soon highly influential physiologist, included Saalmüller's table in his revision of a widely-read handbook on dietary (see Fig. 1B).[37] Yet, even this public presentation could potentially confuse readers, because he only reproduced part of the table (see Fig 1A, B). Shortly afterwards, in 1852, spinach was reported as a vegetable rich in iron in an anonymous encyclopaedic entry for the first time.[38]

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[33] Menghini 1746, 1747; see also Wallerstein & Mettier 1958 p.3.

[34] **A medal for the erroneous iron content of blood:** Not only the iron content of spinach had been overestimated. In several of the earliest reports that claimed to have shown iron as a constituent of blood, authors reported iron content to be leagues too high compared to the values we know today being correct. Based on reports of Menghini (Menghini 1746, 1747), (who described the use of a magnet to identify iron in dried blood!!!), French scientists during the time of the First Republic calculated, that blood contained 70 scruples of iron (depending on the conversion system used ca. 90 g of iron) (Parmentier & Deyeux 1796 p.134-135). This miscalculation even led to some bizarre ideas. For example, it was suggested, that it would be possible to make iron tools and weapons from blood iron (l.c.). Another ridiculous suggestion was to make medallions from the blood of the deceased to provide the bereaved with a durable physical memorability of the beloved ones passed (Parmentier and Deyeux 1796 p.135, John 1814). The complete origin of oddities in Menghini's experiment are though clouded in obscurity and have never been fully explained. Commentators like for example Berzelius were rather sceptical, a few others who tried to replicate Menghini's experiments assumed an experimental error. Some though suspected an outright case of deception and concluded that "*Menghini's paper affords one instances out of many … where we might be assured that the facts as stated cannot be true, yet where it is not easy to assign the source of fallacy, or to determine in what degree the experimentalist was himself deceived or wished to deceive others*" (Bostock 1825, p.369). At least it is apparent, that some of the early estimates were further clouded and overestimated by calculations based on other overestimating assumptions. For example, in the 18th and early 19th century it was commonly assumed, that the human body contained 25 apothecary pounds of blood (Parmentier & Deyeaux 1796 p.134). Nonetheless other scientists soon reported estimates much closer to today's values (Le Canu 1837), but readers referring to those old papers should consider that the author relied also on other erroneous assumptions in their overall calculation in the human body (regarding Le Canu see also Berzelius 1832).

[35] Allaby 2012, p. 285.

[36] **Optimizing the law of the minimum:** It was soon realized that this was an over-simplification, which did not match experimental results. This eventually led to the «Law of the optimum» (Liebscher 1895) according to which "*The minimum factor affects yield more, the more the other factors approach their optimum dosage*" (Mohr & Schopfer 1995 p.571). A further specification was later added in form of "*the law of decreasing productivity*", which accounted for the existence of different growth factors (Mohr & Schopfer 1995 p.571; Mitscherlich 1909).

[37] Tiedemann & Moleschott 1850.

[38] Anonymous 1852 p.172.

In the same year, spinach as the vegetable with the highest iron content was also featured for the first time in a medical journal.[39] It was noted that the ash of spinach contains the highest amount of iron in any of the listed vegetables.[40] At that time the amount of iron phosphate in the ash of spinach was given as 8.67% (see Fig. 1C).[41] The author, however, did not cite any reference to this claim and roughly attributed it to the "*Giessener Schule*".[42]

Several other authors in the 1850s and 1860s took up the idea that spinach is a vegetable rich in iron.[43] Even in some of those early reprints, problems for the reader were introduced (see Fig 1A vs. 1B & 2A vs. 2B & Fig. 3 vs. 2).

Uncertainties could arise from those reports: Various numbers were presented in contradictory fashion and in the case of Richardson it was also unclear whether the presented spinach analysis was based on fresh weight or dry weight (see Fig 2. & Fig. 3). At the same time this "*fact*" of spinach being a vegetable supporting the

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[39] Hessling 1852 p.216.

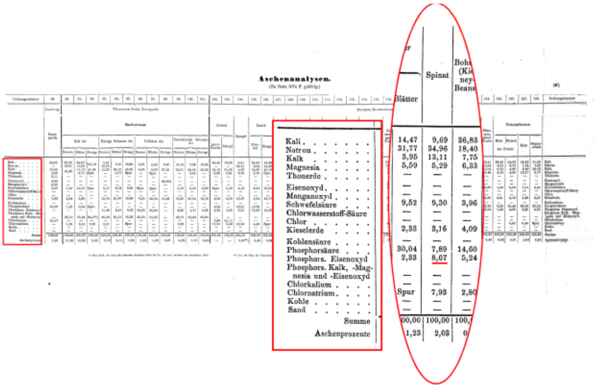
[40] Hessling 1852 p.216.

[41] Hessling 1852 p.216; the presented values were based on data from a publication by Thomas Richardson.

[42] **Saalmüller and Richardson:** The note clearly refers to the school and laboratory of Justus Liebig and the early reports published by Richardson [and possibly Saalmüller]. The biography of Thomas Richardson (1816-1867) is well known (Hartog 1896). He was one of the first British guests in Justus Liebig's laboratory in Giessen and there obtained his PhD in Chemistry (Bud & Roberts 1984 p.103; Fruton 1990 p.53-58; Campbell 2000 p.111). He later became a well-known Chemist in Newcastle upon Tyne (Fruton 1990 p.287) and wrote several text-books on Organic Chemistry. He also provided the First English translation of Justus Liebig's "*Introduction to the First Elements of Chemistry, for the Use of Students*" (see Liebig 1837). There is not much known about Saalmüller. Louis Eduard Saalmüller (1820-?) from Römhild near Meiningen came as private citizen to Giessen to study Chemistry and on the 12.12.1845 enrolled as a chemistry student (see Kössler 1976 p.159). He stayed there from 1846 to 1847/48 (Wankmüller 1980). His short table on the ash content of spinach was his first scientific work. Nothing is known about his later life (see also Fruton 1990 p.304). Fragments of his study time though have survived in letters, depicting him as not being the most commendable student (Busse 2015 p.121). In June 1846, it was noticed by his student colleagues, that after joining one of the local student fraternities, Saalmüller was "*already nearly lost for the field of chemistry*" (transl. by the author; as cited by Busse 2015 p.121), and they ridiculed the discussed fraternities and students: "*Nothing is more seldom for them, then a sober moment.*" (transl. by the author; l.c.). In 1847 Saalmüller would publish a longer work on the chemical composition of Ricinus oil, which would also be partly translated into English and French (Saalmüller 1847; Saalmüller 1848a, 1848b; see also Hunt 1848). It would cause a further scientific discussion, because other authors were unable to replicate some of his analysis and found different results. The „*Ricinusölsäure*" investigated by him was later used as more intense alternative to castor oil (Darmstaedter 1908 p.1847), a remedy which for a long time was used as laxative, but also torture remedy to punish badly behaving children. His discovery today is still remembered in the history of Lipid Sciences for being the first identification of a hydroxylated lipid (Leray 2013 p.301).

[43] von Hessling 1852 p.216; Bernstein 1853 p.157-158; 1864 p.126; Moleschott 1859 p.347; Moleschott 1861 p.50-51 & 75; Leo 1866 p.146; Klencke 1867 p.489-490; Anonymous 1873b; Leuchs 1875 p.539; Ule 1876 p.217.

physiological creation of blood in anaemic patients was further retold as encyclopaedic knowledge.[44]



	Blätter	Spinat	Boh (Ki ney- Beans
Kali	14,47	9,69	36,83
Natron	31,77	34,96	18,40
Kalk	3,95	13,11	7,75
Magnesia	5,59	5,29	6,33
Thonerde	—	—	—
Eisenoxyd	—	—	—
Manganoxyd	—	—	—
Schwefelsäure	9,52	9,30	3,96
Chlorwasserstoff-Säure	—	—	—
Chlor	—	—	—
Kieselerde	2,33	3,16	4,09
Kohlensäure	—	—	—
Phosphorsäure	30,04	7,89	14,60
Phosphors. Eisenoxyd	2,33	8,67	5,24
Phosphors. Kalk, -Magnesia und -Eisenoxyd	—	—	—
Chlorkalium	—	—	—
Chlornatrium	Spur	7,93	2,80
Kohle	—	—	—
Sand	—	—	—
Summe	00,00	100,00	100,
Aschenprozente	1,23	2,03	0

Fig. 3 *Ash analyses of spinach as presented by Richardson 1848 (details magnified) as reprinted in "Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie für 1847/1848" (Liebig & Kopp 1849 p.1075) provided several problems for the reader: (1) A footnote (**) was attached that all analyses of Richardson had been performed on natural (undried) plants. Later reports however told, that the plant had been air-dried (see Fig. 2). This makes it clear that already early after publication of the results a confusion of dry-weights and fresh-weights had occurred. (2) The footnote was only attached in the table to the first column, of results given by him. Not in the spinach column. It was thus easy to overlook. (3) No values for coal (germ. Kohle), sand or carbon dioxide are given. This renders it unclear which method was used for the investigation and how much iron was in the analysed plant.*

In this context two factions arose: Those who preferred to promote a supplementary iron therapy for chlorosis based on the idea of Blaud's pills, and a second faction, which promoted a dietary solution for chlorosis.[45,46] The latter view was

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[44] **Spinach, a blood creating vegetable:** Anonymous 1852; Anonymous 1860 p.784: „*Weiße Rüben enthalten eine geringe Menge von Eisen, Spinat dagegen viel; daher ist es erklärlich, weshalb uns, nachdem wir drei Tage weiße Rüben gegessen, Spinat ein Leckerbissen scheinen wird.*"; Rolfus & Pfister 1865 p.370: „*Eben diesen* [sic] *Eisengehaltes wegen ist der Spinat ein kräftiges, blutbildendes Gemüse, das besonders Bleichsüchtigen sehr wohlthätig wird.*"; Watts 1868.

[45] See for example: Anonymous 1858 p. 29 & Bernstein 1853; Anonymous 1855a & Anonymous a.k.a. Bernstein 1869 p.136: „*…Um nun eines dieser Mittel zu erwähnen, wollen wir den Spinat anführen, dessen Genuss für Kinder und junge Mädchen, die ein bleiches Aussehen haben, ganz vortrefflich ist. Diese Bleichheit rührt von einem Mangel an Eisen im Blute her. Nun kann zwar jeder Arzt Tropfen verschreiben, die Eisen enthalten, aber die Wirkung solcher künstlichen unorganischen Dosen ist sehr zweifelhaft, während der Spinat eisenhaltig von Natur und immer eine bessere, eine organische Arznei und Speise zugleich ist.*"

[46] **Liquid spinach:** Unsurprisingly many iron tonics and remedies became available over the years and especially during the 19th and early 20th century. For a time, some of them were directly prepared from spinach. E.g. Spinol (also known as Spinoferrin), "*a liquid saccharine extract of young, fresh spinach leaves*" was advertised as a leaf free alternative for the "*spinach cure in children*" (Coblentz 1899 p.126; see also p.478; Thoms 1929 p.2046). Another was Spinol siccum, a brown-green amorphic powder with a bitter and salty taste made from Spinol (Coblentz 1899 p.126; Thoms 1929 p.2046). Spinol saccharatum liquidum was an-

not only limited to a small medical circle, but was also soon portrayed in German newspapers, which highlighted the iron value of spinach[47] probably often based on accounts by Moleschott. The legend of spinach being rich in iron though remained somehow limited to a small circle of authors and their audience in Germany at that time.[48] Several of them might have had direct relations to Jacob Moleschott.[49]

The role of Jacob Moleschott

As already noticed, Jacob Moleschott[50] was the first who in 1850 presented the results of iron content of spinach to a wider audience. Beyond this, he was also the anonymous author of the encyclopaedic article that first explicitly reported that spinach is rich in iron.[51] This was later revealed by Moleschott himself, who admitted a couple of years afterwards that he was the author of this article, when he republished a revision.[52]

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other similar product (Thoms 1929 p.2046). In the 1930s companies also introduced a dried spinach powder called Spintrate (Anonymous 1939 p.322-323).

[47] Anonymous 1853; Anonymous 1855a; Klencke 1872; Anonymous 1873a p.678; Anonymous 1874.

[48] For an exception see Anonymous 1869 p.14 & p.136.

[49] **A whisper net:** Carl Theodor von Hessling (1816-1899) was inscribed from 1838 as student at the University Heidelberg (Toepke 1904 p.604) and likely knew Moleschott from his student times (see also Hessling 1852). Otto Ule (1820-1876) was a popularizer of Humboldt and had married the sister of Jacob Moleschott's wife (Meneghello 2017 p.66 footnote 144; see also Ule 1855, 1876 p.217). Bernhard Ritter and Moleschott might have known each other from Moleschott's time in Heidelberg. Ritter was a practical physician in Rottenburg near Heidelberg. Both published articles in the 1847 issue of "*Zeitschrift fuer rationelle Medizin*", published in Heidelberg (Ritter 1847, Moleschott 1847).

[50] **Jacob Albertus Willebrordus Moleschott (1822-1893)** was an important Dutch physiologist and one of the main proponents of Scientific Materialism. After studying Medicine in Heidelberg, he returned to the Netherlands and worked as a physician in Utrecht. During his time in Utrecht and Heidelberg he translated several contemporary works on Natural Sciences (Snell & Moleschott 1842; Mulder & Moleschott 1844a, 1844b; Mulder & Moleschott 1847, Hoeven & Moleschott 1847). In 1847 he returned to Heidelberg as private lecturer. There he wrote the first editions of his most important works, an introduction on Human dietary and the cycle of life, in which he critically discussed Liebig's theories (Moleschott 1850, 1852). Both would become two of the most intensely discussed works on Natural Sciences in continental Europe. In 1856 he became the first Ordinarius of Physiology at the newly found Polytechnikum in Zurich. In 1861 he relocated to Italy and taught at the University Turin and since 1879 at the Sapienza University in Rome. In his later years, he spent most of his time working as a Senator of the newly founded kingdom of Italy. For details on his biography see Hagelgans 1985; Meneghello 2017; Moleschott 1894.

[51] Anonymous 1852 p.172.

[52] **An incorrect citation:** See Moleschott 1861 p.VI-VII: „B*einahe die Hälfte der folgenden Blätter hat bereits anderwärts dem Publikum vorgelegen. Der erste Aufsatz erschien im Jahre 1850 in dem von Brockhaus herausgegebenen Sammelwerke: ‚Die Gegenwart.*‘“. Note that Moleschott is mistaken here, as this article was published in 1852, an error which Moleschott later corrected himself (Moleschott 1863a p.503): „*Vgl. Meinen Aufsatz 'Nahrungsmittel' in der 'Gegenwart' von Brockhaus, 1852, zu dem ich mich*

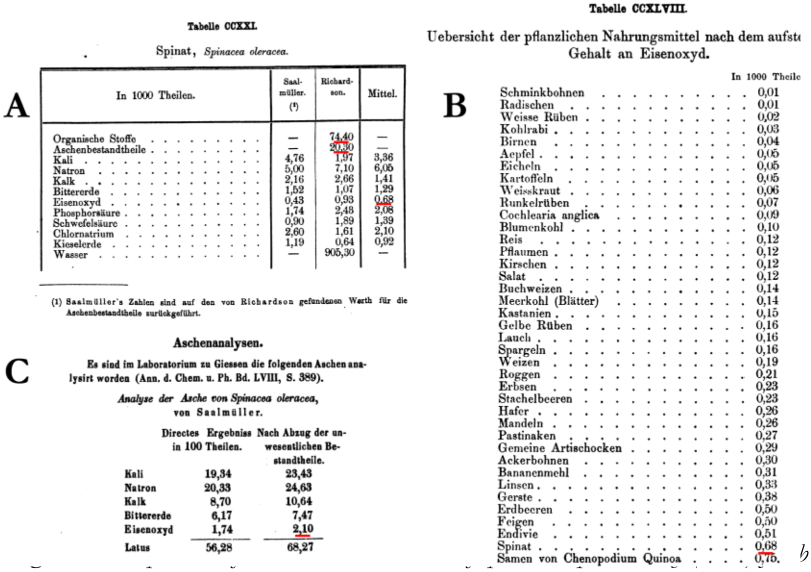
A

Tabelle CCXXI.

Spinat, *Spinacea oleracea.*

In 1000 Theilen.	Saal-müller. (¹)	Richard-son.	Mittel.
Organische Stoffe	—	74,40	—
Aschenbestandtheile	—	20,30	—
Kali	4,76	1,97	3,36
Natron	5,00	7,10	6,05
Kalk	2,16	2,66	1,41
Bittererde	1,52	1,07	1,29
Eisenoxyd	0,43	0,93	0,68
Phosphorsäure	1,74	2,48	2,08
Schwefelsäure	0,90	1,89	1,39
Chlornatrium	2,60	1,61	2,10
Kieselerde	1,19	0,64	0,92
Wasser	—	905,30	—

(1) Saalmüller's Zahlen sind auf den von Richardson gefundenen Werth für die Aschenbestandtheile zurückgeführt.

B

Tabelle CCXLVIII.

Uebersicht der pflanzlichen Nahrungsmittel nach dem aufst
Gehalt an Eisenoxyd.

	In 1000 Theile
Schminkbohnen	0,01
Radischen	0,01
Weisse Rüben	0,02
Kohlrabi	0,03
Birnen	0,04
Aepfel	0,05
Eicheln	0,05
Kartoffeln	0,05
Weisskraut	0,06
Runkelrüben	0,07
Cochlearia anglica	0,09
Blumenkohl	0,10
Reis	0,12
Pflaumen	0,12
Kirschen	0,12
Salat	0,12
Buchweizen	0,14
Meerkohl (Blätter)	0,14
Kastanien	0,15
Gelbe Rüben	0,16
Lauch	0,16
Spargeln	0,16
Weizen	0,19
Roggen	0,21
Erbsen	0,23
Stachelbeeren	0,23
Hafer	0,26
Mandeln	0,26
Pastinaken	0,27
Gemeine Artischocken	0,29
Ackerbohnen	0,30
Bananenmehl	0,31
Linsen	0,33
Gerste	0,38
Erdbeeren	0,50
Feigen	0,50
Endivie	0,51
Spinat	0,68
Samen von Chenopodium Quinoa	0,75.

C

Aschenanalysen.

Es sind im Laboratorium zu Giessen die folgenden Aschen analysirt worden (Ann. d. Chem. u. Ph. Bd. LVIII, S. 389).

Analyse der Asche von Spinacea oleracea,
von Saalmüller.

	Directes Ergebniss in 100 Theilen.	Nach Abzug der unwesentlichen Bestandtheile.
Kali	19,34	23,43
Natron	20,33	24,63
Kalk	8,70	10,64
Bittererde	6,17	7,47
Eisenoxyd	1,74	2,10
Latus	56,28	68,27

Moleschott in 1859. (C) Values presented in "Journal für praktische Chemie – Dritter Band p.121 (Anonymous 1846). Values presented by Moleschott were based on the investigation by Richardson 1848 and Saalmüller 1846, but had been recalculated.

Of the early publications by Moleschott promoting spinach to be rich in iron, several are especially noteworthy. In them[53], Moleschott originally established spinach as a vegetable rich in iron. For example, in 1859 he presented the earlier ash analyses of spinach. In contrast to previous versions though, this time the analysis was recalculated as values adjusted to the values of Richardson (0.68 parts in 1000 parts).[54] The table itself and its recalculation almost certainly might have caused further problems for readers (see Fig. 4A). Furthermore, another table lists spinach explicitly as the richest source of iron (with the exception of quinoa seeds) (see Fig. 4B).[55] However, Moleschott was not the only one in that period who was

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hier bekenne, um manche Aehnlichkeit der Ansichten und Namen zu erklären, und Physiologisches Skizzenbuch [sic] *von Jac Moleschott, Gießen 1861, I. Die Kraftquellen des Menschen.*"

[53] See Anonymous 1852, p 172; Moleschott 1860 p. 483: „*Reich an Eisen, 0,30 p.M. Eisenoxyd und darüber* [hinaus] *sind Ackerbohnen, Linsen, Gerste, Bananenmehl, die Samen von Chenopodium, Quinoa, Erdbeeren, Feigen, Endivie, Spinat und ganz besonders die Lebern der Fische*"; Moleschott 1880 p.50-51: „*Weiße Rüben enthalten eine geringe Menge von Eisen, Spinat dagegen viel; daher ist es erklärlich, weshalb uns, nachdem wir drei Tage weiße Rüben gegessen, Spinat ein Leckerbissen scheinen wird.*" See especially also table CCXLVIII in Moleschott 1859 p.186 (in the Appendix „Zahlenbelege"). See also in Moleschott 1859 table CCXXI p.166 (in the Appendix „Zahlenbelege").

[54] See table CCXLVIII in Moleschott 1859 p.186 (Note: in the Appendix „Zahlenbelege"). Note that this value of 0.68 was not reported in the literature, but was instead based on a recalculation by Moleschott, in which he tried to adjust Saalmüller's 1846 findings to the ash values given by Richardson (Moleschott 1859 Appendix p.166 table CCXXI).

[55] Moleschott 1859 Appendix p.166 table CCXXI.

not sure about how to present results (see Fig. 4C). Interestingly, several of the reprints presented for both the tables of Saalmüller and Richardson in each case with different amounts of ashes recovered (see Fig.2 & 4). It is well possible that this was the origin of the "*decimal error*" at least in the sense that uncertainties in the range of one order of magnitude existed. In any case, it might explain why some people found the story convincing. Without the notes by Jacob Moleschott it is extremely hard to understand how the myth of spinach being rich in iron survived the first phase of its popularization:

During the "*Vormärz*" of the German revolution of 1848, a serious cultural, philosophical, religious and scientific dispute arose, since biologists started to explain human nature in a biological philosophy of life. This conflict was called "*Materialismus Streit*" and Jacob Moleschott, inspired by the philosophy of Spinoza[56,57], Hegel[58] and Feuerbach[59], soon became one of the most vocal supporters of the materialistic monistic world view.

One of the biological battlefields in this dispute was the nutritional role of compositional elements of food. According to Moleschott's materialistic view, the elements of nutrition were not only the basic elements of physiology, but also of cognitive function and faculties.[60] His bon mot "*No thought without phosphor*"[61] soon became a widely-known dictum.[62,63]

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[56] See Thissen 1995 p. 130-131.

[57] **Baruch Spinoza (1632-1677)** was a Dutch philosopher of Portuguese origin and one of the great rationalists of the 17th century. His work was important in being fundamental in modern biblical and religious criticism. He was also sometimes ridiculed as a man named Spinach (Laursen 2000 p.198). In his honour a variety of spinach was named after him. *Spinacia olearacea* var. spinoza.

[58] **Georg Wilhelm Friedrich Hegel (1770-1831)** was a German philosopher and the leading figure in the German Idealism movement.

[59] **Ludwig Feuerbach (1804-1872)** was an important German philosopher who's religion criticism and materialism where highly influential. He also helped to popularize the works of Jacob Moleschott, and his recension of Moleschott's book "Lehre der Nahrungsmittel für das Volk" became famous for the quote „*Der Mensch ist was er isst*" [engl. Man is what he eats] (Feuerbach 1850 p.1082).

[60] See also Meneghello 2017 p.309.

[61] Moleschott 1850 p.116; see also Moleschott 1861 p.21.

[62] **Don't trust the literature – *"Fish is brain food"*, or how Mark Twain fooled scientists for 150 years:** It is noteworthy, that Moleschott's book on nutrition and his most famous quote have been associated with another popular believe, which is that "*fish is a brain-food*" due to its high amount of phosphorus (Atwater 1887, Porterfield 1970). The aphorism is classically attributed to Louis Agassiz (1807-1873). However, this was already doubted during Agassiz lifetime. It was reasoned, that Louis Agassiz (1807-1873) put together Moleschott's winged words and findings from Pasteur's teacher Dumas (1800-1884) who had found high amounts of phosphor salts inside fishes (Atwater 1887). Interestingly already 130 years ago, authors were already stumbling in clarifying the origin of such popular myths in nutrition (l.c.). The episode of fish being a brain-food due to its phosphorous content even received literature fame thanks to a remark on critical thinking by the splendid Mark Twain, who claimed to have replied to a young aspiring author asking for advice on the right diet for an author (Twain 1871): "*Yes, Agassiz does recommend authors to eat fish, because the phosphorus in it makes brain. So far you are correct. But I cannot help you to a decision about the amount you need to eat – at least, not with certainty. If the specimen composition*

However, the true core of the dispute was that Moleschott and other real-philosophers proclaimed the unity of force and matter. [64] No matter without embedded force, no force without matter as carrier.[65] Moleschott expressed that force and matter can only be changed together and that the soul therefore is an impossibility and no more than movement of matter. Presenting their theses as being consequences of empirical sciences, radical natural scientists and philosophers such as Moleschott, Vogt and Büchner discredited university philosophy and especially German idealism as pure speculation.

The opposing party in biology consisted of vitalists, as for example Justus von Liebig, expressing that not every aspect of life and human nature could be explained by natural sciences. In the historical scientific context, Jacob Moleschott soon became the most outspoken critic of the vitalist world view and especially of the works of Justus von Liebig (1803–1873).[66] One of Moleschott's first works was a critical discussion of Liebig's theories on plant nutrition, which in its detailed discussions was rather an homage to Liebig's work.[67] Nevertheless, it did

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you send is about your fair usual average, I should judge that perhaps a couple of whales would be all you would want for the present. Not the largest kind, but simply good, middling-sized whales."

Especially nutrition scientists often recite this episode on a famous Harvard Professor who coined the idea and journalism schools and Courses on Creative Writing love to retell the story of Mark Twain's Double-Pun. Unfortunately, the story is itself not completely correct. Moleschott in 1858 showed measurements highlighting a large amount of phosphorous in fish exactly on the same page on which he presented his famous aphorism "*No thought without phosphor*". He even reasoned, that fish is a good source to match the demand of necessary phosphor. Furthermore, it was not even Agassiz who coined the term that "*fish is brainfood*" due to its phosphorus content. In fact, this nutritional myth was coined numerous years earlier in a journal of the literate Karl Gutzkow (1811-1878). In 1854 in his magazine on "*kitchen conversations*" a review on the book of Moleschott stated: "*A meal of fishes is praised due to its phosphor content as exquisite brain-food*" (Gutzkow 1854; translated by the author). It remains unknown, if Agassiz ever made the claim at all (Atwater 1887; James 1890 p.81ff).

[63] **Misattribution by Lazy writers:** Even though many got it right – numerous scientists, book authors and journalists for more than a century and into the present attributed this aphorism erroneously to a student named Büchner (Chambers 1875 p.151, Fishbein 1929a, Fishbein 1930, Lys 1948, Anonymous 1956b, Hocking 1998 p.279). Ludwig Büchner (1824-1899) indeed used the quote "*Without phosphorous no thought*" in his best-known book "*Kraft und Stoff*", but only to retell in quotation marks what Moleschott said (Büchner 1856, p.17; 1872 p.115). This case example of misquotation is even ongoing 130 years after its misattribution was first highlighted to correct an article in the then new edition of the Encyclopaedia Britannica (Atwater 1887 p.249).

[64] Moleschott 1856 p.33; see also Meneghello 2017 p.159.

[65] Büchner 1859 p.193: „*So wenig ein Gedanke ohne Gehirn sein kann, so wenig kann ein normal gebildetes und ernährtes Gehirn sein ohne zu denken…*"

[66] **Justus von Liebig (1803-1873)** was an important German Chemist teaching in Giessen and Munich. In his classical works, he recognized the importance of minerals for plants and the necessity to fertilize soils to maintain their fertility. He thus later became the "*father of the fertilizer-industry*" (Skrabec Jr. 2013 p.54). He also developed a manufacturing procedure for beef extracts, which became part of the "*iron ration*" that were provided to soldiers (Roth 1875 p.38).

[67] Moleschott 1845; Moleschott received the award of the Teyler Society (Teylersch Gesellschaft 1844).

discuss limitations with regard to presenting data. For example, Moleschott even then explicitly criticized Liebig with regard to ash analyses, which should be more "*exact*" and be provided as mean values.[68]

Although Molschott highly admired Liebig for his experimental wit (Evans 1896) the dispute soon escalated. Justus von Liebig published his „*Chemische Briefe*" and Jacob Moleschott replied with another more voluminous epistle structured as a direct reply: „*Der Kreislauf des Lebens*" (engl. *The Cycle of Life*).[69] First published in 1852 it became the source of a veritable scandal. Moleschott at that time was teaching Anthropology and Physiology at the University of Heidelberg and two years after the book was published, it had caused enough outcry that the rector and senate of the university felt they had to react.[70] They did so by officially denouncing Moleschott's book as "*frivolous*" and "*immoral*" at the state ministry.[71]

In a private audition, it was revealed to Moleschott that he had to stop his provocations, otherwise they would find it easy to remove him from his position with support of the State ministry. Deeply offended by what Moleschott perceived as abandonment of the academic "*freedom of teaching*", until today one of the most vividly defended principles of German universities, Moleschott resigned from his post as lecturer and took the chance to become the first ordinaries of Physiology at the newly founded Polytechnikum in Zurich.[72] A full account much in favour of Moleschott's perspective was presented to a wider German audience in one the first issues of the "*Gartenlaube*", [73] a predecessor of modern illustrated magazines, which a few years later became the first German magazine having a circulation number exceeding 100000.[74] Especially Moleschott's remark that cadavers should be cremated for the sake of agriculture, so that the valuable minerals would not be lost, seems to have provoked an utter outcry among his contemporaries, who saw in this nothing less than a barbaric act of blasphemy, atheism and "*violation of human dignity*".[75] It is to be seen in this context how the note on a high iron content started to get viral.

The books[76], published shortly after the peak of the „*Materialismusstreit*", were the first to present the high iron content of spinach to a wider audience. Due to the intensity by which the „*Materialismusstreit*" was fought, Moleschott soon became a widely read and received author and as for many of the materialist books,

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[68] Moleschott 1845 p.116.

[69] Moleschott 1852.

[70] Evans 1896.

[71] Anonymous 1855b; Evans 1896; Grützner 1906; Kockerbeck 2011.

[72] Grützner 1906.

[73] Anonymous 1854.

[74] See for example Faulstich 2004 p.66. Die Gartenlaube had started in 1853 with a total circulation number. In 1857 the total circulation had already been increased to 45000 and to 70000 in 1858 (Rottner 1858).

[75] Rautenberg 1885 p.25.

[76] Moleschott 1859, 1861.

his works were translated into multiple languages.[77] This is not only visible by the several positive book reviews written by his supporters, but even more by the many authors who openly opposed them. Already by the mid-1860s hundreds of authors had written harsh replies against the materialistic world view. The public outcry was gigantic and soon escalated in lengthy scientific[78] , philosophical and theological replies[79], political pamphlets[80], personal philippics, sharp tongued puns, acrimonious satires, anonymous skits and even theatre plays caricaturing Moleschott.[81,82]

Despite this, Moleschott's works were widely circulated directly and indirectly by authors who intensely recited them, and in the rising nutritional movement both Moleschott's nutrition books and Ludwig Feuerbach, who wrote a multivolume newspaper review of his nutrition book, became classics.[83,84] Therefore, even if early biochemists often tried to disprove many of his special nutritional claims at the end of the 19th century, it is apparent that Moleschott's works were known to many of them.

Moleschott's publications on dietary nutrition also had some other effects. First, the idea that spinach is exceptionally rich in iron, based on his books and his anonymous encyclopaedic article[85], became part of one the major German Encyclopaedias.[86] Second, since by 1867 at the latest spinach for the first time appeared in a cookery-book as being rich in iron and a good remedy for chlorosis.[87] It was used as a schoolbook in educational institutions as "*food for thought for thoughtful*

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[77] Kamminga 1995.

[78] **Ad hominem:** For example, Liebig called Moleschott a "*dilettante*" and "*commuter strolling at the borders of natural sciences*".

[79] Fischer 1853; Michelis 1856.

[80] Anonymous 1856c.

[81] **Scientific dispute:** How intense the dispute was fought at the peak of the Materialismusstreit in 1856 is perhaps best visualised by an anecdote: After the entrance lecture of Moleschott in Zurich on "*Light and Life*", legend tells that "*on his way to the lecture room he met the rector of the university, Hermann Köchly, who was not only an acute philologist but also something of a wag, and who assured him that the peasants, led by their pastors and armed with clubs, were coming down the lake to put a stop to such godless proceedings, just as a dozen years before they had overthrown the government that ventured to offer a professorship to David Strauss.*" (Evans 1896).

[82] Anonymous 1856a; Anonymous 1856b.

[83] **A German Fairy tale:** Moleschott's books on nutrition were reprinted in several editions and they were also translated into Dutch, French, English, Italian, Russian and Spanish (Moleschott 1894 p.227, Moleschott & Flocon 1858, Moleschott 1863a, 1863b). Most of them are now extreme bibliographic rarities. At least the English and French versions of the book did not contain the claim that spinach is rich in iron (Moleschott & Flocon 1858). Not all the editions show nutritional and iron content of spinach and other vegetables.

[84] See also Anonymous 1855b, a defence of Moleschott, which was likely written by Ludwig Feuerbach.

[85] Anonymous 1852.

[86] Anonymous 1860.

[87] Klencke 1867.

young women".[88] Even though relatively rarely, the idea that spinach is rich in iron was also publicized in several local newspapers in the mid-19th century.[89]

The legend that spinach is rich in iron has therefore emerged at a much earlier point in time than it is commonly assumed today. It was Moleschott who first popularized this very special kind of spinozistic spinazism. However, there is no clear sign in Moleschott's books that a decimal error occurred.

The tables presented in their different versions, however, highlight that as early as the 1850s an intense discussion must have been ongoing. Elsewise it would be hardly understandable, why several authors tried to recalculate the table. One obvious reason was certainly that Saalmüller and Richardson had used different descriptions of what was measured, which were not fully compatible. The discrepancies however highlight that there had already been confusion at the very origin when those measurements were presented first. Especially there seem to have also been unclarities with regard to fresh and dry weights.

Emil von Wolff's "Aschenanalyse" (1865–1880)

The earliest mineral analyses of the iron content of spinach were based on the analysis of plant material reduced to ashes. This kind of analysis had become fashionable in early modern chemistry and was performed by many scientists. Everything from "horse excrements" to the content of wine was incinerated, analysed and published in chemical manuals. Soon a flood of such analyses occurred, and it turned out to be increasingly impossible for agronomists, biologists and chemists to follow the ever-increasing number of publications. In the true spirit of the 19th century, everything needed to be catalogued to remain accessible. Prof. Emil von Wolff (see Fig. 5)[90] became the person who was chosen to perform this task, after first ash analyses were also accumulated previously by Moleschott.

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[88] Klencke 1867.

[89] Anonymous 1873a, 1873b, 1873c, 1873d, 1874.

[90] **Emil Theodor von Wolff (1818-1896)** was a German agricultural chemist. He worked as professor and director at the „königl. württembergischen land- und forstwirthschaftlichen Akademie zu Hohenheim". His work was strongly influences by Justus von Liebig and he wrote several books and articles, including a teaching script on agricultural chemistry (Leisewitz 1910). However, over time, Wolff somehow became a serious critic of Justus von Liebig and Wolff's most important textbook (Wolff 1851) became the credo for the "*Stickstöffler*" [nitrogen party] which lay in clinch with the "*Mineralstöffler*" [mineral party], which supported Liebig's views and his effort to introduce a commercial "patent" mineral fertilizer (Stahr, Fellmeth & Blume 2015). Wolff was critical of this fertilizer, which he thought to be not working sufficiently (Stahr, Fellmeth & Blume 2015). He criticized Liebig in this regard harshly: "[regarding practical experiments] – *Mr. von Liebig has no idea of their number and practical importance*" (Stahr, Fellmeth & Blume 2015; transl. by MM). Much like Jacob Moleschott, Emil von Wolff also published a pamphlet seriously criticizing Justus Liebig's "*Chemische Briefe*" and Liebig's attacks on the then leading agricultural chemists (Wolff 1858).
Another important work of Emil von Wolff were his feeding doctrines in which he had collected an extensive set of analyses for carbohydrates, fat and proteins in feeds and diets which were

In modern terms one might say that both Moleschott and Wolff were the first to introduce a Systematic Review or Meta-Analysis to the scientific literature of biology. However, Emil von Wolff was later pinpointed in many reports as being responsible for the decimal error that let to spinach being rich in iron.[91]

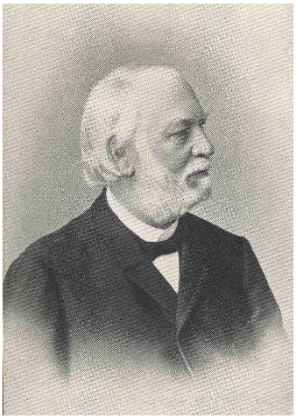

Fig. 5 *Emil Theodor von Wolff (1818-1896) is often unjustly named and shamed as being responsible for introducing spinach as a vegetable rich in iron due to a decimal error. His most important scientific contributions however were as a Professor in Hohenheim, where he helped to develop the field of animal- and plant-nutrition to a modern science.[1] He was also the first in the world to launch a state-owned Experimental Station for Agronomy[1] (Image source: Archive University Hohenheim)*

In 1865 a first version of his collection of ash analyses was published.[92] By 1871 it was updated in depth and he then had also included previously described measurements on the iron content of spinach (see Fig. 6).[93]. However, he did not put any special emphasis on spinach being iron rich and only presented raw tables. Wolff's compilation thereby was based on measurements of two previous publications: The already mentioned publications by Saalmüller and a second article by Richardson.[94]

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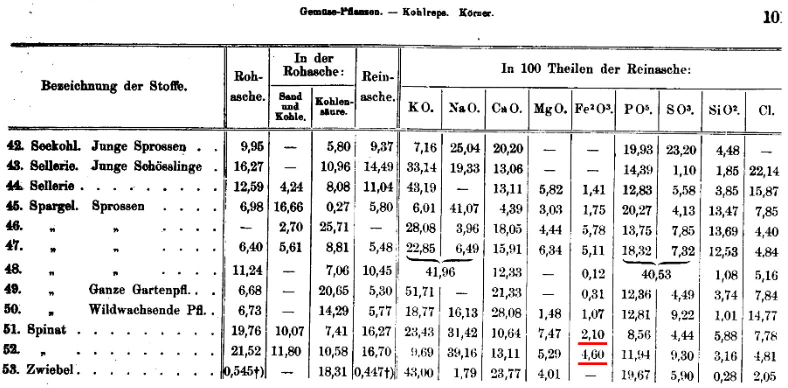
used for optimizing nutrition of livestock's (Ihde 1961 p.810). At his time this work as well as his "Aschen-Analyse" was highly popular (Sachs 1873 p.33; Ihde 1961 p.810).

[91] See for example Bender 1977: "*For a hundred years or more spinach has been (and clearly still is) renowned for its high content of iron compared with that of other vegetables, but to the joy of those who dislike the stuff this is quite untrue. In 1870 Dr E. von Wolff published the analyses of a number of foods, including spinach which was shown to be exceptionally rich in iron. The figures were repeated in succeeding generations of textbooks -after all one does not always verify the findings of others including the 'Handbook of Food Sciences' (Handbuch der Ernahrungslehre* [sic]*) by von Noorden and Saloman in 1920.*"; see also discussion in Sutton 2010a.

[92] Wolff 1865.

[93] Wolff 1871 p.101, p.128, p.147.

[94] Saalmüller 1846; Richardson 1848 as cited by Wolff 1871 p.101.

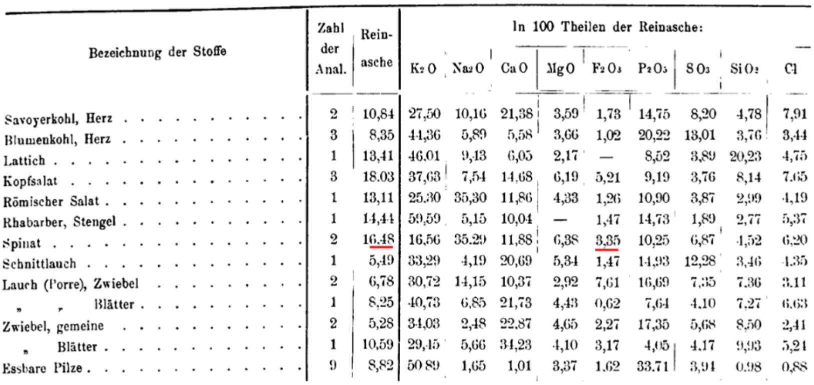


Gemüse-Pflanzen. — Kohlrepe. Körner. 101

Bezeichnung der Stoffe.	Roh-asche.	In der Rohasche:		Rein-asche.	In 100 Theilen der Reinasche:								
		Sand und Kohle.	Kohlen-säure.		K O.	Na O.	Ca O.	Mg O.	$Fe^{2}O^{3}$.	PO^{5}.	SO^{3}.	SiO^{2}.	Cl.
42. Seekohl. Junge Sprossen . .	9,95	—	5,80	9,37	7,16	25,04	20,20	—	—	19,93	23,20	4,48	—
43. Sellerie. Junge Schösslinge .	16,27	—	10,96	14,49	33,14	19,33	13,06	—	—	14,39	1,10	1,85	22,14
44. Sellerie	12,59	4,24	8,08	11,04	43,19	—	13,11	5,82	1,41	12,83	5,58	3,85	15,87
45. Spargel. Sprossen	6,98	16,66	0,27	5,80	6,01	41,07	4,39	3,03	1,75	20,27	4,13	13,47	7,85
46. „ „	—	2,70	25,71	—	28,08	3,96	18,05	4,44	5,78	13,75	7,85	13,69	4,40
47. „ „	6,40	5,61	8,81	5,48	22,85	6,49	15,91	6,34	5,11	18,32	7,32	12,53	4,84
48. „ „	11,24	—	7,06	10,45	41,96		12,33	—	0,12	40,53		1,08	5,16
49. „ Ganze Gartenpfl. . .	6,68	—	20,65	5,30	51,71	—	21,33	—	0,31	12,36	4,49	3,74	7,84
50. „ Wildwachsende Pfl. .	6,73	—	14,29	5,77	18,77	16,13	28,08	1,48	1,07	12,81	9,22	1,01	14,77
51. Spinat	19,76	10,07	7,41	16,27	23,43	31,42	10,64	7,47	2,10	8,56	4,44	5,88	7,78
52. „	21,52	11,80	10,58	16,70	9,69	39,16	13,11	5,29	4,60	11,94	9,30	3,16	4,81
53. Zwiebel	0,545†)	—	18,31	0,447†)	43,00	1,79	23,77	4,01	—	19,67	5,90	0,28	2,05

Fig. 6 *Ash analyses of vegetables as presented by Emil von Wolff in 1871 p.101. Nr. 51 represented the spinach results measured by Saalmüller 1846. Nr. 52 represented the values of Richardson 1848 with a water-content of the fresh substance being 90.53 percent.*

Wolff himself later extended his report by publishing an update, in which he included 1600 further ash-analyses, however this time many of those were based on own analytic investigations.[95] Measurements for spinach however still used the data collected in the 1840s (see Fig 7).



Bezeichnung der Stoffe	Zahl der Anal.	Rein-asche	In 100 Theilen der Reinasche:								
			K_2O	Na_2O	CaO	MgO	F_2O_3	P_2O_5	SO_3	SiO_2	Cl
Savoyerkohl, Herz	2	10,84	27,50	10,16	21,38	3,59	1,73	14,75	8,20	4,78	7,91
Blumenkohl, Herz	3	8,35	44,36	5,89	5,58	3,66	1,02	20,22	13,01	3,76	3,44
Lattich	1	13,41	46.01	9,13	6,05	2,17	—	8,52	3,89	20,23	4,75
Kopfsalat	3	18.03	37,63	7,54	14,68	6,19	5,21	9,19	3,76	8,14	7.65
Römischer Salat	1	13,11	25.30	35,30	11,86	4,33	1,26	10,90	3,87	2,99	4,19
Rhabarber, Stengel	1	14,44	59,59	5,15	10,04	—	1,47	14,73	1,89	2,77	5,37
Spinat	2	16.48	16,56	35.29	11,88	6,38	3,35	10,25	6,87	4,52	6,20
Schnittlauch	1	5,49	33,29	4,19	20,69	5,34	1,47	14,93	12,28	3,46	4.35
Lauch (Porre), Zwiebel	2	6,78	30,72	14,15	10,37	2,92	7,61	16,69	7,35	7.36	3.11
„ „ Blätter	1	8,25	40,73	6,85	21,73	4,43	0,62	7,64	4.10	7.27	6.63
Zwiebel, gemeine	2	5,28	34,03	2,48	22.87	4,65	2,27	17,35	5,68	8,50	2,41
„ Blätter	1	10,59	29,45	5,66	34,23	4,10	3,17	4,05	4.17	9,93	5,21
Essbare Pilze	9	8,82	50 89	1,65	1,01	3,37	1.62	33.71	3,94	0.98	0,88

Fig. 7 *Ash analyses of vegetables as presented by Emil von Wolff in 1880 p.128. Results were even further reduced.*

The perhaps most amusing fact on the early origin of the claim that spinach is rich in iron is the fact, that the complete early hype was based on no more than the results obtained from two studies each investigating a single probe. One thing can be concluded with absolute certainty: Emil von Wolff did not introduce the myth

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[95] Wolff 1880.

that spinach is rich in iron.[96] Those claims had already been popularized for years in the literature by Moleschott[97] and others even before the first compilations of ash-analyses by Wolff were published. However, the question remains[98] if he was responsible for introducing a decimal error to further popularize spinach as being rich in iron:

On the terrors of the table or on the difficulty to read one

Variant 2 of the myth how spinach became rich in iron (originating from a decimal error made by Prof. Wolff) should be principally easy to verify. Several authors had already reported that they were unable to find any such decimal error.[99] Alas, how difficult can it be to read a simple table and compare it with the original reports it had been published in? Unfortunately, there are several problems one must realize when reading Wolff's "Aschen-Analyse".[100]

At this point a surprising finding needs to be revealed. When locating the article by Richardson quoted by Wolff[101] it was found that this article had not been published in the Journal as Wolff reported it to be. Even after an intensive search in other issues of Justus Liebig "Annalen der Chemie" (formerly Ann. Chem Pharm.) it was impossible to trace the original publication quoted. Only after an in-depth literature search, looking through old volumes, it was eventually possible to find early reprints of Richardson's article[102,103,104], which lead to another surpris-

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[96] **"Yellow Press":** The legend that Prof. Wolff was responsible for the claim that spinach is rich in iron even gained him a status of immortality in the "yellow press". In a recent listing of the 500 most important people in history, one should know, he was ranked on place 114, closely outranking Popeye and Usain Bolt (Anonymous 2015a p.52).

[97] See Anonymous 1852; Moleschott 1859; Wolff 1871, 1880.

[98] See Bender 1977; Sutton 2010a.

[99] See Sutton 2010a, 2010b; Terrell 2007; Sutton 2016.

[100] **A confusion matrix:** Many problems of the original table have been already highlighted in the comments attached to an online version of Sutton's spinach analysis. For example, some of the table header are not perfectly labelled, because the columns "*sand & coal*" (orig. "*Sand und Kohle*") and "carbonic acid" ("orig. *Kohlensäure*) must be read as percentage of dry weight in the "raw ash". Furthermore, readers will notice that the composition of the "pure ash" (orig. "*Reinasche*") in both spinach analyses does not add up to 100, either exceeding or undercutting. The reason for this is, that the original reports used different chemical annotation systems. When Wolff organized his tables, he had to unify it, and therefore several mineral constituents needed to be recalculated. As in the example of the spinach probes, this sometimes led to minor calculations slips, which could easily lead to confusion when reading the tables. This error is further accompanied by other minor rounding errors, often found in many of the presentations in Wolff's Aschen-Analyse.

[101] **Another misquotation:** Wolff quoted Richardson: Annal. Chem. Pharm. Bd. 67. Heft 3 1848 to be the source of his data without giving the exact location.

[102] See Anonymous 1861; Liebig & Kopp 1849 p.1049; Watts 1868.

[103] **A lost article:** Wolff states in his "*Aschen-Analysen*", that all values for Richardson have been obtained from an article in "Annal. Chem. Pharm. Bd. 67 Heft 3 1848". In the main volumes of this issue though no article from Richardson is present (Readers are advised, that at this time numeration of the volumes changed, which leads to some further confusion). By pure chance an

ing finding: The presence of a decimal anomaly. According to several early sources (Anonymous 1861, Watts 1868), Richardson reported that the dry-weight of air-dried spinach contained 2.03% ash (see Fig.2, 3). Wolff, however, later reported that the dried plant contained 21.52% raw ash (see Fig. 6).[105] Actually, this issue might indeed be a potential origin for variant 2 and variant 3 of the myth, how spinach became rich in iron. In this context, it is also necessary to highlight, that Moleschott also readjusted Saalmüller's findings to those of Richardson. When Sutton eventually writes that the legend of the decimal error has been busted and there is no sign this had ever occurred, he also highlights that it is possible that Wolff mixed up fresh and dry weight, but that there is no indication in the literature.[106]

This at least is wrong. There is indeed an indication that it might have been misread which seems to have originated from two possible readings of the table presented by Richardson. Nonetheless we though cannot be sure which reading is

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early reproduction (Anonymous 1861) was found, which gave some further hints and reported, that the analysis was also reprinted in the "*Jahresberichte*" of Liebig and Kopp for the year 1847 (Liebig & Kopp 1849). The "*Jahresberichte*" again itself clarify, that the original data were presented as a simple appendix of "Annal. Chem. Pharm. Bd. 67 Heft 3 1848". Unfortunately, none of the digitized version, nor versions checked in various libraries contain this appendix and even the official website of today's journal "*Justus Annalen der Chemie*", which provides access to a complete digitized archive of the Journal history, does not know about this Appendix. The last article of the digital journal's volume, which might also contain the table, was found to be in digital suspense. The original article therefore remains lost.

[104] **A copy of a lost article:** The oldest locatable reprint of Richardson dates to 1849 (Liebig & Kopp 1849). Several digitized versions of this text-books are available on the internet. Readers though should be warned that several of those versions (especially those found on Google Books) unfortunately present a digitalisation error on the pages that contain the tables. The reason for this is, that the table was originally printed on a large fold-out. A complete version and zoom able of the table can be found in the digital library of the University and State library Düsseldorf. (Note: The PDF version might present the table unreadable, the direct link using the digital collection frontend of this very page might not work).

[105] **Mix-up Fresh and dry weight?** While it might be easy to attribute this to ambiguity in reading, the reports are though very precise in the expression, and for example the English account (most likely written by Richardson himself) noted: "*found in the air-dried plant 2.03 % ash*"). The earliest report though makes it clearer, how a misreading of percentage ash per fresh-weight instead of percentage ash per dry-weight might have occurred. In fact, at the bottom of the copy of the original table (Liebig & Kopp 1849), one can find an addendum marked with **, which in the table is itself only attached to one measurement. The addendum notes: "*that the results are given 100 parts of vegetable in the natural (undried) state in all analyses of Richardson*". The note ** in the table though is only attached to the results for asparagus, and therefore the reader might be unsure if this note meant to be relevant for all values of the very column, or for all values in the row for "ash percentage". Unfortunately, we cannot know for sure, which reading is the correct one. The values presented as percentage ash for different plant species do not allow to draw any meaningful conclusion. Yet it is obvious, that all later sources close to Richardson (Watts published several books together with Richardson, Liebig was the supervisor of his dissertation thesis and editor of journals that reprinted Richardson) always reported, that the ash was measured in air dried plants.

[106] Sutton 2010b.

correct. For once it is certain that Jacob Moleschott was the first to popularize the belief that spinach is rich in iron, and indeed this might have been caused by a kind of decimal error, originating from mixing up fresh weight and dry weight. As a concluding remark, it should be noticed that Wolff himself was very much aware of the problems inside his compilation[107] and several authors later severely criticized the collected data.[108]

Over several decades many authors have assumed that Wolff was the one responsible for the origin of the myth that spinach is rich in iron. There is no evidence at all that Wolff contributed to popularizing the spinach iron myth. While Wolff's "*Aschen-Analyse*" was widely available to scientists, it hardly received any broader public attention, even though some of his other works were quite popular in his time.[109] Eventually, it seems worth highlighting that Wolff's "*Aschen-Analyse*" was quite different from most other scientific works of his time, because he very carefully tried to provide all references for his data.[110]

Boussingault

After Richardson and Saalmüller reported the first measurements of iron in spinach[111], the French scientist Boussingault[112], who had already gained a larger than life reputation for precise and accurate measurements[113], was the first one to reinvestigate the content of iron in spinach and many other foods.[114]

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[107] Wolff 1871; see also Wolff 1880.

[108] See for example Quinton 1912. There see especially the Appendix.

[109] His book "*Praktische Düngerlehre*" would see a total of 18 editions until 1926 (Stahr, Fellmeth & Blume 2015).

[110] Stahr, Fellmeth & Blume 2015.

[111] Saalmüller 1846; Richardson 1848.

[112] **Jean Baptiste Boussingault (1802-1887)** especially gained reputation for one of the most famous experiments in biology. After Priestley with a candle and a mouse had discovered that plants produce oxygen from "noxious", carbon dioxide rich air (an experiment he ironically reports to work best with spinach) (West 2015 p. 133), it remained still unknown, if this was a nutritional process. It was Boussingault, first growing a plant under controlled environmental conditions, who could proof, that carbon dioxide was an essential plant nutrition, and that it was converted by plants in a mostly stoichiometric ratio of 1:1 to oxygen.

[113] **This incrédible reputation of Boussingault** is perhaps best illustrated by an anecdote, which might well represent one of the founding legends of reliable and replicable modern natural sciences:

When Boussingault performed one of his key experiments, which eventually proved that air's carbon dioxide is the key plant nutrient and was converted to oxygen in a stoichiometric ratio of 1:1 during the day, Boussingault and his colleagues realized a problem. Boussingault and his experiment partner Dumas each weighed and recorded their results independently, and after some days they noticed, that the plants started to produce carbon dioxide during the day, instead of consuming it. When they realized this, they became totally frustrated because they lacked any explanation. This was continuing for several days, until Victor Henri Regnault, another physicist who had been observing the experiment, started "*to laugh at their long faces*" and admitted, that every morning while Boussingault and Dumas were at lunch, he breathed into their measurement apparatus after sneaking into the laboratory. Regnault told them then, that he did this "*to*

Iron values reported by him are much lower, than the ones previously reported for spinach: He reported a value of 0.0045 gram iron per 100 g matter. A translated German version of his article appeared only a couple of years later.[115]

In his investigation Boussingault did not mention the earlier reports and Wolff's compilation of "*Aschen-Analysen*". This might have led Sutton to the conclusion that it was Bunge who first uncovered problems in Wolff's analysis of spinach. But it was Boussingault who had shown much lower values twenty years before Bunge also re-measured spinach. Nevertheless, even Boussingault's findings were not universally accepted and questioned by later researchers.[116]

Gustav von Bunge? Origin of the decimal error? (1892)

Gustav von Bunge[117], a physiologist at the University of Basle is the second scientist, who is often accused of being responsible for establishing the myth that spinach is rich in iron, due to a decimal error he made.[118] As a general introduction it seems worth highlighting that, in his later career, he was often called the father of Neovitalism. While this is not wrong, it must be stressed that this is especially true only in relation to a theosophical dispute. In contrast, his biochemical analysis often mixed up views from vitalists and materialists and on the base of biochemi-

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be convinced, that you were not taking an u for a x, and could really determine such small amounts of carbon dioxide" (retold from Palladin 1926 p.3, who heard it from Timiriazev, who had heard it from Boussingault himself).

[114] Boussingault 1872; see also Boussingault 1874 p.108-134.

[115] Birnbaum et al. 1874 p.827-829.

[116] **Scepticism**: Several authors have remarked scepticism on the spinach iron values presented by Boussingault, too. For example, Sherman (1912 p.233) noted: "*Boussingault's figures, however, are not sufficiently accurate to be of value at the present time…*"; see also identical Lichtin (1924, p.361). However, the origin of this scepticism was not revealed. Another author simply remarked that Boussingault's iron values for spinach "*were too high*" (Scott 1923, p.159) without giving full references. Most likely all criticisms on Boussingault's iron analyses were based on an earlier article by Stockman (1895, p.484), who already had noticed that "*All recent research tends to show that the older estimations of iron in organic substances have given results invariably much too high…*". Stockman however was especially concerned with the overall digest intake values of iron presented by Boussingault, which caused him to replicate those measurements more thoroughly. Regarding the origin of the problem Stockman was convinced, that overestimations were caused by methodological issues and based on "*sufficient care not having been taken to thoroughly destroy the organic matter present*" (Stockman 1895, p.484).

[117] **Gustav Bunge (1844-1920)** was German physiologist from Dorpat, where he taught from 1874 to 1886. He then became professor in Basel. His main work was his teaching book "*Lehrbuch der physiologischen und pathologischen Chemie*", which at the turn of the century was one of the most successful science books of his time. Active in the temperance movement, some of his works also became internationally known and influential. He was also the most important neovitalist (see for example Bunge 1886). In a physiological context he was especially interested in the physiological aspects of mineral nutrition and especially iron, which he found to be lacking in milk (Schmidt 1973 p.34). He was one of the main apostles to support a dietary approach featuring "organic" iron from foods. For details on his biography see Schmidt 1973.

[118] Sutton 2010a.

cal experiments Bunge tried to verify, which dietary view is correct, and which is not. In regard of his spinach analysis it seems certain that he was highly familiar with Moleschott's earlier work.[119]

By 1890 the small Laboratory of Bunge in Basle had landed a veritable scientific coup, when Zinoffsky supported by Bunge found out that numerous earlier measurements of the iron content of haemoglobin had been inaccurate[120]. Even though the discrepancy was comparably small, the discovery was the important step necessary to find the correct stoichiometric molecular formula of haemoglobin later. Until the complete structural composition of haemoglobin was revealed decades later, Zinoffsky work was the definitive paper on haemoglobin. Even today his finding of the "*Zinoffsky constant*" of 0.34 mg% is widely used in different types of blood analysis tests and his sharp logical reasoning are often taught in University classes on organic chemistry.[121] Re-examination of iron content in a plant extract was only a logical next step.[122]

In 1892, Bunge openly questioned Wolff's "*Asche-Analysen*" based on two examples – The iron content of strawberries and the iron content of spinach, which he both found more than one order of magnitude too high.[123] The problems identified were clearly highlighted in the footnotes of this article, in which Bunge states: "*According to one analysis, 100g of dried leaves would contain a half gram of iron! This number is 16 times too high.*"[124] Apparently, this article could theoretically be the

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[119] Bunge especially in his early articles often cites the works of Jacob Moleschott (von Bunge 1871, 1874a).

[120] Zinoffsky 1886; Jaquet 1888; for discussion see also Wyman & Gill 1990 p.124.

[121] See for example Cahn 2003 p.37. Zinoffsky's experiment was especially remarkable, because it was the first that allowed to determine an empirical formula for an organic super-macromolecule with a minimal weight of 16700 Å.

[122] **Spinach in the lab:** Readers should remember that at that point in time the molecular composition of chlorophyll was still unknown. At the end of the 19th century it was still a widely popular misconception, that iron played a similar role in the chlorophyll pigment, as it did in haemoglobin. Bunge's laboratory was ahead of its time, as it already realized, that the iron in haemoglobin is indeed part of the molecular structure and that haemoglobin might be composed of several subunits. Other researchers argued that iron might be only artificially linked to the haemoglobin during crystallization, and it was widely believed, that the magnesium in chlorophyll extracts was also only an impurity. It would take another 20 years, until Richard Willstädter (1872-1942) at the ETH Zurich was able to prove, that magnesium is the central atom in chlorophyll (Willstädter & Stoll 1913) – a breakthrough for which he eventually received the Nobel Prize in Chemistry in 1915 (Kuhn 1949; Trauner 2015). Today the role of iron in the electron transport chains has been intensely studied. One of the most important discoveries was the discovery of the Hill reaction (Hill 1937, 1940), which eventually proved that the oxygen produced during photosynthesis does not originate from carbon dioxide but H_2O molecules. Reduction of Fe^{3+} to Fe^{2+} plays an essential role in these processes. Isolated chloroplasts for the further investigation of the hill reaction were often extracted from spinach and made the it a scientific model organism (see for example Jagendorf 1950; Krogmann & Jagendorf 1957; Park 1966).

[123] See Bunge 1892 p.181-182.

[124] **Tenfold too high iron content:** Bunge 1892 p.182 footnote 3: already noticed too high values in previous analyses: „*Auch zur Bestimmung des Eisengehaltes in den Spinatblättern wurde ich durch die hohen*

origin of the decimal error legend, which Sutton claimed to be non-existent, connecting two of the original proponents (Bunge and Wolff) and involving an error in the range of one order of magnitude, which can easily be understood as a decimal error. In its original German version, the article leaves it open to the reader whether it was a kind of typographical, mathematical or methodological decimal error. Interestingly there is even a strong argument that makes it very plausible that Bunge might have indeed assumed a typographical decimal error, which had been completely overlooked in the last 140 years:

The table in Wolff's "*Aschen-Analyse*" for spinach does indeed contain a discrepancy easy to spot– In fact the number of parts of mineral elements exceeds 100 % by more than what is explainable by a simple rounding issue (101.7%). Wolff reported for the first of the two spinach plants an iron content of 2.1. By shifting the digit by one position to 0.21% the summed value for all elementary minerals would come very close to an overall sum of 100 (99.83%). Even though it is unlikely that this is the correct way to read these tables, it is worth mentioning, because it is a further possible source for readers who are aware of the story on the decimal error and are trying to verify it superficially.

Additionally, it needs to be mentioned, that in Bunge's article there are numerous discrepancies in reporting Boussingault. Of the six values Bunge reprints from Boussingault, six did not match the values originally published.[125] In this case, Sutton's second question is clearly answered. Bunge was the scientist who discovered the "decimal error" by finding that the results were more than one order of magnitude too high.

Bunge himself believed that qualitative results still confirmed the old reports that spinach is rich in iron, but with a much lower calculated amount. Accordingly, he started to promote spinach as a useful additive for infant nutrition, because he had estimated that especially milk contained only a small amount of iron.

Zahlen veranlasst, welche in Wolff's ‚Aschen-Analysen' für dieselben angegeben sind. Nach der einen Analyse würden 100 gr. der trockenen Blätter einen halben Gramm Eisen enthalten! Diese Zahl ist 16mal zu hoch! Für die Richtigkeit meiner Analyse bürgt die Übereinstimmung mit der Analyse Boussingault's. Vergl. die Tabelle im Eingang der Abhandlung." In a similar way he also criticized the iron contents given in Wolff's "Aschen-Analyse" for strawberries (Bunge 1892 p.181-182): "*Zur Bestimmung des Eisens der Walderdbeeren veranlasste mich der auffallend hohe Eisengehalt, welcher für dieselben in Wolff's ‚Aschen-Analysen' auf Grund einer Analyse von Richardson (Ann. d. Chem. u. Pharm., Bd. 67, Heft 3, 1848) angegeben ist. 0,14 Fe auf 100 trockener Beeren! Diese Zahl ist, wie meine beiden Bestimmungen lehren 15mal zu hoch ausgefallen! Die Beeren zu meiner Analyse waren bei Dorpat, die zweiten bei Basel gesammelt. Da beide Analysen das gleiche Resultat ergaben, so scheint es, dass der Eisengehalt der Walderdbeeren ein sehr constanter ist.*"

[125] **Discrepancies:** For rice [fr. *Riz*] Boussingault 1872 reported that 100gr contained 0.0015 g iron, Bunge 1892 citing Boussingault reported 100g rice [germ. *Reis*] contained 1.7 mg. Similar for the other entries. For spinach [fr. *Feuilles d'epinards*] Boussingault reported 0.045 g, whereas Bunge 1892 citing Boussingault reported 100g spinach [germ. *Spinat*] contained 39.1 mg. It is possible that this discrepancy originated from further recalculations of Boussingault's data.

Reading Bunge's article, which covers the iron content of spinach as a side note, one might wonder why he was especially taking these two examples. The only reasonable explanation is that he was already aware that they had been promoted for their iron content. More difficult to answer is the question, when he performed those experiments. The only hint he gives is that some of his samples (those of strawberries) were collected in Dorpat and Basle. It is interesting that it highlights the possibility that parts of this investigation had already occurred much earlier. Indeed, he had already made measurements of a strawberry at his time in Dorpat.[126] It turns out that Bunge had already questioned some of Richardson's results in 1874 and therefore repeated the measurement to then confirm that the mineral contents of natron were indeed as high as described.[127] Bunge at that time might have already been aware of Boussingault's data. Furthermore, strawberries might have been of historical interest in this context to Bunge, because they had been described to contain iron very early in scientific publications.[128]

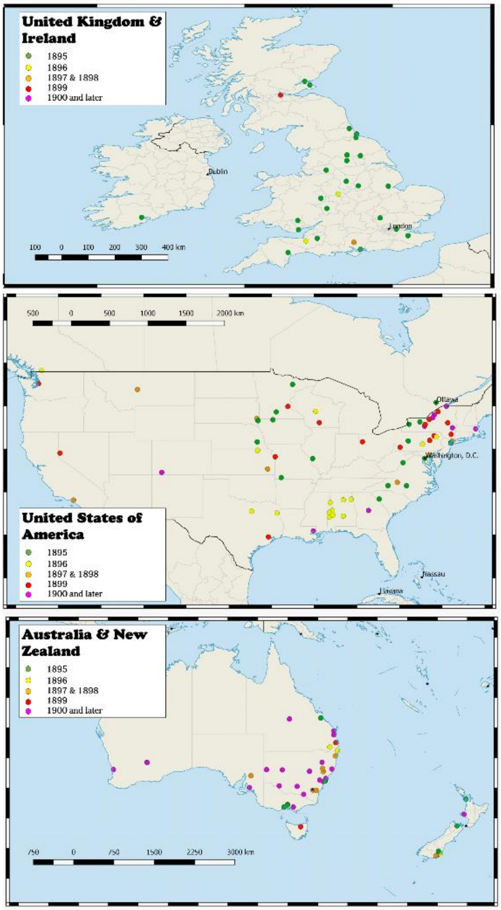

Fig. 8 *Following the presentation of Professor Bunge in 1895 and a short notice, which had reviewed his lecture in Nature, hundreds of newspapers would start to retell the story of spinach being rich in iron. The presented maps show the first occurrences of known articles in the time frame from 1895 to 1920. Prevalence was highest in the US states New York and Pennsylvania, where the story was retold for several years in different news outlets.*

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[126] Bunge 1874b p.26.

[127] Bunge 1874b p.26.

[128] **Strawberry fields forever:** Anonymous 1784: A historical account on iron in strawberries: "*Aus dem vorigen Artickel, daß es eine den Naturforschern sehr bekannte Sache sey, daß sich in den Aschen der Pflanzen sehr viele Theile finden, die der Magnet zieht, und die mithin die Natur des Eisens an sich haben müssen; aber dass man dieses Metall ohne Einäscherung in seiner ursprünglichen metallischen Gestalt in den Pflanzen angetroffen habe, ist eine Sache, die weniger bekannt und gemein ist. Zwar hat man hin und wieder Goldkörner in Weinbeeren, nach Bechers Versicherung, angetroffen; auch Goldfäden an den Wurzeln des Getraydes;*

What remains though is the irony that anecdotal reports in later times in hundreds attributed the decimal error to have been made by Bunge. How did this happen? How did the legend that spinach is rich in iron become internationally well known, whereas blood-sausages (which were also promoted by Bunge) did not?

From scientific dispute to common knowledge and back again (1892–1930)

Very soon after Bunge had published his findings that the original reports on spinach content had been exaggerated, his report developed a life of its own. The origin of this was, that Bunge still found a lot of iron in spinach compared to other food, which he repeated in lectures at conferences. The most important of those was a lecture at the 13th Congress of Internal Medicine, held in Munich in April 1895.[129]

Already in the very June of the same year, a first report of Bunge's presentation appeared in the English Text corpus. An anonymous editorial in John Harvey Kellogg's[130] Journal "*Modern Medicine and Bacteriological Review*", retold Bunge's lecture and especially the story that spinach is rich in iron and especially richer than for example the yolk of an egg.[131] Simultaneously it was also included in a pamphlet on the "*Rationale of Blood Regeneration*".[132] Originating from those retellings, the story of spinach and iron eventually went viral on an international scale. In its

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Zinn und Bley im Inneren der Pflanzen […]; *aber daß man Eisen mitten im ätzenden Saft einer Pflanze finden werde, hat man vielleicht nicht einmal für möglich gehalten...* […] *Insbesondere sey die Sache wahr, weil sie ohne alle Zweydeutigkeit mit Augen ist gesehen worden.*"

[129] Bunge 1895.

[130] **John Harvey Kellogg (1852-1943)** was an American medical doctor and is today best known to be one of the inventors of Cornflakes and Peanut Butter. He was the head of a large Sanatorium in Battle Creek (Michigan) and in 1892 he became one of the two editors of "*The Bacteriological World and Modern Medicine*", which was published both in London and New York and was later renamed into "*Modern Medicine and Bacteriological Review*". Due to Kellogg's promotion of a strictly vegetarian diet and his interest in meat substitution products it is possible that he was the author of the Editorial. What is certain however is that at least later he was in direct contact with Gustav von Bunge (see Findbuch zum Nachlass von Gustav von Bunge (1844-1920) at the University Library Basle, Entry 84.80: Letter of J.H. Kellogg to G. Bunge 28th June 1907 incl. 2 photographs). See also Schmidt 1973.

[131] **Spinach propagation:** Anonymous 1895b p.150; The anonymous editor briefly described a lecture held by Gustav Bunge (own transl.): "*At the German Congress of Internal Medicine, held last April, Prof. E.* [sic] *Bunge, the famous physiological chemist of Basle, Switzerland, presented an interesting paper relating to the therapeutic use of iron, which give facts of great practical interest. First of all, Prof Bunge called attention to the physiological role of iron in the body. He stated that the proportion of iron entering into the composition of the body has been greatly overestimated.*" In this article a table containing the iron content of several foods and vegetables is shown, in which spinach is shown to be the one richest in iron (35.9 mg) and the editorial continues with (Anonymous 1895b p.150-151): "*It is interesting to note, in the above table, the large proportion of iron contained in certain vegetable substances, particularly in lentils, apples, and spinach. This perhaps explains the craving which invalids sometimes have for spinach and similar substances.*"

[132] Anonymous (1895c).

issue of August 1st, Nature reported Bunge's results in a short notice in its news section.[133] The results were that dozens of local newspapers and scientific news bulletins would retell the story over the next months and years and even beyond.

By 1910 more than two hundred news-papers around the world, in Australia, Canada, England, Germany, Ireland, New Zealand, Scotland, the United States and Wales had reiterated the story (See Fig. 8 & Appendix 1). The articles often simply echoed the findings reported in Nature, sometimes they added their own exaggerations. The most extreme example might be an early report which itself introduced its own three order of magnitude decimal error, by reporting spinach contained 36 grams of iron in 100 g dry weight.[134,135,136]

Prevalence of articles occurring was highest in the two U.S. states New York and Philadelphia (see Fig. 8), which probably had a lasting influence on the further propagation of the iron-spinach legend. Consequently, already by 1899, a New York press agency could report[137] that the "*Spinach craze*" was "*the latest health fad*", and spinach the most "*precious of vegetables*", "*good for the liver*", "*guaranteed to clear the complexion*" and that it would "*insure a long life*". The article went on to conclude, that if the "*spinach habit grows to anything like the proportions reached by the oatmeal habit we shall shortly turn into a strong, iron-built, fresh-complexioned, anti-bilious nation.*" It was printed together with the description of an odd "*Rat Diet*" to cure baldness, highlighting that "*the eating of rats by a human being insures a fine head of hairs.*" Not surprisingly by 1899 the first tonics promoted spinach iron as the active ingredient.[138]

In the aftermath, the legend that spinach was rich in iron had been well established in the US. In the early 20th century it became widely used in thousands of advertisements of an iron tonic (see Fig. 9), which flooded American and especially New York newspapers and promoted Nuxated Iron[139] to contain iron as healthy as that of spinach.

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[133] Anonymous 1895a p.326: "*A RECENT number of Modern Medicine and Bacteriological Review contains an article on Prof. Bunge's important paper on the therapeutic value of iron, read at the German Congress of Internal Medicine last spring. An interesting table is quoted showing the amount of iron found in various food substances. Spinach contains considerably more iron than the yolk of eggs…*".

[134] Anonymous 1898.

[135] The error was apparently plagiarized from a German article (Fröhlich 1898), which had been published earlier in the same year.

[136] Sometimes, the little press stubs could not even correctly restate the name of the Professor Bunge correctly. Thus, in some of those articles he turned into the chemist Bingo (see for example Anonymous 1899a, 1899b), Professor Büngе (Anonymous 1897) or into unnamed prominent specialists (Anonymous 1899c).

[137] Anonymous 1899a.

[138] See Anonymous 1899a: "*So convinced has the medical profession become of the value of the once despised spinach that, according to the sanitary record, 'it is already an active ingredient in several new and salable tonics'.*"

[139] **Nuxated Iron** was a "patent medicine" sold by the Dae Health Laboratories in Detroit (Michigan). The name nuxated referred to the ingredient extract from Nux vomica, which led the American Medical Association to highlight in a laboratory analysis that it contained small amounts of strychnine (Anonymous 1916 p.30-32). Nuxated Iron was promoted by the compa-

One of the proponents featuring prominently in those clips was the world heavy-weight boxing champion Jack Dempsey[140,141] Those advertisements might have had a direct influence on the popularization of spinach being rich in iron. Bud Sagendorf[142], one of the long-time drawers of Popeye comics, recalled in 1979 that "*the old salt's spinach fetish developed in the 1930s when some doctors were saying heavyweight boxing greats like Jack Dempsey, Gene Tunney[143], Jim Braddock[144], Max Schmeling[145], Joe Louis[146] and Max Baer[147] ate spinach because 'it had iron in it.'*"[148,149]

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ny's sales department as containing iron in an especially healthy organic form. Advertisements often highlighted that for "i*ron to be of the slightest value to the human system must be in a combination which may be easily assimilated*" (Anonymous 1917). Testimonials pinpointed at the "disadvantage" of classical remedies such as Blaud's pills: "*In the case of metallic salts of iron, iron acetate etc., it is very doubtful if sufficient iron can be taken up and incorporated into the blood…*" and exaggeratingly added that "*Unlike the older inorganic iron products* […it] *does not injure the teeth, make them black, or upset the stomach*" (Anonymous 1917).

[140] Jack Dempsey (1895-1983) a.k.a. the "*Manassa Mauler*" was an US-boxer and from 1919 to 1926 World Heavy-weight Champion.

[141] **The Pugilist Nostrum:** A book of the American Medical Association later recalled: "…*some may remember the heavy advertising campaign for a 'patent medicine' rejoicing in the name of Nuxated Iron.* […] *First came endorsements of physicians, some of whom were described in the advertisements as noted, well-known specialists, but who on investigation proved to be superannuated advertising quacks. Then there were testimonials by retired generals and judges and* […] *two former United States Senators.* […] *But the nuxated endorsements that really touched the popular fancy were those from the sporting fraternity.* […] *Then came the pugilist series, opened by Jess Willard, who told how Nuxated Iron helped him to whip Frank Moran. When, in the course of events, Jess was knocked out by Jack Dempsey, the world learned,* […] t*hat it was this nostrum that put Jack 'in such superb condition' and helped him whip Jess. As Dempsey continued his successful career, each victory brought a testimonial from the champion ascribing his success to the marvels of Nuxated Iron*: *'How Nuxated Iron Helped Me To Whip Carpentier.' 'How Nuxated Iron Helped Me To Whip Tom Gibbons' and following the pyrrhic victory over Firpo, 'How Nuxated Iron Helped Me Win Four Great Battles.'*" (Cramp 1936 p.202). See also Cramp 1921 p.535-543.

[142] Forrest Cowles Sagendorf (1915-1994) was an American Cartoonist. From 1948 to 1967 he was responsible for the Popeye comic book. Already during the late 1930s he worked on developing Popeye toys and games. Since 1959 he was also in lead of the Thimble Theatre comic strip, aposition which he held until 1986. Even afterwards he would produce further Popeye strips.

[143] James Joseph "Gene" Tunney was an American boxer. He held the heavyweight title from 1926 to 1928.

[144] James J. Braddock (1905-1974), called the "*Cinderella Man*" was an American boxer who held world heavyweight title from 1935 to 1937. He was especially known for his iron chin.

[145] Max Schmeling (1905-2005) was a German boxer. He was world heavyweight champion between 1930 and 1932. Especially his two fights against Joe Louis in 1936 and 1938 became famous due to the nationalities of both boxers.

[146] Joseph Louis Barrow (1914-1981), better known as Joe Louis. He was world heavyweight champion from 1937 to 1949.

[147] Maximilian Adelbert Baer (1909-1951) was an American boxer in the 1930s and one-time world heavyweight champion (1934-1935).

[148] Anonymous 1979a.

[149] **Toys of Popeye the pugilist champ:** Many Popeye toys from the 1930 itself returned to this "iron" boxing theme. Most notably perhaps the "*Popeye the Champ*" toy in which, when wound up, Popeye and his opponent as celluloid puppets spun around with flying arms through a small boxing-ring. In another metal toy a wound-up Popeye used his iron arm on a punching bag.

Doctor Says: Eat Spinach
Together With a Little Organic Iron FOR RICH RED BLOOD
and to revitalize worn-out, exhausted nerves—quickly helps increase strength, energy and endurance.

NUXATED IRON ENRICHES THE BLOOD-GIVES YOU NEW STRENGTH AND ENERGY

Why Do Women Fail To Heed Nature's Warnings Of Iron Starvation Of The Blood
In so many cases, UNTIL THE CRASH IS UPON THEM, and their nerves are all played out, their health impaired and their strength and energy gone?
WHAT DO YOU THINK OF THE WOMAN IN THE PICTURE BELOW?

NUXATED IRON ENRICHES THE BLOOD-GIVES YOU NEW STRENGTH AND ENERGY

STEALING A SECRET OF STRONG MEN'S STRENGTH
Medical Science shows why Spinach and Carrots with organic iron often so surprisingly increase one's strength, vigor and endurance.

NUXATED IRON ENRICHES THE BLOOD-GIVES YOU NEW STRENGTH AND ENERGY

HOLD FAST TO HEALTH
With The Mighty Strength-Giving Power of NUXATED IRON
HELPS MAKE RICH RED BLOOD

The Vatican at Rome Recommends Nuxated Iron
If you lack BODILY or MENTAL VIGOR; If you are WEAK; NERVOUS or IRRITABLE, TRY NUXATED IRON TODAY.

Nuxated Iron CONTAINS ORGANIC IRON LIKE THE IRON IN YOUR BLOOD and LIKE THE IRON IN SPINACH, LENTILS AND APPLES.

NUXATED IRON also contains a remarkable product, brought to the attention of the French Academy of Medicine by the celebrated Dr. Robin, which represents the principal chemical constituent of active living nerve force FOR FEEDING THE NERVES, so that NUXATED IRON might be said to be both a BLOOD and a NERVE FOOD.

THERE ARE 30,000,000,000,000 RED BLOOD CORPUSCLES in your blood and each one must have iron.

Today about one person out of every three is said to suffer more or less from the great devitalizing weakness brought on by malnutrition or lack of sufficient nourishment; which is caused NOT BY LACK OF FOOD but often by LACK OF SUFFICIENT ORGANIC IRON in the blood to enable us to GET THE STRENGTH OUT of our food.

IRON IS THE MASTER PRINCIPLE OF THE BLOOD AND BLOOD IS LIFE. Our forefathers ate the husks of grains and the skins and peels of vegetables and fruits, rich in strength-giving organic iron, but modern methods of cookery throw all these things away — hence the alarming increase, in recent years, in Anaemia—iron starvation of the blood with all its attendant ills.

When, as a result of iron starvation, you get up feeling tired in the morning, when you find yourself nervous, irritable and easily upset; when you can no longer do your day's work without being all fagged out at night; when your digestion all goes wrong, or you have pains across the back, shortness of breath, heart palpitation or your face looks pale and drawn, do not wait until you go all to pieces and collapse in a state of nervous prostration, or until in your weakened condition you contract some serious disease, but consult your family physician and have him take a specimen of your blood and make a "blood-count" of your red blood corpuscles or test the iron-power of your blood yourself by adding plenty of spinach, carrots, or other iron-containing fruits and vegetables to your daily food and take organic iron—Nuxated Iron—with them for a while and see how much your condition improves. Thousands of people have surprisingly increased their strength, energy and endurance in two weeks time by this simple experiment. But be sure the iron you take is organic Nuxated Iron and not metallic iron which people usually take and which is made merely by the action of strong acids on small pieces of iron —an entirely different iron from Nuxated Iron. The fact that you may have taken metallic iron without receiving any benefit does not prove that Nuxated Iron will not help you. Nuxated Iron represents organic iron in such a highly concentrated form that one dose is estimated to be approximately equivalent (in organic iron content) to eating half a quart of spinach or one quart of green vegetables. It is like taking extract of beef instead of eating pounds of meat. Nuxated Iron is used by over 4,000,000 people annually.

Benedictus PP XV

WHAT THE VATICAN SAYS ABOUT NUXATED IRON
"I am happy to inform you that your gift of Nuxated Iron has been accepted with particular gratitude by the Holy Father, who, persuaded by its beneficial effects, and AFTER HAVING IT SPECIALLY ANALYZED BY THE DIRECTOR OF THE PHARMACY OF THE VATICAN, formulates the most sincere wishes that your product may become famous and be as appreciated by the public AS ITS VALUE CERTAINLY MERITS."

(J. Tedeschini, Institute of the Secretary of State - Vatican)

"The composition of Nuxated Iron is such that the physiological and therapeutical effects cannot fail to be produced, as is usually the case in the prescription of pharmaceutical products of this kind."

(F. Narciso Durlbiacheim, Director of the Pharmacy of the Vatican.)

Beware of substitutes. Look for the letters N.I. on every tablet. Your money will be refunded by the manufacturers if you do not obtain perfectly satisfactory results. At all druggists.

Fig. 9 *In the decades of the 20th century, American newspapers were flooded with advertisements for "Nuxated Iron", which claimed to be have organic iron, like the iron in the blood and spinach.*

At the same time, Bunge's table listing spinach as the vegetable richest in iron started to become reprinted in numerous text books.[150] Decimal errors though are also found in those text books sometimes. Bunge's findings were also handed down for decades by verbally presenting the table at lectures. Bunge's pupil Emil Abderhalden (1877–1950) for example used the table for many years in his own lectures.[151]

The high iron content of spinach is a myth. A first wave (1900–1945)

One interesting aspect that has remained unknown until now is the question how the stories of a decimal error and/or a mix-up of fresh weight and dry weight were born in later secondary articles? The answer to this question is difficult, because we cannot know with certainty how readers received different kind of early articles. Sutton highlights that Bunge noticed the mistake of previous measurements, but Sutton reasoned that this was only a methodical error and the story of a decimal error was later made up by other authors. However, Sutton is completely wrong in his assumption how the legend spread in the 20th century. By attributing it to Bender and raising the possibility it might have been originated earlier by a German Scientist named "Schupan" [sic], whom Sutton was initially unable to track down, Sutton lays a time-frame that ranges from the 1930s to the 1970s if interpreted most generously.

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[150] See for example the tables in Hirschfeld 1900 p.244; Grawitz 1902 p.183; König 1904 p.353; Vierordt 1906 p.394; Cohnheim 1908 p.p.353; Strauss 1909 p. 237; Lorand 1911 p.69.

[151] See Abderhalden 1906 p.408-409.

After a careful inspection, several very early sources give a sufficiently plausible explanation of how the two different reasons for discrepancies in early iron measurements might have arisen, and how the high iron content of spinach became known as a legend. The first classification of the high iron content of spinach as kind of "myth" appeared only a few years after Bunge had published the second volume of his highly popular text book, when Carl Wegele concluded it to be a "*Fable*" without giving any reason for this conclusion[152].

A much more likely explanation for the legend of the decimal error and the variation in which there was a mix-up of fresh-weight and dry weight is an early text book on food compositions. In 1912 Tibbles introduced his voluminous work on food composition prominently with comparing the iron findings of Boussingault and Bunge for spinach and other foods.[153] The comparison is noteworthy as such, as the data presented can easily mislead the reader by the form it is presented in. Not so careful readers might assume that Bunge presented values ten times as high as those of Boussingault. The reason is that Boussingault's fresh weight values for spinach are presented as 0.0045 per cent, while Bunge's data which originated from dry weight is presented as being 0.045. Thus, the value appears to be exactly ten times too high (if not read correctly). Before 1930 no further mentions other than by Wegele were found, who concluded, that the high content of spinach is a myth.

Another origin of scepticism about spinach measurements arose from newly performed analyses of iron in spinach shortly after 1900. For example, in 1906 the German pharmacy student Serger reported that he found the iron content of spinach to be three times higher than those reported by Bunge.[154] His short article also highlighted the possibility of methodical variation influencing results, because not all iron will be recovered by liquid extractions. He also noted that some spinach extracts, sold commercially, reported incredibly high amounts of iron on their labels.[155]

Several authors started their own measurements and often recognized the problems with the early data. In the USA for example[156], a number of samples of

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[152] Wegele 1911 p.43.

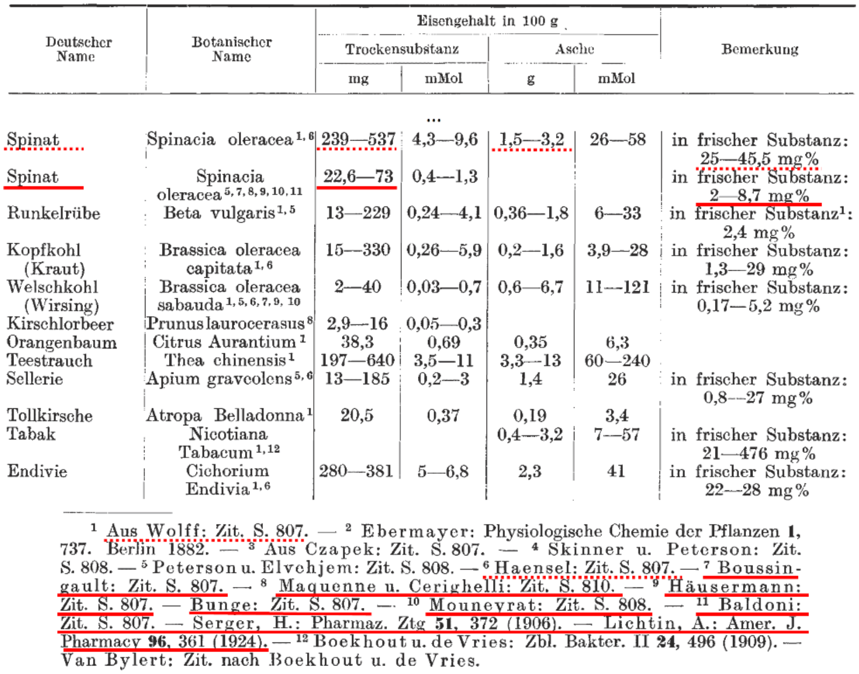
[153] Tibbles 1912 p.4-5.

[154] Serger 1906 p.372.; see also discussion in Anonymous 2015b.

[155] **Blood correcting liquor:** Serger 1906 gave the example of "*Extr. Ramkulini*" which had reported to contain 2 p.c. iron, which he thought was at least one order of magnitude higher than the values he had reported. Extractum Ramkulini (a.k.a. Ramkulin) according to the manufacturer (Pharmaceutisch-chemisches Institut in Gernrode (Harz)) was produced from broadleaf spinach and carrots (Arends 1903 p.374). It was used around 1900 for the preparation of several drugs, including Pilulae Ramkulini, which were sold as "*Ramkulin Blut-Korrektionspillen*" and Ramkulinum liquidum, which was advertised as "*Blut-Korrektions-Liquor*" (Arends 1903 p.374). The manufacturer described Extr. Ramkulini as organic-herbal drug that was able to improve the blood, provide necessary alkalis and thus could be used to fight anaemia and chlorosis (Arends 1903 p.374).

[156] Sherman 1907.

spinach and other vegetables were examined and compared to the values of Bunge (which were found to be slightly higher but contained less water).



Deutscher Name	Botanischer Name	Eisengehalt in 100 g				Bemerkung
		Trockensubstanz		Asche		
		mg	mMol	g	mMol	
			...			
Spinat	Spinacia oleracea[1,6]	239—537	4,3—9,6	1,5—3,2	26—58	in frischer Substanz: 25—45,5 mg%
Spinat	Spinacia oleracea[5,7,8,9,10,11]	22,6—73	0,4—1,3			in frischer Substanz: 2—8,7 mg%
Runkelrübe	Beta vulgaris[1,5]	13—229	0,24—4,1	0,36—1,8	6—33	in frischer Substanz[1]: 2,4 mg%
Kopfkohl (Kraut)	Brassica oleracea capitata[1,6]	15—330	0,26—5,9	0,2—1,6	3,9—28	in frischer Substanz: 1,3—29 mg%
Welschkohl (Wirsing)	Brassica oleracea sabauda[1,5,6,7,9,10]	2—40	0,03—0,7	0,6—6,7	11—121	in frischer Substanz: 0,17—5,2 mg%
Kirschlorbeer	Prunus laurocerasus[8]	2,9—16	0,05—0,3			
Orangenbaum	Citrus Aurantium[1]	38,3	0,69	0,35	6,3	
Teestrauch	Thea chinensis[1]	197—640	3,5—11	3,3—13	60—240	
Sellerie	Apium graveolens[5,6]	13—185	0,2—3	1,4	26	in frischer Substanz: 0,8—27 mg%
Tollkirsche	Atropa Belladonna[1]	20,5	0,37	0,19	3,4	
Tabak	Nicotiana Tabacum[1,12]			0,4—3,2	7—57	in frischer Substanz: 21—476 mg%
Endivie	Cichorium Endivia[1,6]	280—381	5—6,8	2,3	41	in frischer Substanz: 22—28 mg%

[1] Aus Wolff: Zit. S. 807. — [2] Ebermayer: Physiologische Chemie der Pflanzen **1**, 737. Berlin 1882. — [3] Aus Czapek: Zit. S. 807. — [4] Skinner u. Peterson: Zit. S. 808. — [5] Peterson u. Elvehjem: Zit. S. 808. — [6] Haensel: Zit. S. 807. — [7] Boussingault: Zit. S. 807. — [8] Maquenne u. Cerighelli: Zit. S. 810. — [9] Häusermann: Zit. S. 807. — Bunge: Zit. S. 807. — [10] Mouneyrat: Zit. S. 808. — [11] Baldoni: Zit. S. 807. — Serger, H.: Pharmaz. Ztg **51**, 372 (1906). — Lichtin, A.: Amer. J. Pharmacy **96**, 361 (1924). — [12] Boekhout u. de Vries: Zbl. Bakter. II **24**, 496 (1909). — Van Bylert: Zit. nach Boekhout u. de Vries.

Fig. 10 *Table from a pharmacology textbook by Heffter & Heubner 1934 p.811, which explicitly highlighted that some authors, such as Wolff 1871 and Haensel 1909 (red dotted underline) had presented iron values in spinach with dry weight values more than tenfold higher than those presented by other authors (red underlined) (see Baldoni 1905; Boussingault 1872; Bunge 1901; Häusermann 1897; Maquenne & Cerighelli 1921; Mouneyrat 1906, 1907; Serger 1906; Lichtin 1924). The table is a likely source for the original decimal error legend. Note that both Haensel and Mouneyrat presented spinach and lettuce to contain the most iron according to some accounts (Boresch 1931 p.260).*

Another author, who started to perform own measurements of iron in spinach was Werner Schuphan, who collected data from spinach plants for over 20 years from 1935 to 1958. His results were eventually published in 1958 and showed a mean iron content of 7 mg% (range: 2–27 mg%) based on the fresh weight.[157] Schuphan's dataset was based on 127 plant samples and provided, for the first time, a suitable range in which iron is present in plants. In general, these results confirmed the earlier data by Boussingault, Bunge and Sherman. Schuphan never reported, that the fame of spinach being rich in iron originated from a decimal error or a mix-up of dry weight and fresh weight. However, he is linked with an-

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[157] Schuphan 1958 p.2.

other spinach legend of not to use copper pots for cooking, because spinach might completely loose vitamin C.[158]

Other scientists started to severely criticizes Wolff's compilation and even more the underlying original data on a more general basis[159], while other authors especially criticized measurements by Richardson with regard to an unusual water content[160]. Even though not comparable with modern fallout, as early as from the 1910s to 1930s some newspapers started to report that the high iron content of spinach is a "myth", though typically without stating the reason for this misbelief.[161]

The most likely origin of the story of a decimal error however is a text book publication presentation from 1934, in which the authors explicitly highlighted a tenfold difference in the amount of iron in spinach that had been presented by different authors until then (see Fig. 10). It is most likely also the origin of the comment made by Hamblin[162] that German scientists who had reinvestigated the iron content of spinach in the 1930s found that "*the original workers had put a decimal point in the wrong place and made a tenfold overestimate of its values*".

Spinach becomes Pop-culture (1900–1945)

As early as the 19th century spinach was sometimes used in British Literature in the context of meaning "*nonsense*". [163] The peak of this early use was a chapter of a children's book by Lewis Carrol (see Fig. 11). A wider use, however, only started much later in American literature. Only after the turn of the century spinach became pop culture and "*I say It's spinach*", approximately meaning "*nonsense*" or "*rubbish*", grew into a well-known aphorism in the American English vernacular.

It is not apparent when this development really started, but it might very well date as far back to when "*Emily Spinach*" became a legendary inhabitant of the White House.[164] Legend tells that this little garter snake, who received its name from its green colour, became the pet of Theodor Roosevelt's daughter Alice, who loved to use it as tool of choice to play pranks and carry it to parties and dinners,

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[158] Schuphan 1948 p.230.

[159] Quinton 1912.

[160] Heinze 1903.

[161] Anonymous 1939.

[162] Hamblin 1981.

[163] **Gammon and spinnage:** In British English spinach was already linked with "*nonsense*" or "*humbug*" before the turn of the century (Knowles 2006): The term "*gammon and spinach*" (sometimes spelling spinnage), both referred to a common English dish, but also meant nonsense and appeared in various nursery rhymes (Miller 1872), several newspapers, and literary works (Knowles 2006). Some of those were further propagated by calendar snippets in the 1920s. (see for example Dickens 1920: "*What a world of gammon and spinnage it is, though, ain't it?*". At the least the nursery rhymes, however were already widely known and published in New England before 1900 (Miller 1872).

[164] see Roosevelt-Longworth 1935; Cordery 2007 p.78,91.

Gammon and spinach... "What is it?" the Empress said faintly, as she put her spy-glass to her eye. "Why, it's Spinach, I declare!" ...The Empress took up the spoon in an absent manner, and tried to balance it across the back of her hand, and in doing this she dropped it into the dish: and, when she took it out again, it was full of spinach. "How curious!" she said, and put it into her mouth. "It tastes just like real spinach! I thought it was an imitation—but I do believe it's real!" And she took another spoonful. "It won't be real much longer," said Bruno.
But the Empress had had enough spinach by this time...

Fig. 11 *Illustration and extract from a chapter of a children book by Lewis Carrol, which featured a bizarre scene of an Empress, who was served spinach. It was directly followed by an even more ridiculous chapter, which told an absurd lecture by a Professor who explained the basic concepts of Science and its most important Axioms (Axiom 1: Whatever is, is; Axiom 2: Whatever isn't, isn't), before entertaining the audience with a set of experiments: In one he created black-light in a closed chamber by pouring a bottle of black ink over a lit candle, just to find for his great delight that: "…every atom of the Yellow Light turned Black! That was indeed the proudest moment of my life! Then I filled a box with it. And now —would anyone like to get under the blankets and see it?"*
In another he presented an elephant to be observed by a Megaloscope: "You know you can't see a Flea, properly, without a magnifying-glass—what we call a Microscope. Well, just in the same way, you can't see an Elephant, properly—without a minimifying-glass." (Carrol 1893).

where she would pull it out of her purse.[165] Newspapers took up the story when it was reported that she was wearing the snake around her neck.[166] The story of

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[165] Cordery 2007 p.78,91,476; Teichmann 1979 p.31.

[166] **Fact or Fiction? You can bet on it:** The story was indeed widely reported in the American and even international press (Anonymous 1904a; 1904b; 1904c; 1904d). It even led to a several thousand-dollar bet, whether the story was true or not. Yet after some weeks the newspapers had to report, that Alice Roosevelt denied the story (Anonymous 1904e). Amusingly Alice Roo-

Emily Spinach eventually found an inglorious end and left the White House with the legacy and legend of an unsolved murder mystery and heinous crime.[167] But this was only the beginning of popularizing "spinach":

Zerſtreutheit.

„Aber, Herr Profeſſor, Sie nehmen ja den Braten mit den Fingern!" — „Ah ſo, entſchuldigen Sie, ich glaubte, es wäre Spinat."

"But Professor, you take the roast with the fingers!" – "Ah, pardon me, I thought it was spinach."

Fig. 12 *Scientists only very rarely quote popular sources and inspirations from outside the realm of science. This little spinach sketch is a typical example. It was likely the unmentioned inspiration for a pun in Sigmund Freud's work on Humor. (Caption translated by the authors, Source: Fliegende Blätter 1860)*

Another famous creation was the publication of a small cartoon in the New Yorker in 1928[168], which received wide appraisal and long-lasting fame.[169] In the caption of the one framed strip a mother tells her daughter: "*Eat your broccoli*" and the daughter replies "*I say it's spinach and I say to hell with it*".[170]

Quite ironically, spinach became also linked to nonsense in a widely-read publication of one of the most popularized scientists of the 20th century: in a short

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sevelt revived the story in her early memoires (Roosevelt-Longworth 1935 p.59), and the story has stayed ever since as a fact in the literature. See also Teague 1981 p.69,84.

[167] Truman 2007 p.VII.

[168] Drawn by Carl Rose (1903-1971) and captioned by E.B. White (1899-1985) the cartoon appeared in the 8th December issue of the New Yorker.

[169] **Its spinach:** For the immediate and lasting fame of the cartoon especially in New York see for example: Soskin 1929: "*One of the candidates for immortal fame is Carl Roses drawing…*"; Hawes 1938 sketch on p.VII; Smith 1968; Drew 1973; Knowles 2007 p.56; Lee 2000 p.156,206-208; Mankoff 2014.

[170] **To err is humour:** Ironically the little sketch itself became the reminder of another type of errors – slips to the mind. When an author remembered the little cartoon in one of his articles decades later, he received many letters of people, who still remembered it (Smith 1968): Memories though often differed, and descriptions sometimes described a little boy or a girl, either wearing glasses or not. Additionally, readers were notified of slight minor differences in the pronunciation of the remembered caption (Smith 1968).

pun, Sigmund Freud used spinach to illustrate the principle of absurd jokes (see also Fig. 12).[171] Additionally, Freud was also most likely the first to highlight the idea that many children abhor spinach to a wider audience.[172] Both aspects are beautiful and easy to relate to, joined in the New Yorker cartoon mentioned – in an image being even more popularized in the 1930s by Shirley Temple's performance in "*Poor Little Rich Girl*", in which the singing child actor in a musical scene enacts the role of a union chief who "*represents all the kids of the union*" that are protesting to be forced to eat the despised green, herself somehow resembling the curly girl from the cartoon.[173] She eloquently highlights how despised spinach is by all children, before she gives in and agrees to eat her spinach. According to one

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[171] **Spinach and the principle of absurd jokes:** In 1905 Sigmund Freud (1856-1939) introduced spinach to illustrate the concept of absurd jokes: "*As the fish was served to a guest at the table he put both hands twice in the mayonnaise and then ran them through his hair. Being looked up by his neighbor with astonishment, he seemed to have noticed his mistake and excused himself, saying: 'Pardon me, I thought it was spinach.'*" A first English translation of this pun appeared in 1916 in New York (Freud 1905; Freud 1916 p.213).

[172] **Spinach abhorred by children:** The concept that many children loath spinach and are forced by their parents to eat it, today is common knowledge. However, it was first highlighted to a wide audience by Sigmund Freud, in one of his most important works on dreams. Considering, why spinach of all things was served in the dream he had just analysed, he wrote: "*I still might ask why in the dream it was spinach that was served up. Because spinach called up a little scene which recently occurred at our table. A child* […] *refused to eat spinach. As a child I was just the same; for a long time I loathed spinach, until in later life my tastes altered, and it became one of my favourite dishes. The mention of this dish brings my own childhood and that of my child's near together. 'You should be glad that you have some spinach,' his mother had said to the little gourmet. 'Some children would be very glad to get spinach.' Thus I am reminded of the parent's duties toward their children*" (Freud 1915 p.15). Sigmund Freud's books were indeed widely discussed in the American literature of the 1920s, including references to Freud's spinach remark, such as for example in the following little skit in Vanity Fair, with which a short humorous Analysis of Alice's Dream [in Wonderland] was introduced: "*When I say that I like to ride on the front seat on top of the bus and am told that that is a complex, I no longer pretend to be bored. I am bored. If I refuse to eat spinach, as I always do, it has ceased to make conversation for me to be told that I have an inhibition. I invariably reply that spinach is the broom of the stomach. And when fanatical amateurs ask me, 'But why do we dream?' I am inclined to reply, 'Why not?' and go on reading Alice in Wonderland.*" (Bluphocks 1922).

[173] **Eat your spinach, Baby:** In "*Poor Little Rich Girl*" from 1936, Shirley Temple (1928-2014), the most popular child actor of all times and then most photographed personality on the planet (Windeler 1978), played the role of a girl neglected by her rich father, herself becoming the role model of all children loathing spinach. Being lost at a rail-station she meets two vaudeville actors and subsequently becomes a radio star. In one of the musical scenes Temple joins the duet of Jack Haley (1897-1979) and Alice Faye (1915-1998) singing "*You've Gotta Eat Your Spinach, Baby*", in which spinach is broadly advertised as a healthy vegetable that produces rosy cheeks and red lips. Temples entry line "*Pardon me…Did I hear you say spinach?*" even directly refers to the absurd joke of Sigmund Freud featuring spinach.

The movie was 20th Century Fox most successful production in 1936, and the song was also released separately as 78 RPM shellac in several countries, including a production featuring Mae Questel, the famous voice of Betty Boop (Questel 1936). "*Poor Little Rich Girl*" remained beloved over the years and saw a multitude of commercial TV broadcasts and home video releases, including a colored re-release, ensuring that the movie would remain in the collective memory of several generations.

of her biographies, "*in the mid-1930s kids ate their spinach and breakfasts because this girl said they should.*"[174] Indeed, even before "*Poor Little Rich Girl*" Temple featured in countless articles, which often depicted her as well-behaved because she ate her spinach, sometimes especially highlighting that she loved Popeye.[175] Some of those stories, including a Hollywood legend, even directly referred to spinach being rich in iron.[176]

The most energetic propagandist for spinach certainly was no other than Popeye the sailor.[177] In 1929 the first cartoon strips and in 1933 the first animated film shorts appeared, soon starting to feature spinach as the base for the sailor's superpowers.[178] More than 100 Popeye movies had already been filmed and screened before 1942 under the direction of Fleischer Studios. Typically, they premiered at the cinema "Paramount Theatre" in New York on Broadway and at that time they were the most popular animated series. Around the United Stated "Popeye Clubs" were founded, which so successfully experimented with Junior Matinees that whole cities fell into protest when they were closed during the summer holidays.[179] Popeye's signature quotes, "*I eats my spinach*" and "*I yam what I yam*" became popular catchphrases, echoed by generations of children.[180]

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[174] Windeler 1978 p.42.

[175] **A spinach starlet**: See for example: Anonymous 1935, p.62 Sargent 1935 p.82; Ellsworth Fitch 1935 p.43: "*And everybody must be aware by now that Shirley is a spinach starlet.*" In interviews Shirley Temple was often asked if she ate her spinach, which she answered that she did, even if she had "*done songs about not liking it*" and "*made ugly faces while eating it*", sometimes joking that she even taught her dogs to like the despised vegetable (Knight 1936). In a time-frame of only a few years, hundreds of articles on Shirley Temple featuring spinach appeared inside American newspapers.

[176] **An ironclad experiment:** Anonymous 1935 p.62: "*Mothers with children, beware; never give your young ones magnets, if you want them to eat spinach! Shirley Temple's parents told their chee-ild* [sic] *to eat spinach 'because it had iron in it and would make her strong.' Then they gave her a toy magnet. When it didn't pull the spinach, Shirley refused to swallow the 'iron' story – and now she will NOT eat spinach.*" See also Anonymous 1934 & Kendall 1934 for other versions of this widely retold tale.

[177] **An Iron Arm:** Popeye has many names in different countries. His Italian version is known under the name "*Braccio di Ferro*" (engl. iron arm).

[178] **Spinach, I yam what I am:** Popeye was first presented to the public audience as a side character of the comic strip "*The Thimble Theatre*" in 1929. In 1933 Popeye the Sailor eventually got his own series, which was produced for 9 years by the Fleischer Studios. Since the early episodes Popeye gained his super-powers after eating spinach. However, there is no reference to the iron content of spinach in those early cartoons (Sutton 2010a). Additionally, Popeye from 1935 to 1938 featured on several serial radio broadcasts in overall 204 episodes, most of which are today thought lost. In those radio shows however Popeye did not eat spinach, but received his powers from eating his Wheatena breakfast cereals, which were sponsoring the program. Since 1942 several hundred further animated cartoons have been produced for early cinema and TV presentations.

[179] See for example Anonymous 1936a p.8.

[180] **Materialism – "Matter and Force":** Ironically, even the Oxford Dictionary of Catchphrases (Farkas 2002 p.161) is unable to tell the whole history of Popeye's signature line "*I yam what I yam*". It is nothing less than an English individualistic malapropism and translation of a famous German quote by Ludwig Feuerbach, who once wrote "*Der Mensch ist, was er ißt* (engl. *Man is*

Further theatrical features and later animated coloured TV series would introduce hundreds of further Popeye animations, including at least several, in which spinach is linked to being rich in iron.[181] More commonly, he referred to spinach promoting children's health and especially growth. From the Popeye studios in New York it would be only a small way to glamorous Hollywood, where a first generation of "food gurus" would take up the idea that spinach is rich in iron.[182] Promoting "Healthy food" as a remedy, the stars and sets would be served with "*Iron Cocktails*" full of freshly crunched spinach.[183] From there the "*Iron Cocktail*" also made it into several well-known diet and cookery books.[184].

Another pivotal figure in promoting spinach as rich in iron was played by the most influential doctor in the United States at his time – Dr. Morris Fishbein. After becoming editor of the Journal of the American Medical Association (JAMA) in 1924 Fishbein started a vendetta attacking quackery and medical hoaxes.

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what he eats)" (Feuerbach 1850; see also Feuerbach 1866). Popeyes misappropriate use of this quote is more than an ironic incidence, it is for once eulogy to the nutrition philosophy of Jacob Moleschott itself: Feuerbach used his well-known quote first in a positively commenting review of Jacob Moleschott's book on nutrition (Feuerbach 1850). Yet Comics are the ultima ratio perfecting reductionism, and the most artful use of this reductionism allows it for everybody to find identification in them.

Yet, critics of Feuerbach might have rallied behind Popeye as well, as they have long used Feuerbach's quote inappropriately to caricaturize him. Feuerbach and Moleschott in their early works had especially condemned a pure vegetarian diet. Popeye, when becoming a super-hero after eating spinach, in this becomes indeed the antithesis and caricature of Feuerbach, who once on basis of the principle of "*simili simili nutrici*" and political incorrect prejudice wrote "*Who does not know the merits of the English worker, who is strengthened by his Roastbeef, in contrast to the Italian Lazzarone, who's predominate vegetable diet explains a lot of his preposition to slothfulness.*" If Popeye had followed the advice of Feuerbach, maybe he would have preferred blood, beef and meat instead of spinach.

In any case, "*I yam what I yam*" became the foundation of an individualistic identity for Popeye. A character, who could express thoughts, but as it is the property of all cartoon characters projected with light on the canvas of cinemas, not bound to physical matter, yet often highly physical in his deeds.

[181] **Rusting spinach:** See for example the episode "*Gopher Spinach*" from 1954, in which Popeye raises some baby spinach plants, which after watering he rubs dry, remarking that: "*Now, to get you good and dry, so your iron wouldn't rust*".

[182] **The spinach food guru:** One very prominent food-guru of this period was the self-acclaimed dietary expert Bengamin Gayelord Hauser (1895-1984) who's iron cocktails in 1934 were advertised as follows: "*Never have I seen more absorbed expressions than those on the faces of the fashionables gathered around a table in the Elizabeth Arden salon yesterday noon. On the table were platters of crisp yellow carrots, raw spinach, sliced oranges, tomatoes and cabbage, all artistically grouped.* […] *It might have been the setting of a debut tea. It WAS the debut of the spinach cocktail in society. Behind the table Dr. Bengamin Gayelord Hauser was putting vegetables into a press which extracted the juices and out of the juices he was making cocktails. Spinach and orange, celery and tomato, orange and carrots. Some make beautiful complexions, others are for pep and still others, he said, can produce in one the charms of a Mae West.*"

[183] See for example Hauser 1934 p.32 and cover texts.

[184] The "*Iron cocktail*" was for example included in the "*Official Cook Book*" of the "*Hay System*", where it would be still presented in the mid-1980s, featuring the "*Iron Cocktail*" not less than three times (Smith 1987 p.35,155,333).

Publishing in Hygeia and JAMA, his greatest influence came from a medical column, which at its height was syndicated to 700 newspapers, several bestselling books and 100 speeches he delivered per year.[185]

In his newspaper column, he promoted spinach as good sources for iron multiple times. Yet, amusingly, Fishbein also criticized the spinach mania in the 1930s from early on in publicly held lectures. He also helped to eventually ban the Nuxated Iron advertisements from the newspapers. He was also one of the first to widely propose, that even if spinach might contain a lot of iron, it might not be a good mineral food due to the oxalic acid content often found in spinach.

Besides all this, another incident today nearly forgotten led to spinach becoming part of the cultural common vocabulary. In the early beginning of the 1936 & 1940 presidential elector campaigns it appears that Eleanor Roosevelt had a favourite bon mot: "*Oh, spinach!*" which was also repeated in the reports of the public media, as for example in Life magazine.[186]

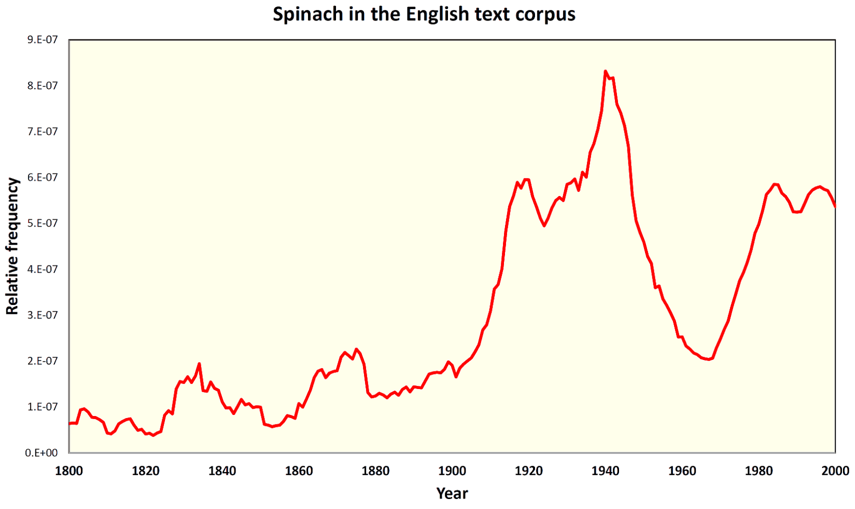

Fig. 13 *The spinach mania. Spinach became a phenomenon of the pop culture in the 1920s to 1940s.*

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[185] Locin 1985.

[186] **Oh, spinach:** Hellman 1949 p.72: "*If anything goes amiss on her [Eleanor Roosevelt] trips, her favorite expletive is, 'Oh, spinach!*' According to newspaper reports, Mrs. Roosevelt first used the expression in 1936 after leaving the radio symposium "*Young America Looks Ahead*" at a Town Hall meeting and afterwards found admiring women blocking her way (Anonymous 1936c). In some articles from the mid-1930s it was suggested that the then First Lady even herself had unwittingly coined this slang expression (Anonymous 1936b). However, this seems rather unlikely, as the phrase can be found in a few sources from the 1920s and it had been already featured extensively in dozens of daily comic strips of "Just Kids" at least since 1931, which had been produced by King Features Syndicate Inc. Nonetheless, by 1937 the expression had gained so much traction, that it even gave name to a New York musical comedy.

Apparently, the spin doctors of Franklin D. Roosevelt's challenger Wendell Willkie turned this into a winged word that appears to have been commonly used during the electoral campaign, perhaps much like Barack Obama's "*Yes, we Can*" or Donald Trump's "*Make America Great Again*" in more recent campaigns. When challenged during a radio interview, Willkie replied: "*That's a lot of spinach*" and later often stated "*I can tell spinach from spinach*". Eventually it even landed on the candidate campaign buttons as "*Spinach is Spinach*".[187]

However, these anecdotes are only an illustration that spinach became a very common word during the 1930s and 1940s in the United States. This was already noted by de Lys, who wrote in 1948 that during the first decades, spinach became universally advertised in American newspapers.[188] This subjective perception is quantitatively underlined by a Google ngrams[189] analysis of the American text-corpus, which highlights a peak use of the word spinach climaxing in the 1940s (see Fig. 13). Furthermore, many advertisements of iron tonics repeated the high iron content of spinach as a reference for their own products. Eventually, Popeye would introduce the last step to advertise spinach as healthy food with his piped face sticking from spinach cans. This context makes it plausible and somehow apparent how the journalistic and public relations practices acted as a catalyst to ensure the further oral tradition of the Spinocchio tale that spinach is rich in iron.

However, while this context provides a reasonable framework how the urban academic legend was established as common knowledge in the USA, it can hardly explain how it also became well known in Germany. Apparently, the context of the iron spinach legend there is different and at least partially based on other circumstances. For example, Bunge's results on the iron content of spinach appears to have never been as widely publicized in the late 19th and early 20th century in German newspapers as it has been for example in the United States.

Popeye was not widely introduced in Germany before the 1970s. Nonetheless, the legend of iron rich spinach was well known there for several generations, too. Numerous aspects might have supported this oral tradition. First, Gustav von Bunge widely advertised to feed an additional spoon full of spinach to young infants to avoid symptoms of iron deficiency. This advice was widely popularized by members of the rising discipline of paediatrics[190], especially in Germany. Some leading paediatricians even explicitly promoted spinach due to its iron content for children in their second year of their lives.[191] Furthermore, as it has already been

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[187] **Spinach is Spinach:** Those buttons were widely used in the 1940 presidential election campaigns and stated in full: "*Willkie says – Spinach is Spinach – It sure is Franklin*".

[188] Lys 1948.

[189] Michel et al. 2011.

[190] See for example the leading German textbooks of paediatrics, which especially advertised a spinach diet for treating anaemic conditions in young children (Pfaundler 1920 p.150) or directly emphasized spinach to be especially rich in iron (Bendix 1899 p.27; Heubner 1911 p.64).

[191] See for example Bendix 1899 p.27, who especially remarked: „*Spinat (Eisen!)*".

highlighted, many books on nutrition reprinted and retold the findings of Bunge for several decades.

Yet beyond this, there are some further possible catalysts that need to be taken into consideration. One aspect might be, that during the First World War and in a context of increasing food scarcity, several brochures started to retell that spinach is rich in iron, particularly reprinting the findings of Bunge's iron nutrition table.[192] Another reason, which appears to have been neglected so far in the tradition of the iron rich spinach myth, might be the influence of children books beside Popeye. The earliest example of this tradition is most likely included in the "*Child Health Alphabet*", which was first published in 1918 by Mrs. Frederick Peterson[193] (see Fig. 14). It was widely used in the 1920s by the Child Health Organisation, the books sponsor, to promote healthy behaviour in schools and children in general.[194] Historical accounts,

I is for *Iron*
in Spinach and Eggs,
Builds Red Blood and Sinews
for strong Arms and Legs.

Fig. 14 *One of the oldest examples of spinach being rich in iron presented inside Children Books. Illustration from the Child Health Alphabet which was first published in 1918.*

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[192] Block 1915 p.19-20; Cohn 1915 p.9; Hink 1915 p.22.

[193] Antoinette Rotan Peterson (1871-1959) was very active in the development of the Child Health Organization (CHO), in which she worked in the Board of trustees. In this position, she wrote several children books, published by the organisation. Her husband Frederick Peterson (1859-1938) was Secretary of the organization and an influential neurologist in New York. In the early 20th century he helped to translate the first editions of works by Sigmund Freud and Carl Gustav Jung into English (Freud 1909 p.iii; Oberndorf 1953 p.128), even though he was himself rather sceptical on the raising profession of psychoanalysis (Oberndorf 1953 p.107), which he viewed as "a species of *voodoo religion characterized by obscene rites and human sacrifices*" (Fishbein 1932a p.357) believing that "*Psychoanalysis is to psychology what cubism is to art*" (Butler 1921 p.250). He was also a vivid supporter the Temperance Society (Crooker 1914 p.229-230), which had introduced the "Education on Wheels" project, a predecessor of the CHO's information/propaganda campaigns. Today Frederick Peterson is especially remembered for his role in the development of the "*electric chair*".

[194] See Rogers 2005 p.32; The Child Health Organization (CHO) was located in New York and during the 1920s, it was very active in the promotion of a healthy life-style for children. CHO produced several successful children books, games and also health plays. Its most successful invention though was Cho-Cho the health clown who already by 1920 had visited half a million children (Jean 1920). It also introduced the term "*health education*" into the medical system (Kramarae & Spender 2000 p.986).

told at the time it appeared, recall that especially the "*Spinach and Iron*" rhyme (see Fig. 14) worked especially well.[195]

Another prominent example is the multivolume "*Nesthäkchen*", in which spinach plays a role in one of the key episodes of the first book.[196] It would be revealed in a later volume that spinach is healthy, because it is rich in iron.[197] Many other children's books would portray spinach as being healthy because it was portrayed as being rich in iron over the years.

Starting with the introduction of canned spinach baby food and frozen spinach products, the iron spinach legend became eventually the playground of public relation companies and hundreds of dietary guides, which performed only a superficial fact checking for their studies. Beyond this however, there was possibly also an oral tradition, with mothers and fathers telling their children, that spinach was healthy and full of iron. Furthermore, the sujet of iron rich spinach also became introduced in jokes and wits presented by newspapers to their public audience.[198]

It's spinach – The origin of the story of the decimal error (1946–2010)

For several decades, the iron content in spinach seems to have not been widely questioned in the public media, even though scientists in specialists' articles reanalysed the content intensively. Sutton's claim though that a wave of debunking the iron spinach myth only started in the 1970s and 1980s with reports by Bender and Hamblin is incomplete. In fact, the modern wave most likely started with a popular book by Claudia de Lys[199,200], on "*American Superstitions*", which saw numerous

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[195] **Spinach propaganda:** "*Children's books of rhymes and fairy stories have been prepared, appealing to the child's natural interest. The effect* […] *may be shown by the little Irish boy who returned to the Charity Organization Society one day with his mother. Mrs. McGarity seemed excited and said: 'Say, Mrs Murray, ain't there something beside spinach what makes my boy race? Ever since you give my Micky that book he wants spinach every day and I am tired of washing it.' Mrs. McGarity had been told that Micky needed foods with iron in them because he had anemia but it had made no impression, but Micky was sufficiently impressed by this rhyme to insist upon having spinach.*" (Jean 1920 p.370).

[196] The books were first published by Else Ury from 1913 to 1925 and since then have been reprinted several times. In the first Volume „Nesthäkchen und ihre Puppen" [Transl.: Nesthäkchen and Her Dolls) (Ury 1913, p.30; see also Ury 1913, p.9).

[197] Ury 1925 p.708: „*Von dem Spinat musst du nehmen, Jetta. Er ist besonders gut. Spinat ist eisenhaltig, der geht ins Blut* […]"" [You have to take of the spinach, Jetta. It is especially good. Spinach is rich in iron, it goes into the blood…].

[198] **Jokes on spinach and iron:** See for example: Anonymous 1969: „*Black Prague Humor: Mr. Novak asked Mr. Novotny: 'Do you know that our government has decreed to start a large import of spinach from Denmark?' 'Yes – That once more proofs how our comrades worry for the health and well-being of the nation', answered Mr. Novotny. 'But no, it is due to the iron content. It has turned out, that this spinach has more iron than the iron ore of the Soviet Union.'*", which was published shortly after the Prague Spring in a Swiss newspaper.

[199] **The National Committee of 13:** Claudia de Lys was an American Anthropologist born in France and since the 1930s "*the world's foremost authority on Superstitions*" (Blinn 1942). At the time of publication of her book she also had become the president of a "*National Committee of 13 Against Superstition, Prejudice and Fear*" (Anonymous 1947). Newsreels and newspapers intensely

revisions and was first published in 1948. A lengthy paragraph in the book covered popular misbeliefs on the nutritional value of spinach.[201] In many points this book seems to be either directly or indirectly an important source for Hamblin's later article. Beside the decimal error, most other details of Hamblin's introduction are found in the very early edition of this book. During the 1950s in the United States several newspaper articles appeared stating that spinach is not rich in iron, typically though without revealing the source of their information (Anonymous 1958a). At the latest by the late 1950s de Lys variant of the story, that spinach is not rich in iron, also emerged in continental Europe magazines (Anonymous 1959).

By the early 1960s spinach again received attention in the public media in Germany. The main reason for this might be that spinach became the first frozen vegetable available in the supermarket. Furthermore, warnings emerged, reporting spinach as a cause for food poisoning. It appears to have occurred at that time that the myth of spinach being rich in iron started to become debunked in the wider public.

A report noticing that the spinach content was tenfold overestimated appeared in 1960.[202] This early version, however, slightly differs from modern retellings, how spinach became rich in iron due to a decimal error. In fact, it is reported that Bunge and several other first investigators like Boussingault, Czadek, Mouneyrat

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reported on the committee, which was raised to fight the most serious threads to mankind, such as triskedaphobia (a.k.a triskaidekaphobia) and pantophobia. The penultimate goal was at one time described as follows (Anonymous 1946a, 1946b): "*The committee is trying to prove on a popular level, that superstitions can be eradicated.*" or more ironically that: "*The committee feels it may in time get mankind to substitute logic and common sense for its eternal wish for flight from reality*". This committee, in fact was also related to the movie industry and had its headquarter at 1501 Broadway ("Room 1313"). This address generally is better known as Paramount Building and Theatre. By 1933 Popeye became part of Paramount Pictures and later Paramount Pictures' Famous Studio. This address was the heart of Popeye land, which saw the premiere of the early Popeye clips on the silver screen, including his famous first appearance with Betty Boop (Fleischer 2005), the made of pen and ink queen of all the talkartoons.

Claudia de Lys was very active in her work during the 1930s and 1940s, whereby she gave lectures and wrote constantly, while also appearing on radio broadcasts (Anonymous 1945; Binn 1942). At least some of her lectures directly referred to Food superstitions.

[200] Among the other members of the committee were many prominent and rising members of the entertainment industry, as for example the designer John Vassos, and the heavyweight champion Jack Dempsey, who once tested Houdini's "*iron stomach*" with his "*iron fist*". Several members of the committee of 13 had previously during the war also worked on a radio show supporting food supply, which was mentored by Eleanor Roosevelt. De Lys' book on superstition had lasting influence. Even contemporary authors on the suspense still use it as classic reference or on essays on creative writing.

[201] Lys 1948 p.240-242: „*In America the humble green leaves* [of spinach] *became almost a fetish. Many parents who had been forcing their children to eat spinach were amazed when chemists announced that the nutritive value of spinach had been considerably over-rated… Furthermore, contrary to popular belief, spinach is a relatively poor source of iron. Only twenty per cent* [sic] *of its iron content is nutritionally available.*"

[202] Schwietzer 1960.

etc. reported the correct results, but numerous at that time contemporary textbooks mistook the amount per dry-weight as the amount of fresh-weight and thus overstated the amount by "*ten times*".[203] This is most likely the first account, which reported that the amount of iron in spinach was overrated ten times and it was especially addressed to physicians who were still following Bunge's advice to add spinach as nutrition food for young infants. Short abstracts of the article were also distributed and discussed in other journals.[204,205]

By the mid-1960s and early 1970s public interest in spinach increased further due to an increasing number of reports on food poisoning associated with spinach consumption in infants.[206] The reason for this problem soon became known when it was found that over-fertilization might lead to accumulation of nitrate in spinach.[207] This nitrate can become subsequently converted biochemically to nitrite, for example if the spinach dish was warmed up or eaten later after one or two days of storage, even when kept in a refrigerator.[208] This was apparently of special importance to mothers with infants and many public and scientific reports covered the problem. A widely circulating German popular scientific magazine retold this story and that the iron content of spinach had been tenfold overrated.[209] Some German speaking newspapers repeated the story that the original iron content was rated ten times too high[210].

Originating from this report[211], by the latest in 1978 the exact claim, that the iron content of spinach "*has been stated erroneously ten-fold too high for decades*" finally made it into the first specialty encyclopaedias (List et al. 1978) and remained there

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[203] Schwietzer 1960.

[204] See for example: Zacharias 1960 p.439-440, where it is also ironically noted by the referee, that the daily meal of 500 g spinach might be somehow overrated: "*Der Tagesbedarf von 10 mg kann somit auf keinen Fall durch eine Tagesmahlzeit von 500g [250g ist wohl der richtigere Wert (der Ref.)] gedeckt werden…*". The version of tenfold too high iron values was also highlighted in a short stub in popular German science magazine "*Naturwissenschaftliche Rundschau*" of the same year (Anonymous 1960), which noted: „*Daß der Spinat zur Würde des eisenreichsten Gemüses gekommen ist, wird wahrscheinlich an einem Übertragungsfehler bei der Zusammenstellung von Nahrungsmitteltabellen aus Originalarbeiten liegen. Noch heute findet man in der Fachliteratur Angaben von 30mg% Eisen.*" The latter article however referred to another source: Bundesgesundheitsblatt 3,29; 1960.

[205] Note: In the most common later retold versions of the spinach decimal error, authors reported that mistakenly 35mg/100g instead of 3.5 mg/100g fresh-weight had been reported. It's apparent, that this retold narrative originated from the Schwietzer 1960 article and the retold narratives of this article, which reported: "*Es wird darauf hingewiesen, dass der Eisengehalt im frische Spinat nur 30-40 mg/kg und nicht wie in vielen Hand-, Lehr- und Tabellenbüchern noch erwähnt, 300-400mg/kg beträgt*" (Schwitzer 1960 as cited by Zacharias 1960).

[206] Hölscher & Natzschka 1964; Sinios & Wodsak 1965; Anonymous 1966; for a review see also Commoner 1968.

[207] Schuphan & Harnisch 1965; Schuphan & Schlottmann 1965; Schuphan 1965.

[208] See Schuphan & Harnisch 1965.

[209] Thier 1968: "*Von diesen galt das Eisen früher als wertvollster Bestandteil des Spinats, denn sein Gehalt wurde jahrzehntelang irrtümlich um das Zehnfache zu hoch angegeben.*"

[210] See for example: Falk 1968, who directly quoted Thier 1968.

[211] Thier 1968.

till today.[212] It also became widely known in Germany after it was covered by a widely circulating illustrated magazine.[213] The story of the decimal error in the 1970s was also presented in lectures held in Germany and Great Britain.[214]

Eventually the tenfold error story was also taken up by British and American media and was prominently reported in the late 70s and several media outlets and newspapers instantly retold the syndicated story.[215] Those accounts were already widely known in Germany in the 1960s. Bender's and especially Hamblin's article in 1981 though ensured that this became widely known internationally.[216]

Sutton's key conclusion that a decimal error never occurred and that this interpretation was made up by Bender and later publicized by Hamblin therefore is busted. In fact, the problem was described at least a decade earlier as a tenfold discrepancy by authors in Germany and Switzerland.

The interesting question remains why it took so particularly long in the media to widely cover that spinach is no good source of iron. There are certainly several obvious reasons for this. The spinach story is quite harmless; thus, it might have appeared only slightly charming before the story of the decimal error was introduced to a wider audience. Furthermore, touching several different fields of sciences, it is difficult to interpret and not all primary text resources are easily accessible. It is possible that simply nobody felt responsible and the story was rather passed on by oral tradition. Considering that many authors who told the spinach iron story quietly dropped the idea in their later publications might indicate that ongoing discussions might have occurred.

There might be, however, a further more disturbing aspect which might have contributed to the lack of attention: In 1963 the president of the University of South Florida, John Allen[217], held a public lecture on the importance of Academic Freedom, which he introduced with the remark that "*Popeye is a fraud*".[218] And he stated, "*that a university research scientist discovered a few years ago that iron in spinach is not*

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[212] Römpp 1996, 2006.

[213] See for example Snippets in the Google Book Search for die BUNTE 1963, 1965, 1973.

[214] See for example Bender 1972; Lobsenz 1979; Pefanis 1979; see also discussion in Sutton 2010b, 2016.

[215] Lobsenz 1979 pointed out in a syndicated news article, that the iron content "*was overestimated tenfold as a result of a typographical error in a nutrition handbook: A decimal point was accidently misplaced.*" The author of the article highlighted that this revelation was presented at a then recent medical meeting by Prof. G.W. Lohr [sic]. See also Aylward 1979; Pefanis 1979. The later article also clarifies another issue. When Hamblin could not exactly recall his source for the spinach decimal error, he though remembered that he had seen it in the Reader's Digest. Considering Pefanis 1979, he might however have confused it with the Science Digest which also covered the spinach iron story. See also coverage in Anonymous 1979b, 1979c and discussion in Rekdal 2014.

[216] See Bender 1972; Hamblin 1981.

[217] John Stuart Allen (1907-1982) was an American astronomer who had a pivotal role in the foundation of the University of South Florida. In 1957 he became president of a newly founded university without any students. Actively promoting the new academic centre to students, government and companies, his legacy was to build a new university from scratch.

[218] Meiklejohn 1963 p.1.

usable by humans." He went on telling that "*this was a pretty perplexing discovery. What would mothers* […] *cunning their sons into eating spinach 'so you can be strong like Popeye' have to say about it? And how about the spinach growers? The spinach market might take a nosedive.*" He eventually reported that "*pressures were applied to keep the report from being published. But it was after a delay.*". Is this story true? Without further material emerging providing meat to the story it cannot be taken at face value. John Allen certainly used his talks on "Academic Freedom" to popularize the University of South Florida, which he had just founded and for which he tried to attract the first generation of students. At least it is not completely implausible, because since the 1850s there had been hard scientific confrontations between those promoting a diet based intake of organic iron especially by food and those who promoted iron medication and iron fortification of food by supplementing inorganic iron.

The history of ideas, science and errors

In 1964 the information scientist Eugene Garfield argued, based on an idea of science fiction author Isaac Asimov on the Genetic Code of the DNA, that citation networks are a useful tool to study the history of ideas[219]. This article and Garfield's further work greatly helped to establish and popularize the wide use of the Science Citation Index (SCI).[220] The anecdote on Isaac Asimov though shows the limitations of such a system, being based on extreme reductionism, assuming scientific ideas just travel from one scientific publication to the next. The very initial case study, which supported this concept, being based on the monk Gregor Mendel, whose great discovery was "completely ignored" during his lifetime, was severely limited by the selected literature considered by earlier investigators.[221]

Reality, however, is more complex, and scientists do no live in a social vacuum, but are influenced by grey media, newspapers, pop-culture and public perception like everybody else. The spinach iron story and the development of the legend with the decimal error is a prime example of this; hardly traceable by citation links alone and clouded by a pile of incorrect citations, misquotations and misunderstandings. The most powerful ideas do not follow a linear citation flow, but are inherited in a zig zag scheme pinball between authors, scientific journals, newspapers and public relation companies. The absence of clear citation links should not let us assume that there are no digammas in the history of ideas.

The case of Jacob Moleschott and the iron in spinach is a good example of this. Even though he is rarely cited in scientific investigations today, many of his ideas have been embedded in the collective unconscious of common knowledge. Nobel prize winner Max Planck once assumed that "*a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its oppo-*

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[219] Garfield 1964, 1970, 1979.

[220] See also Mielewczik et al. 2017.

[221] See also Mielewczik et al. 2017.

nents eventually die, and a new generation grows up that is familiar with it."[222] The case of spinach and iron and the decimal error rather highlights that scientific ideas can re-emerge from the unconscious of the common knowledge[223], even long after it was forgotten who brought up those ideas originally.

Alternative metric indices, such as Altmetric, now try to take this into account, measuring the impact on newspapers and public forums. Based on those the 19th century texts, which introduced spinach as an iron rich vegetable, they have certainly "*fared well compared to its contemporaries*".

Nevertheless, none of those metrics can measure the quality of a scientific report. Nor can they estimate in how far public text and pop culture feeds back into the scientific ivory tower. Authors certainly can never be sure in which context new generations of researchers will discuss their results. The history of science certainly is always also the history of errors and the history of scholarly disputes.

Students who try to trace the history of ideas, might consider that finding new contextual pieces is like solving a puzzle in the dark with most pieces lost during childhood. Once Humpty-Dumpty was broken, "*all the King's horses and all the King's men, could not set him back together again*".[224] Thanks to the spinach iron tale and the following iconoclasm at least the yolk of the egg found a jolly good bed.

Conclusions

Urban legends are developing and spreading stepwise. They can, however, be based both on a grain of truth or originate from general mistakes. Even if scientific errors or problems are noted in scientific journals, an incomplete revelation and proliferation of the reasons and extent of the problem can have serious consequences. The early measurements of spinach are a prime example of this: Uncertainties related to both methodology and the possibility of additional typographical errors did not only lead to the myth that spinach is rich in iron, but also clouded the general perception how widely prevalent such problems were. In the end it was not the fault of a single scientist and hordes of journalists that triggered the myth, but simple quality issues in the peer review of the journals that published the original data. The quantitative analysis of plant ash for most of the 19th century in many instances did not fare better than the qualitative spagyrical experiments in the centuries before. Especially in chemistry the community was well-aware of the limitations and intensely discussed problems in scientific publications, leading to an academic modern journal culture early in the second half the 19th century.

Moleschott's nutrition tables are, however, among the first attempts to implement the use of systematic reviews, a methodology still widely used in evidence-based medicine. The approach though was limited, being derived from a multitude

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[222] Max Planck (1858-1947) as cited by Barber 1961 p.597; see also Planck 1949.

[223] For comparison see Jung 1968.

[224] Denslow 1903.

of single case studies on plants grown under various conditions and analysed by various differing methods, which were often not even disclosed. Eventually data from at least 5 decades became largely uninterpretable and even after this, the problems let to decades of further problems for the raising dietary movement when creating their nutrition tables.

Essence: Readers should not assume that because they spot one error, others are absent. Scientists, Journalists and readers share a joint responsibility in propagating of academic myths. Scientific errors are like sand grains in the desert, it's impossible to find and collect all of them.

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Literatur

Allaby, M. (2012). Oxford Dictionary of Plant Science. Third Edition. Oxford University Press, Oxford.

Abderhalden, E. (1906). Lehrbuch der Physiologischen Chemie in dreissig Vorlesungen. Urban & Schwarzenberg, Berlin & Wien.

Acemoglu, D., Ozdaglar, A., ParandehGheibi, A. (2010). Spread of (mis)information in social networks. Games and Economic Behavior 70(2), 194–227.

Anonymous a.k.a. Pope, A. (1711). An Essay on Criticism. W. Lewis, London.

Anonymous (1784). Beobachtungen über gediegenes Eisen in den Erdbeeren. Magazin für das Neueste aus der Physik und Naturgeschichte 2(4), 40–44.

Anonymous (1846). Analyse von Asche von Spinacia oleraceae, von Saalmüller. Journal für praktische Chemie (Hrsg. Erdmann & Marchand) 39, 121.

Anonymous (1852). Die Nahrungsmittel. Published in: Die Gegenwart – Eine encyklopädische Darstellung der neueren Zeitgeschichte für alle Stände. Siebenter Band. Brockhaus, Leipzig.

Anonymous (1853). Aus dem Reiche der Naturwissenschaft. XVIII Die Nahrungsmittel für das Volk. Berlin 26th June Volks-Zeitung 1(65), 4 and Supplement p. 1.

Anonymous (1854). Jacob Moleschott. Die Gartenlaube 35, 410–412.

Anonymous (1855a). Die Nahrungsmittel für das Volk. (Aus dem Reich der Naturwissenschaften). (Post-Ausgabe) Fränkischer Kurier (Mittelfränkische Zeitung) 22(140), 2–3.

Anonymous (1855b). Jacob Moleschott und das vermeintlich „Unsittliche“ in der Naturwissenschaft. In: Jahrbücher für Wissenschaft und Kunst. Zweiter Band. Verlag von Otto Wigand, Leipzig.

Anonymous (1856a). Der Humor in Kraft und Stoff oder die exacten Ungereimtheiten der modernen Realphilosophie in unexacten Reimen. Verlag von Gustav Georg Lange, Darmstadt.

Anonymous, a.k.a. Dr. Mantis, a.k.a. Adolf von Harless (1856b). Goethe im Fegefeuer – Eine materialistisch-poetische Gehirnsekretion. Gebrüder Scheitlin, Stuttgart und München.

Anonymous (1856c). Die Geschichte der Dekatholisierung der katholischen Schweiz. In G. Phillips’ und G. Goerres’ Historisch-Politische Blätter für das historische Deutschland. Zweiter Band: 1005–1027.

Anonymous (1858). Die Nahrungsmittel. Published in Die gesammten Naturwissenschaften. Zweiter Band. Baedeker Verlag, Essen.

Anonymous (1860). Meyer’s Neues Converations-Lexikon für alle Stände. 11. Bd. Marengo-Ozon. Verlag des Bibliographischen Instituts, Hildburghauen & New York.

Anonymous (1861). Handwörterbuch der reinen und angewandten Chemie. Achter Band. Druck und Verlag von Friedrich Vieweg und Sohn, Leipzig.

Anonymous a.k.a. Bernstein, A.D. (1869). Allgemeine Bibliothek der gesammten Populaeren Naturwissenschaften. Erster Band. Dritte Auflage. Verlag von Chr. Schmidt, New York.

Anonymous (1871). Die Krankheit unserer Generation. Aesculap 1, 62.

Anonymous (1873a). Zur Nahrungsmittel-Lehre. Das bayrische Vaterland. 7. Jahrgang No. 172, 26th July p. 678.

Anonymous (1873b). Von der Golkoppa, 8.Juli. Silesia 14(30), 398.

Anonymous (1873c). Zur Hauswirthschaft. Volkswirthschaftlich Blaetter. Beilage zum Pusterthaler Boten. 8th August 32, S1–S2.

Anonymous (1873d). Zur Hauswirthschaft. Meraner Zeitung 23ter Juli 7(58), 4.

Anonymous (1874). Unsere Nahrungsmittel. Unteroffizier-Zeitung. Zeitschrift für den Unteroffizier, den Unteroffizier-Aspiranten und Einjährig-Freiwilligen aller Waffen 1(23), 123.

Anonymous (1895a). Notes. Nature 52(1344), 325–327.

Anonymous (1895b). The therapeutic value of Iron. Modern Medicine and Bacteriological Review 4(6), 150–152.

Anonymous (1895c). The Rationale of Blood Regeneration. Rothschild Bros. & Co, New York.

Anonymous (1897). Iron in vegetable Food. The Literary Digest 14(17), 524–525.

Anonymous (1898). Eisenhaltige Nahrungsmittel. Der Deutsche Correspondent, 24th April 1898. Baltimore, USA p. 2.

Anonymous (1899a). Spinach craze the latest health fad – “Most precious of Vegetables” Good for the Liver. – Many Fine Qualities – It is guaranteed to Clear the Complexion and insure long life – A Rat Diet will cure baldness. Rochester Democrat and Chronicle (Rochester, N.Y., USA), 28th February 1899, p. 7.

Anonymous (1899b). To be healthy, eat spinach. Specialists have discovered that the plant is unusually wholesome. The Daily Herald (Delphos, Ohio, USA). 10.July.1899, p. 6.

Anonymous (1899c). Virtues of Spinach. Poughkeepsie Eagle-News (Poughkeepsie, New York, USA), 22nd March 1899, p. 7.

Anonymous (1904a). Miss Roosevelt makes pet of a 2-foot snake. Rock Island Argus (Rock Island, Ill. 15th August 1904) 53(256), 1.

Anonymous (1904b). Green chain a snake. The Washington Post (14th August 1904), A2.

Anonymous (1904c). Miss Alice Roosevelt and a garter snake. The Pokeespsie Evening Enterprise (Poughkeepsie, N.Y.) 23rd August 1904 p. 6.

Anonymous (1904d). Left it to Miss Roosevelt. Man bets 5,000$ to 1,000$ that she didn’t wear a snake on her neck. The Sun (New York) 71(358), 1.

Anonymous (1904e). Miss Alice Roosevelt. New York Times (25th August 1904).

Anonymous (1916). Nuxated Iron. Annual Reports of the Chemical Laboratory of the American Medical Association 9, 29–34.

Anonymous (1917). Former United States Senator Mason, Pioneer in Pure Food and Drug Legislation, Father of Rural Free Delivery System, Takes Nuxated Iron. Advertisement in Illustrated World 27, 135.

Anonymous (1932). Doctor says spinach makes him feel sad. The Marshall News Messenger (Marshall, Texas, USA) 30th November p. 7.

Anonymous (1934). Shirley tests spinach’s iron. The Detroit Free Press (Detroit, Michigan, USA), 30th October 1934, p. 13.

Anonymous (1935). —. Screenland – The Smart Screen Magazine 30(4), 62.

Anonymous (1936a). Popeye first in Affection of South Bend. The Motion Picture and the Family 3(2), 8.

Anonymous (1936b). “Oh Spinach!” says First Lady. Tampa Morning Tribune (Tampa, Florida, USA), 6th March 1936, p. 9.

Anonymous (1936c). ‘Oh Spinach’ favorite term of the First Lady. The Minneapolis Star (Minneapolis, Minnesota, USA), 28th February 1936, p. 6.

Anonymous (1939). Accepted foods and their nutritional significance; Council on Foods and Nutrition (American Medical Association). American Medical Association, Chicago.

Anonymous (1945). Woman's Club Promise Interesting Meeting. Orangetown Telegram 52(88), 1.

Anonymous (1946a). The committee of 13. As published online at the Getty Images Webpage. www.gttyimage.co.uk Clip 520049083.

Anonymous (1946b). The committee of 13. As published online at the Getty Images Webpage. www.gettyimages.co.uk Clip 52004985.

Anonymous (1947). Showbiz helping Committees of 13 on Superstitions. The Billboard 59(24), 48.

Anonymous (1956a). Punctuation. Compton's pictured Encyclopedia and fact-index. Volume 11. Fe. Compton & Company, Chicago.

Anonymous (1956b). You may think it's true but... It's the bunk. Herald Magazine 29th January 1956 p. 4.

Anonymous (1960). Eisenarmer Spinat. Naturwissenschaftliche Rundschau 13, 142.

Anonymous (1966). Spinach – A risk to babies. BMJ 1(5482), 250–251.

Anonymous (1969). Schwarzer Prager Humor. Die Tat, December 13th p. 2.

Anonymous (1979a). Jeepers Creepers Popeye is 50! Philadelphia Daily News. 11th January p. 24.

Anonymous (1979b). Spinach: Fresh Look ("I say it's spinach"). Science Digest 85,96.

Anonymous (1979c). Popeye and the spinach myth. British Nutrition Foundation 26:66–67.

Anonymous (1988). Reader's Digest. Facts and Fallacies. Reader's Digest Association, New York.

Anonymous (1989). Popeye. I y'am what I y'am. Ravette Cartoon Classics. Cox & Wyman, Reading.

Anonymous (2010). Wissen aktuell – Popeye und der Mythos Spinat. Radio SRF, Switzerland. 4th Sept 2010.

Anonymous (2012). Es brodelt in der Gerüchteküche: Iglo räumt auf mit den Zubereitungs-Mythen. Presseinformation, Hamburg 23.10.2012 https://www.presseportal.de/pm/54941/2348803 (last accessed 20.11.2017).

Anonymous (2013). Nummer 1: Iglo ist der Deutschen liebste Spinatmarke. Presseinformation, Hamburg, 08.05.2013. https://www.presseportal.de/pm/54941/2467676 (last accessed 20.11.2017).

Anonymous (2015a). The Mental_Floss 500. There's a canon of very important people everybody knows. This is the one you *should* know. The Mental_floss (Collector's Edition) 15(9), 16–59.

Anonymous a.k.a. Joachim D. (2015b). Sources of the spinach-iron myth: Serger 1906, Haensel 1909, Kobert 1914. https://historiesofecology.blogspot.co.uk/2015/08/further-comments-on-spinach-and-iron_4.html (last accessed 30. November 2017).

Anonymous (2016). Bissen Wissen: Das Märchen vom Eisen im Spinat. MDR Wissen 29.12.2016 https://www.mdr.de/wissen/video-72118.html

Arbesman, S. (2012). Paradox of hoaxes: How errors persist, even corrected. https://www.wired.com/2012/09/opinion-errors-knowledge-crowdfixing/

Arbesman, S. (2013). The Half-Life of Facts: Why Everything We Know Has an Expiration Date. Penguin Group, New York.

Arends, G. (1903). Neue Arzneimittel und Pharmaceutische Spezialitäten einschließlich der neuen Drogen, Organ- und Serum-Präparate. Verlag von Julius Springer, Berlin.

Atwater, W.O. (1887). How food nourishes the body. The chemistry of foods and nutrition II. The Century Illustrated Monthly Magazine 34, 231–252.

Aylward, J. (1979). Popeye A Phony? Say it isn't so! The Indianapolis Star (Indianapolis, Indiana, USA) 23rd January p. 18.

Baigant, C., Harrell, F.E., Buyse, M., Emberson, J.R., Altman, D.G. (2008). Ensuring trial validity by data quality assurance and diversification of monitoring methods. Clinical Trials 5, 49–55.

Baldi, B. & Moore, D.S. (2009). The Practice of Statistics in the Life Sciences. W.H. Freeman and Company, New York.

Baldoni, A. (1905). Ein Beitrag zur biologischen Kenntnis des Eisens. Archiv für experimentelle Pathologie 52, 61.

Barber, B. (1961). Resistance by Scientists to Scientific Discovery. Science 134, 596–602.

Barham, A. (2006). The Pedant's Revolt. Know what know-it-alls know. Delacorte Press, New York.

Beck-Bornholdt, H.-P. & Dubben H.-H. (2001). Der Hund, der Eier legt: Erkennen von Fehlinformation durch Querdenken. Vollständig überarbeitete und erweiterte Neuauflage. Rowohlt Taschenbuch Verlag GmbH, Reinbek bei Hamburg.

Bender, A. (1972). The Wider Knowledge of Nutrition. Inaugural Lecture. October 24. Queen Elizabeth College., University of London. Castle Cary Press Ltd., Somerset.

Bender, A. (1977). Iron in spinach. Spectator 9th July p. 18.

Bendix, B. (1899). Lehrbuch der Kinderheilkunde fuer Aerzte und Studirende. Zweite Auflage. Urban & Schwarzenberg, Berlin & Wien

Bernstein, A. (1853). Aus dem Reiche der Naturwissenschaft. Ein Buch für Jedermann aus dem Volke. Verlag von Franz Duncker, Berlin.

Bernstein, A. (1864). Gemüse und Fleisch. In: Die Land und Hauswirthschaft in der Volks- und Fortbildungsschule. (Hrsg. D. Kompfe), p. 126, Schulbuchhandlung von F.G.L. Greßler, Langesalza.

Berzelius, J. (1832). Jahres-Bericht über die Fortschritte der physischen Wissenschaften. 11, 317.

Birnbaum K., Boeckmann Fr., Herrmann F., Michalis A., Nies F., Zoeppritz K. (1872). Ueber den Eisen Jahresbericht über die Fortschritte der Chemie der Thierernährung und der chemischen Technologie der landwirthschaftlichen Nebengewerbe. Dreizehnter bis fünfzehnter Jahrgang: die Jahre 1870–1872, 74–75.

Blinn, O.S. (1942). Activities at the Woman's Club. Scarsdale Inquirer (Scarsdale, N.Y.) 24(45), 14.

Block, J. (1915). Blut als Nahrungsmittel! Unsere Ernährung und der hohe Wert der Eiweisskoerper des Blutes; seine Verwendung zur billigen Herstellung von Brot und Speisen, insbesondere während des Krieges. Naturwissenschaftlicher Verlag in Godesberg bei Bonn.

Bluphocks, L. (1922). 'Twas Brillig and Slithy Freuds. The Truth, at Last, About the Greatest Dream in the World. Vanity Fair July 1922, p. 59, 106.

Boresch, K. (1931). Die anorganischen Bestandteile. In: Pflanzenernährung. Erster Band. p. 180–284. Verlag von Julius Springer, Berlin.

Bostock, J. (1825). An elementary System of Physiology. Volume 1. Wells and Lilly, Boston.

Boussingault, J.B. (1872). Du fer contenu dans le sang et dans les aliments. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 74, 1353–1359.

Boussingault, J.B. (1874). Agronomie, chimie agricole et physiologie. Deuxième Edition, Revue et Considérablement Augmentée. Tome Cinquième. Gauthier-Villars, Imprimeur-Libraire, Paris.

Braconnot, H. (1808). Examen des acides végétaux – Qui saturent la potasse et la chaux dans les plantes. Annales de Chimie ou Recueil de Mémoires concernant la chimie et les arts qui en dépendent, et spécialement La Pharmacie. Tom. 65, 277–308.

Braconnot, H. (1810). Untersuchung der Pflanzensäuren, die das Kali und den Kalk in den Pflanzen sättigen. (Trommsdorffs) Journal der Pharmacie fuer Aerzte, Apotheker und Chemiker 19(S2), 29–92.

Buchheim, R. (1847). Analysen von Pflanzenaschen. Pharmaceutisches Centralblatt 18(8), 114–122.

Büchner, L. (1856). Kraft und Stoff. Empirisch-naturphilosophische Studien. Vierte vermehrte und mit einem dritten Vorwort versehene Auflage. Verlag von Meidinger Sohn & Cie, Frankfurt a.M.

Büchner, L. (1859). Kraft und Stoff. Empirisch-naturphilosophische Studien. Sechste vermehrte und verbesserte Auflage. Verlag von Meidinger Sohn & Comp, Frankfurt a.M.

Büchner, L. (1872). Kraft und Stoff. Empirisch-naturphilosophische Studien. Steiger, New York.

Bud, R., Roberts, G.K. (1984). Science versus Practice: Chemistry in Victorian Britain. Manchester University Press, Manchester.

Bunge, G. von (1871). Ueber die physiologische Wirkung der Fleischbrühe und der Kalisalze. Pflügers Archiv European Journal of Physiology, 4(1), 235–282.

Bunge, G. von (1874a). Der Kali-, Natron-und Chlorgehalt der Milch, Verglichen mit dem Anderer Nahrungsmittel und des Gesammtorganismus der Säugethiere. C. Mattiesen, Dorpat.

Bunge, G. von (1874b). Ueber den Natrongehalt der Pflanzenaschen. Justus Liebig's Annalen der Chemie und Pharmacie 96(N.R.), 16–27.

Bunge, G. von (1886). Vitalismus und Mechanismus. Verlag F.C.W. Vogel, Leipzig.

Bunge, G. von (1892). Weitere Untersuchungen über die Aufnahme des Eisens in den Organismus des Säuglings. Zeitschrift für Physiologische Chemie 16. 173–186.

Bunge, G. (1895). Ueber die Eisentherapie. Verhandlungen des Congresses für Innere Medicin. (Hrsg. E. Leyden & Emil Pfeiffer). Dreizehnter Congress. Gehalten zu München, vom 2.–5. April 1895. Verlag von J.F. Bergmann, Wiesbaden. p. 133–193.

Bunge, G. (1901). Der Kalk und Eisengehalt unserer Nahrung. Zeitschrift für Biologie 45, 532ff.

Busse, N. (2015). Der Meister und seine Schüler: Das Netzwerk Justus Liebigs und seiner Studenten. Georg Olms Verlag, Hildesheim Zürich New York.

Butler, G.F. (1921). Cubism in Medicine. Illinois Medical Journal 39, 250–256.

Cahn, R.W. (2003). The Coming of Materials Science. Pergamon Materials Series. 2nd Edition. Pergamon, Amsterdam London New York Oxford Paris Shannon Tokyo.

Campbell, W.A. (2000). The Nitrogen Industry. In: Chemistry Society and Environment – A new history of the British Chemical Industry. (Ed. C.A. Russell). The Royal Society of Chemistry, Cambridge (UK).

Carrol, L. (1893). Sylvie and Bruno concluded. With Forty-Illustrations by Harry Furniss. MacMillan and Co., London.

Chambers, T.K. (1875). A manual of diet in health and disease. Smith, Elder & Co., London.

Christian, H.A. (1903). A sketch of the history of the treatment of chlorosis with iron. Medical Library and Historical Journal 1, 176–180.

Coblentz, V. (1899). The newer remedies. Third edition. P. Blakiston's Son & Co, Philadelphia.

Cohn, M. (1915). Die Ernährung des älteren Kindes während der Kriegszeit. Friedrich Brandstetter, Leipzig.

Cohnheim, O. (1908). Die Physiologie und Verdauung der Ernährung: 23 Vorlesungen für Studierende und Ärzte. Urban & Schwarzenberg, Berlin – Wien.

Cole, G.D., Shun-Shin, M.J., Nowbar A.N., Buell, K.G., Al-Mayahi, F., Zargaran, D., Mahmood, S., Sing, B., Mielewczik, M., Francis, D.P. (2015a). Difficulty in detecting discrepancies in a clinical trial report: 260-reader evaluation. International Journal of Epidemiology 44, 862–869.

Cole, G.D., Nowbar, A.N., Mielewczik, M., Shun-Shin, M.J., Francis, D.P. (2015b). Frequency of discrepancies in retracted clinical trial reports versus unretracted reports: blinded case-control study. BMJ 351, h4708.

Commoner, B. (1968). Threats to the integrity of the nitrogen cycle: Nitrogen compounds in soil, water, atmosphere and precipitation. p. 70–95. In: Global Effects of Environmental Pollution (Ed. S. Fred Singer). A Symposium organized by the American Association for the Advancement of Science held in Dallas, Texas, December 1968. D. Reidel Publishing Company, Dordrecht Holland.

Cordery, S.A. (2007). Alice. Alice Roosevelt Longworth, from White House Princess to Washington Power Broker. Viking, New York.

Cramp, A.J. (1921). Nostrums and Quackery. Articles on the Nostrum Evil, Quakery and Allied Matters Affecting the Public Health; Reprinted, With or Without Modifications, from the Journal of the American Medical Association. Volume II. Press of the American Medical Association, Chicago.

Cramp, A.J. (1936). Nostrums and Quackery and Pseudo-Medicine. Volume III. Press of the American Medical Association, Chicago.

Crooker, J.H. (1914). Shall I Drink? The Pilgrim Press, Boston New York Chicago.

Daley, D.J., & D. G. Kendall. (1965). Stochastic rumours. Journal of the Institute of Mathematics and Its Applications 1, 42–55.

Darmstaedter, L. (1908). Handbuch zur Geschichte der Naturwissenschaften und der Technik. Zweite, umgearbeitete und vermehrte Auflage. Springer Verlag, Berlin Heidelberg.

Denslow, W.W. (1903). Denslow's Humpty Dumpty. G.W. Dillingham Co., New York.

Dickens, C. (1920). The Charles Dickens Calendar. A quotation from works of Charles Dickens for every day in the year. (Compiled by B.W. Matz). Cecil Palmer, London.

Dietz, K. (1967). Epidemics and Rumours: A Survey. Journal of the Royal Statistical Society. Series A (General) 130(4), 505–528.

Doherty, C. & McDonnell C.M. (2012). Tenfold Medication Errors: 5 Years' Experience at a University-Affiliated Pediatric Hospital. Pediatrics 129, 916–924.

Drew, B. (1973). It's only a shanty but to Sellers it's home. The Daily News (Tarrytown N.Y.) 19th October 1973 p. 26.

Drösser, C. (1997). Falsches Komma. Spinat ist gesund, weil er besonders viel Eisen enthält. Zeit Online, http://www.zeit.de/stimmts/1997/1997_41_stimmts

Ellsworth Fitch, L. (1935). Imagine their feelings! Street & Smith's Picture Play 43(2), 42–43.

Engber, D. (2016). Who will debunk the debunkers? https://fivethirtyeight.com/features/who-will-debunk-the-debunkers/

Evans E.P. (1896). Sketch of Jacob Moleschott. Appletons' Popular Science Monthly, July 1896, 399–406.

Falk, C. (1968). Spinat im für und Wider. Die Tat, February 3rd p. 25

Farkas, A. (2002). The Oxford Dictionary of Catchphrases. Oxford University Press, New York.

Faulstich, W. (2004). Medienwandel im Industrie- und Massenzeitalter (1830–1900). Vandenhoeck & Ruprecht, Göttingen.

Feuerbach, L. (1850a). Naturwissenschaft und Revolution. Blätter für Literarische Unterhaltung Band 2, p. 1069–1071, p. 1073–1074, p. 1077–1079 & p. 1081–1083.

Feuerbach, L. (1866). Das Geheimniß des Opfers. Oder der Mensch ist, was er ißt. In: Gottheit, Freiheit und Unsterblichkeit vom Standpunkte der Anthropologie. Ludwig Feuerbach's sämmtliche Werke Band X., p. 1–36. Verlag von Otto Wigand, Leipzig.

Fischer, K.P. (1853). Die Unwahrheit des Sensualismus und Materialismus. Verlag von Theodor Blässing, Erlangen.

Fishbein, M. (1929). How widely accepted theory was advanced by Agassiz "Because brain needed phosphorus". The Miami News 20th March 1929.

Fishbein, M. (1929b). Health. No diet is suitable unless it has plenty of vegetables. Times Herald (Olean, New York, USA), 4th September 1929, p. 6.

Fishbein, M. (1930). Shattering Health Superstitions. An Explosion of False Theories and Notions in the Field of Health and Popular Medicine. Horace Liveright, New York.

Fishbein, M. (1932a). Fads and Quackery in Healing. An analysis of the foibles of the healing cults, with essays on various other peculiar notions in the health field. Friede Covici, New York.

Fishbein, M. (1932b). Doctor says spinach makes him feel sad. Marshall Evening Messenger (Marshall, Texas, USA) 56(122),1.

Fishbein, M. (1936). Your Health. Enough iron in body to make five carpet tacks; Important in Blood. Bradford Evening Star and the Bradford Daily Record (Bradford, Pennsylvania, USA) 3rd January p. 2.

Fishbein, M. (1938a). Health Talks. Shamokin News-Dispatch (Shamokin, PA., USA) 15th February p. 4.

Fishbein, M. (1938b). The Family Doctor. Chief value of spinach lies in way used. The Indiana Gazette (Indiana, Pennsylvania, USA), 11. February 1938, p. 11.

Fleischer, R. (2005). Out of the Inkwell: Max Fleischer and the Animation Revolution. The University Press of Kentucky, Lexington.

Francis, D.P., Mielewczik, M., Zargaran, D., Cole, G.D. (2013). Autologous bone marrow-derived stem cell therapy in heart disease: Discrepancies and contradictions. International Journal of Cardiology 168, 3381–3403.

Franks, S. (2006). I know You know. In: Psych. (performed by The Friendly Indians), USA Network. https://www.youtube.com/watch?v=rEgnZ05PaMg

Frazer, J.G. (1921). Apollodorus. The Library. Translated by Sir James George Frazer. Loeb Classical Library Volume 121. Harvard University Press, Cambridge, MA; William Heinemann Ltd. 1921, London.

Freud, S. (1905). Der Witz und seine Beziehung zum Unbewussten. Franz Deuticke, Leipzig und Wien.

Freud, S. (1909). Selected papers on hysteria and other psychoneuroses. The Journal of Nervous and Mental Disease Publishing Company, New York.

Freud, S. (1915). On Dreams. Rebman Company, New York.

Freud, S. (1916). Wit and its relation to the unconscious. Moffat, Yard and Company, New York.

Fröhlich, H (1898). Eisenhaltige Nahrungsmittel. Illustrirte Curorte Zeitung 2, 1–2.

Fruton, J.S. (1990). Contrasts in Scientific Style. Research Groups in the Chemical and Biochemical Sciences. Memoirs of the American Philosophical Society Vol. 191. American Philosophical Society, Philadelphia.

Garfield, E., Sher, I. H., and Torpie, R. J. (1964). The use of citation data in writing the history of science. Philadelphia: Institute for Scientific Information Inc.

Garfield, E. (1970). Citation indexing for studying science. Nature 227, 669 – 671.

Garfield, E. (1979). Is citation analysis a legitimate evaluation tool? Scientometrics 1/4, 359 –375.

Grawitz, E. (1911). Klinische Pathologie des Blutes nebst einer Methodik der Bluntuntersuchungen und spezieller Pathologie und Therapie der Blutkrankheiten. Verlag von Otto Enslin, Berlin.

Grützner, P. von (1906). Moleschott, Jacob. in: Allgemeine Deutsche Biographie, herausgegeben von der Historischen Kommission bei der Bayerischen Akademie der Wissenschaften 52, 435–438.

Gutzkow, K. (1854). Anregungen – Unsere Nahrungsmittel. In: Unterhaltungen am häuslichen Herd. Band 2. Brockhaus, Leipzig. 9, 142–144.

Haden, R.L. (1938). Historical aspects of iron therapy in anemia. The Journal of the Medical Association 111, 1059–1061.

Haensel, E. (1909). Über den Eisen- und Phosphorgehalt unserer Vegetabilien. Biochemische Zeitschrift 16, 9.

Hagelgans, U. (1985). Jacob Moleschott als Physiologe. Marburger Schriften zur Medizingeschichte 14. Lang, Frankfurt am Main; Bern; New York.

Hamblin, T. J. (1981). Fake. BMJ, 283(6307), 1671–1674.

Hamblin, T.J. (2010). Spinach – I was right for the wrong reason. http://mutated-unmuated.blogspot.co.uk/2010/12/spinach-i-was-right-for-wrong-reason.html

Hartog, P.J. (1896). Richardson, Thomas (1816–1867) Dictionary of National Biography, Volume 48. Smith, Elder & Co., London https://en.wikisource.org/wiki/Richardson,_Thomas_(1816–1867)_(DNB00)

Harvey, E.H. Jr. et al. (Eds.) (1987). Reader's Digest Book of Facts. The Reader's Digest Association Inc, Montreal.

Hauser, B.G. (1934). Here‘s how to be healthy. Tempo Books Inc., New York.

Hawes, E. (1938). Fashion is Spinach. Second Printing. Random House, New York.

Hecht, M. (2010). Of spinach, decimal points. The Philadelphia Inquirer (Philadelphia, Pennsylvania, USA) 12th July p. D2.

Heffter, A. & Heubner, W. (Eds.) (1934). Handbuch der experimentellen Pharmakologie. Dritter Band, 2. Teil: Allgemeines zur Pharmakologie der Metalle. Eisen – Mangan – Kobalt- Nickel. Springer-Verlag GmbH, Berlin Heidelberg.

Heinze, B. (1903). Untersuchungen von verschiedenen Gurkensorten in verschiedenem Entwickelungszustande sowie über sauere Gurken. Zeitschrift für Untersuchung der Nahrungs-und Genußmittel, sowie der Gebrauchsgegenstände 6(12), 529–544.

Hellman, G.T. (1940). Mrs. Roosevelt. Her admirers have their own 1940 platform: "A new president but the same first lady". Life 8(6), 70–78/

Hessling T. von (1852). Ueber die Eisenwirkung in kranken Organismen. Mit besonderer Berücksichtigung der Stahlquellen bei Steben in Oberfranken (Baiern). Illustrirte Medizinische Zeitung 1:207–230

Heubner, O. (1911). Lehrbuch der Kinderheilkunde. Dritte umgearbeitete Auflage. Verlag von Johann Ambrosius Barth, Leipzig.

Hill, R. (1937). Oxygen Evolved by Isolated Chloroplasts. Nature 139(3525), 881.

Hill, R. (1940). Production of Oxygen by Illuminated Chloroplasts. Nature 146 (3689), 61.

Hink, H. (1915). Es muss reichen! Sparsame Volksernaehrung eine Bedingung unseres Sieges. Braunsche Hofbuchdruckerei und Verlag, Karlsruhe.

Hirschfeld, F. (1900) Nahrungsmittel Ernährung der Gesunden und Kranken. Verlag von August Hirschwald, Berlin.

Hocking, M.B.B. (1998). Handbook of Chemical Technology and Pollution Control. Academic Press, San Diego London Boston New York Sydney Tokyo Toronto.

Hölscher, P.M., Natzscka, J. (1964). Methämoglobinämie bei jungen Säuglingen durch nitrithaltigen Spinat. Deutsche Medizinische Wochenschrift 89(37), 1751–1754.

Hoeven, J. van der (1847). Handbuch der Zoologie. Nach der zweiten, verbesserten und vermehrten holländischen Auflage ins Deutsche übersetzt von Jac. Moleschott. Bötticher'sche Buchhandlung, Düsseldorf.

Horbach, S.P.J.M., Halffman, W. (2017). The ghosts of HeLa: How cell line misidentification contaminates the scientific literature. PLoS ONE12(10), e0186281. https://doi.org/10.1371/journal.pone.0186281

Huang, Y., Liu, Y., Zheng, C., Shen, C. (2017). Investigation of Cross-Contamination and Misidentification of 278 Widely Used Tumor Cell Lines. PLoS ONE12(1), e0170384. https://doi.org/10.1371/journal.pone.0170384

Hunt, T. (1848). On the fatty acids of Castor Oil; by M. Saalmüller. The American journal of science and arts 58, 106–107.

Ihde, J. (1961). American Chemists at the turn of the Century: S.M. Babcock, Harvey Wiley, Ira Remsen, T.W. Richards and Edgar Fahs Smith. p. 805–830 In: Great Chemists (Ed. Eduard Faber). Interscience Publishers, New York London.

Ioannidis, J.P.A. (2005). Why most published research findings are false. PLOS Medicine 2(8), e124.

Jagendorf, A.T. (1950). Oxidation and reduction of pyridine nucleotides by purified chloroplasts. Arch. Biochem. Biophys. 62, 141–150.

James, W. (1890). The principles of psychology. Vol. 1. Drummond, New York.

Jaquet A. (1888). Elementaranalyse des Hundeblut-Haemoglobins. Zeitschrift für Physiologische Chemie 12, 285–288.

Jean, S.L. (1920). Health Organization work in Public Schools. Addresses and Proceedings of the 58th Annual Meeting, Salt Lake City, Utah July 4–10th 1920. Addresses and Proceedings of the National Education Association of the United States 58, 369–371.

John, J.F. (1814). Chemische Tabellen des Thierreichs. – Oder systematische Uebersicht der Resultate aller bis jetzt zerlegten Animalien. Maurersche Buchhandlung, Berlin.

Jung, C.G. (1968). Der Mensch und seine Symbole. Walter, Olten, Freiburg im Breisgau.

Kafka (1864). Aus der Praxis. Neue Zeitschrift für homöopathische Klinik 9, 90–92.

Kafka (1865). Cases of secondary diseases after measles. The North American Journal of Homeopathy 13, 225–227.

Kamminga, H. (1995). Nutrition for the People, or the Fate of Jacob Moleschott's Contest for a Humanist Science. Published in The Science and Culture of Nutrition, 1840–1940 (Eds. Kamminga H. & Cunningham, A.). Clio Medica 32, 15–47.

Kandhway, K. & Kuri, J. (2014) Optimal control of information epidemics modeled as Maki Thompson rumors. Communications in Nonlinear Science and Numerical Simulation 19(12), 4135–4147.

Kendall, R. (1934). Around and About in Hollywood. The Los Angeles Times (Los Angeles, California, USA), 31st October 1934, p. 17.

Kerr, R.A. (1999). No Easy Answers in Mars Probe's Fiery Death. Science 286, p. 18.

Kirkpatrick, L.D., Francis (2010). Physics: A Conceptual World View. Brooks/Cole, Canada.

Klencke, H. (1867). Chemisches Koch- und Wirthschaftsbuch oder die Naturwissenschaften im weibliche Berufe. Ein Lehrbuch für denkende Frauen und zum Gebrauche in weibliche Erziehungsanstalten. Zweite, neu durchgearbeitete und vermehrte Ausgabe. Verlag von Eduard Kummer, Leipzig.

Klencke, H. (1872). Was heißt: unser tägliches Brot. Sächsische Dorfzeitung – Ein unterhaltendes Blatt für den Bürger und Landmann 34(27), 3–4.

Knowles, E. (2006). The Oxford Dictionary of Phrase and Fable. Second Edition. Oxford University Press.

Knowles, E. (2007). The Oxford Dictionary of Modern Quotations. Third edition. Oxford University Press.

Kockerbeck, C. (2012). Jacob Moleschott: "Ohne Phosphor kein Gedanke". Biologie in unserer Zeit 41, 73–74.

König, J. (1893). Die menschlichen Nahrungs- und Genussmittel, ihre Herstellung, Zusammensetzung und Beschaffenheit, nebst einem Abriss der Ernährungslehre. 3rd Edition. Julius Springer, Berlin.

König, J. (1904). Chemie der menschlichen Nahrungs- und Genussmittel. Vierte verbesserte Auflage. Verlag von Julius Springer, Berlin.

Kössler, F. (1976). Register zu den Matrikeln und Inskriptionbüchern der Universität Gießen WS 1807/08 – WS 1850. Universitätsbibliothek, Giessen.

Kovács, L., Csupor, D., Lente G., Gunda, T. (2014). 100 Chemical Myths: Misconceptions, Misunderstandings, Explanations. Springer, Heidelberg New York Dordrecht London.

Knight, M. (1936). Shirley Temple is growing up. The Evening Sentinel (Carlisle, PA, USA), 29th April 1936, p. 6.

Knuth, D.E. (1989). The errors of TEX. Software—Practice & Experience 19, 607–685. Reprinted with additions in Literate Programming, 1992, Center for the Study of Language and Information, Stanford, California, pp. 243–339.

Kramarae, C., Spender, D. (Eds.) (2000). Routledge International Encyclopedia of Women: Global Women's Issues and Knowledge. Routledge – Taylor & Francis Group, New York and London.

Krogmann, D. W., & Jagendorf, A. T. (1957). A spectrophotometric assay of the Hill reaction with ferricyanide. Plant Physiology 32(4), 373–374.

Kruszelnicki, K.S. (2001). mythconceptions. Why Popeye was wrong. The Sydney Morning Herald (Sydney, New South Wales, Australia) Good Weekend 16th June p. 9.

Kuhn, R. (1949). Richard Willstädter (1872–1942). Die Naturwissenschaften 36, 1–5.

Laursen, J.C. (2000). Spinoza in Denmark and the Fall of Struensee, 1770–1772. Journal of the Histories of Ideas 61(2), 189–202.

Le Canu, L. (1837). Études chimiques sur le sang humain. Thesis Faculte de Mediciae de Paris.

Lee, J.Y. (2000). Defining New York Humor. University Press of Mississippi, Jackson.

Leisewitz, C. (1910). Wolff, Emil von. In: Allgemeine Deutsche Biographie, herausgegeben von der Historischen Kommission bei der Bayerischen Akademie der Wissenschaften 55, 115–117.

Lémery (1713). Sur l'usage du fer en médicine. Histoire de l'Académie Royale des Sciences MDCCXIII, 25ff.

Leo, L. (1866). Die Gesundheitslehre für gebildete Leser. Verlag von August Hirschwald, Berlin.

Leray, C. (2013). Introduction to Lipidomics. From Bacteria to Man. CRC Press, Boca Raton – London – New York.

Lesar, T.S. (2002). Tenfold Medication Dose Prescribing Errors. The Annals of Pharmacotherapy 36, 1833–1839.

Leuchs, J.C. (1875). Nahrungsmittelkunde für Stadt und Land mit Berücksichtigung der Haus- und Volksarzneimittel, Schändlichkeiten und Gifte. Verlag von C. Leuchs & Co, Nürnberg.

Lewis, H.A. (2015). Math mistakes that make the news. Primus 25(2), 181–192.

Lewis, M. & Swanson, R. (2009). Astronautics and Aeronautics: A Chronology, 1996–2000. NASA SP-2009-4030. NASA History Division, Washington D.C.

Lichtin, A. (1924). The iron content of spinach. American Journal of Pharmacy 96, 361–364.

Liebig, J. (1837). Introduction to the first elements of chemistry for the use of students. (Translated from the German by Thomas Richardson) A. Schloss, London.

Liebig, J. & Kopp, H. (1849). Jahresbericht über die Fortschritte der reinen pharmaceutischen und technischen Chemie, Physik, Mineralogie und Geologie für 1847 u. 1848. J. Ricker'sche Buchhandlung, Giessen.

Liebscher, G. (1895). Untersuchungen über die Bestimmung des Düngerbedürfnisses der Ackerböden und Kulturpflanzen.Journal für Landwirtschaft 43, 49–216.

List P.H. (1978). Hagers Handbuch der pharmazeutischen Praxis. Vollständige vierte Neuausgabe. Sechster Band: Chemikalien und Drogen Teil B: R,S. Springer-Verlag, Berlin/Heidelberg, p. 479.

Lobsenz, N. (1979). Family Report. Does spinach really make you strong? Sunday Journal News (Family Weekly) (White Plains, New York, USA) 14th October p. 29.

Locin, M. (1985). Medicine man. Working to cure the ills of the American Medical Association. The Chicago Tribune Magazine 25th August p. 10.

Lorand, A. (1911). Die rationelle Ernährungsweise. Praktische Winke über das Essen und den Nutzen oder Schaden der verschiedenen Nahrungsmittel. Verlag von Werner Klinkhardt, Leipzig.

Lys, C. de (1948). A treasury of American superstitions. The Philosophical Library, New York.

Mankoff, B. (2014). How About Never--Is Never Good for You?: My Life in Cartoons. Henry Holt and Company, New York.

Maquenne, L. & Cerighelli, R. (1921). Sur la distribution du fer dans les végétaux. Comptes Rendus de l'Académie des Sciences 173, 273–278.

McDowell, L. (2017). Mineral Nutrition History: The early years. Animal Science Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville Florida USA.

Meiklejohn, D. (1963). Without Academic Freedom Man Can Never Find Truth. The Evening Independent (St. Petersburg, Florida, USA) 19th March p. 1–2.

Meneghello, L. (2017). Jacob Moleschott – A Transnational Biography: Science, Politics, and Popularization in Nineteenth-Century Europe. Transcript Verlag, Bielefeld.

Menghini, V. (1746). De ferrearum particularum sede in sanguine. De Bononiensi Scientarum et Atrium Instituto Atque Academia Commentarii 2(2), 244–266.

Menghini, V. (1747). De ferrearum particularum progressu in sanguinem. De Bononiensi Scientarum et Atrium Instituto Atque Academia Commentarii 2(3), 475–488.

Michel, J. B., Hoiberg, D., Clancy, D., Norvig, P., Orwant, J., Pinker, S., Nowak, M. A., und Aiden, E. L. (2011). Quantitative analysis of culture using millions of digitized books. Science 331, 176–182.

Michelis, F. (1856). Der Materialismus als Köhlerglaube. – Ein offenes Sendschreiben als Herausforderung zum wissenschaftlichen Kampfe an die Vertreter des neuen Materialismus in Deutschland. Verlag Theissing'sche Buchhandlung, Münster.

Mielewczik, M., Francis, D.P., Studer, B., Simunek, M.V., Hossfeld, U. (2017). Die Rezeption von Gregor Mendels Hybridisierungsversuchen im 19. Jahrhundert – Eine bio-bibliographische Studie. Nova Acta Leopoldina NF 413, 83–134.

Miller, C.T. (1872). Frog opera, with pollywog chorus: a burletta founded upon the nursery tale and old song of A frog he would a wooing go. Alfred Mudge & Son, Boston.

Mitscherlich, C.G. (1847). Lehrbuch der Arzneimittellehre. Erster Band, Zweite verbesserte Auflage. Verlag von G. Bethge, Berlin.

Mitscherlich, E.A. (1909). Das Gesetz des Minimums und das Gesetz des abnehmenden Bodenertrages. Landwirtschaftliche Jahrbücher 38, 537–552.

Mohr, H., Schopfer, P. (1995). Plant Physiology. Springer-Verlag, Berlin Heidelberg.

Moleschott J. (1845). Kritische Betrachtung von Liebig's Theorie der Pflanzenernährung, mit besonderer Angabe der empirisch constatirten Thatsachen. Erven F. Bohr, Haarlem.

— (1847). Bilin im Blute. Zeitschrift für Rationelle Medizin 6, 387–393.

— (1850). Lehre der Nahrungsmittel für das Volk. Verlag von Ferdinand Enke, Erlangen.

— (1852). Der Kreislauf des Lebens – Physiologische Antworten auf Liebig's Chemische Briefe. 1. Auflage. Verlag von Victor von Zabern, Mainz.

— (1856). Licht und Leben. Rede beim Antritt des öffentlichen Lehramts zur Erforschung der Natur des Menschen, an der Züricher Hochschule. Gesprochen am 21.Juni 1856. Zweite Auflage. Verlag von Meidinger und Sohn und Comp., Frankfurt a.M.

— (1859). Physiologie der Nahrungsmittel – Ein Handbuch der Diätetik. 2. Auflage. Ferbersche Universitätsbuchhandlung Emil Roth, Giessen.

— (1861). Physiologisches Skizzenbuch. Ferbersche Universitäts-Buchhandlung Emil Roth, Giessen.

— (1863a). Der Kreislauf des Lebens – Physiologische Antworten auf Liebig's Chemische Briefe. 4.Auflage. Verlag von Victor von Zabern, Mainz.

— (1863b). физiологическiя ризы. ИздАн1к В. Гглчввл и А. Чкгкнинл, Moscow.

— (1880). Kleine Schriften. Verlag von Emil Roth, Gießen.

— (1894). Für meine Freunde. Lebens-Erinnerungen. Verlag von Emil Roth, Giessen.

Moleschott, J. & Flocon, F. (1858). De L'Alimentation et du Régime. Librairie Victor Masson, Paris.

Moser, J. (1870). Lehrbuch der Chemie fuer Land- und Forstwirthe. Verlag von Paul Parey, Berlin.

Mould, R.F. (1996). Medical Anecdotes. Omnibus Edition. Can be taken in large or small doses. Suitable for after dinner, recommended as a tonic for the general public, can be taken with alcohol, cures boredom and all bad humors. Taylor & Francis Group, New York.

Mouneyrat, A. (1906). Chimie Analytique. – Méthode de recherche et de dosage de petites quantités de fer. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 142, 1049–1051.

Mouneyrat, A. (1907). Chimie biologique. – Du fer dans le tissus végétaux et animaux. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 144, 1067.

Mulder, G.J. & Moleschott, J. (1844a). Versuch einer allgemeinen physiologischen Chemie. Akademische Verlagshandlung von C.F.Winter, Heidelberg.

Mulder, G.J. & Moleschott, J. (1844b). G.J. Mulder über den Werth und die Bedeutung der Naturwissenschaften für die Medicin. Eine Rede, gehalten bei der Eröffnung seiner chemischen Vorlesungen an der Universität zu Utrecht. Akademische Verlagsbuchhandlung von C.F. Winter, Heidelberg.

Mulder, G.J. & Moleschott, J. (1847). Die Ernährung in Ihrem Zusammenhange mit dem Volksgeist. Bötticher'sche Buchhandlung, Utrecht und Düsseldorf.

Nekovee, M., Moreno, Y., Bianconi, G., & Marsili, M. (2007). Theory of rumour spreading in complex social networks. Physica A: Statistical Mechanics and its Applications, 374(1), 457–470.

Neurath, M.L., Lee, C.O. (1941). A history of Blaud's pills. Journal of Pharmaceutical Sciences 30, 60–63.

Nowbar, A., Mielewczik, M., Karavassilis, M., Dehbi, H.-D., Shun-Shin, M.J., Jones, S., Howard, J.P., Cole, G.D., Francis, D.P. (2014). Discrepancies in autologous bone marrow stem cell trials and enhancement of ejection fraction (DAMASCENE): weighted regression and meta-analysis. BMJ 348, g2688.

Oberg, J. (1999). Why the Mars probe went off course. IEEE Spectrum 6(12), 34–39.

Oberndorf, C.P. (1953). A history of psychoanalysis in America. Grune & Stratton, New York.

Palladin, V.I. (1926). Palladin's Plant Physiology. 3rd edition. P. Blakiston's et Son & Co, Philadelphia.

Panteleit, S. (2013). Warum Socken immer verschwinden und wohin: 300 spannende Alltagsfragen. 1. Auflage. Wilhelm Goldmann Verlag, München.

Park, R. B., Kelly, J., Drury, S., & Sauer, K. (1966). The Hill reaction of chloroplasts isolated from glutaraldehyde-fixed spinach leaves. Proceedings of the National Academy of Sciences, 55(5), 1056–1062.

Parmentier, A.A., Deyeux, N. (1796). Abhandlung über das Blut. Reil's Archiv für die Physiologie 1(2), 76–140.

Pefanis, A.E. (1979): Spinach iron is a myth. The National Culinary Review 2–5, 12pp.

Pfaundler, M. von (1920). Krankhafte Veraenderungen des Blutes und der blutbereitenden Organe. Konstitutionsanomalien und Stoffwechselkrankheiten. In: Lehrbuch der Kinderkrankheiten (Ed.: Feer, E.), 6. Verbesserte Auflage. Verlag von Gustav Fischer, Jena.

Planck, M. (1949). Scientific Autobiography. (F. Gaynor, trans.). Philosophical Library, New York.

Porterfield W.R. (1970). Superstitions and some not so Super – Knock on wood, throw salt over your shoulder if you think it helps, but it's just common sense to avoid walking under a latter. The Milwaukee Journal 12. May 1970.

Prang, M. (2010). Vegetarier leben länger: Die 101 größten Gesundheitsirrtümer. 2. Auflage. Verlag C.H.Beck oHG, München.

Questel, M. (1936). Oh, My Goodness / You've Gotta Eat Your Spinach, Baby. Decca Records (Australia), Columbia Graphophone (Aust.) LTD. Sydney, N.S.W.

Quinton, R. (1912). L'eau de mer milieu organique. 2nd edition. (Eds.: Masson et al.) Libraires de L'academie de medicine, Paris.

Rapoport, A. & Rebhuhn, L.I. (1952). On the mathematical theory of rumor spread. The Bulletin of mathematical Biophysics 14(4), 375–383.

Rautenberg, E. (1885). Verbrennen und Begraben bei unseren Vorfahren. Verlag Leopold Voss, Hamburg & Leipzig.

Rekdal, O.B. (2014a). Academic urban legends. Social Studies of Science 44(4), 638–654.

— (2014b). Academic citation practice: A Sinking Sheep? Portal: Libraries and the Academy 14(4), 567–585.

Richardson, T. (1848). Annal. Chem. Pharm. Bd. 67. Heft 3 [as cited by Wolff 1871].

Ritter, B. (1847). Zur Feststellung der Indicationen und Contraindicationen bei der Anwendung der Schwefelätherinhalationen in Krankheiten. Zeitschrift für Rationelle Medizin 6, 349–376.

Ritter, B. (1859). Medicinal- und Sanitäts-Policei – I. Wege und Mittel zum Schutz gegen die Cholera. Deutsche Zeitschrift für die Staatsarzneikunde, mit vorzüglicher Berücksichtigung der Strafrechtspflege in Deutschland und Oesterreich 14, 3–75.

Röhlig, M. (2005). 1000 Fragen – Macht Spinat wirklich stark? Spiegel Online 31.12.2005 http://www.spiegel.de/lebenundlernen/schule/1000-fragen-macht-spinat-wirklich-stark-a-376292.html

Rogers, N. (2005). Vegetables on Parade. American Medicine and the Child Health Movement in the Jazz Age. p. 23–72 In: Children's Health Issues in Historical Perspective (Eds. Krasnick Warsh & Strong-Boang). Wilfried Laurier University Press, Ontario.

Rolfus, H. & Pfister, A. (1865). Nahrung. Real-Encyclopaedie des Erziehungs- und Unterrichtswesens nach katholischen Principien. Dritter Band. Druck und Verlag von Florian Kupferberg, Mainz.

Roosevelt Longworth, A. (1935). Crowded hours: Reminiscences of Alice Roosevelt Longworth. Charles Scribner's Sons, New York London.

Rost, F. (2017). Lern- und Arbeitstechniken für das Studium. 8. Auflage. Springer VS, Berlin.

Roth, E. (1875). Jahresbericht über die Leistungen und die Fortschritte auf dem Gebiete des Militair-Sanitätswesens. II. Jahrgang. Bericht für das Jahr 1874. Verlag von August Hirschwald, Berlin.

Römpp (1996). Eisenpräparate. Römpp Lexikon Chemie, 10. Auflage, Bd. 2, Cm-G, (Ed. J. Falbe & M. Regitz). Thieme, Stuttgart New York p. 1098.

Rottner, A. (1858). Ein Besuch der Officin von Brockhaus Leipzig. Die Gartenlaube 6, 237–239.

Saalmüller, L. (1846). Analyse der Asche von *Spinacea oleracea*. Annalen der Chemie und Pharmacie. 57/58 Heft 3, 389.

— (1848a). Sur les acides gras de l'huile de ricin. Journal de pharmacie et de chimie 13, 391–394.

— (1848b). Sur les acides gras de l'huile de ricin. Annuaire de chimie 288–290.

Sachs, J. (1873). Grundzüge der Pflanzenphysiologie. Separatabdruck des Dritten Buchs der Dritten Auflage des Lehrbuchs der Botanik. Verlag von Wilhelm Engelmann, Leipzig.

Sargent, T. (1935). New Slant on Shirley! Screenland – The Smart Screen Magazine 30(5), 18–19 & 82.

Sauser, B.J., Reilly R.R. & Shenhar, A.J. (2009) Why projects fail? How contingency theory can provide new insights – A comparative analysis of NASA's Mars Climate Orbiter loss. International Journal of Project Management 27, 665–679.

Schmidt G. (1973). Das geistige Vermächtnis von Gustav von Bunge. Dissertation, Medizinische Fakultät, Universität Basel.

Schuphan, W. (1948). Gemüsebau auf ernährungswissenschaftlicher Grundlage: Ein Lehr- und Nachschlagewerk. H.A. Keune, Hamburg.

— (1958). Der Oxalsäuregehalt des Spinates (*Spinacia oleracea* L.) als Maβstab für seinen Wert als Nahrungsmittel. Qualitas Plantarum et Materiae Vegetabiles 5(1–2), 1–22.

— (1965). Der Nitratgehalt von Spinat (Spinacia oleracea L.) in Beziehung zur Methämoglobinämie der Säuglinge. Zeitschrift für Ernährungswissenschaft 5(3–4), 207–209.

Schuphan, W. & Harnisch S. (1965). Über die Ursache einer Anreicherung von Spinat (Spinacia oleraeea L.) mit Nitrat und Nitrit in Beziehung zur Methämoglobinämie bei Ratten. Zeitschrift für Kinderheilkunde 93, 142–147.

Schuphan, W. & Schlottmann, H. (1965). N-Überdüngung als Ursache hoher Nitrat- und Nitritgehalte des Spinats (Spinacia oleracea L.) in ihrer Beziehung zur Säuglings-Methämoglobinämie (Untersuchungen an frischem, transportiertem, gelagertem und tiefgefrorenem Spinat). Zeitschrift für Lebensmittel-Untersuchung und Forschung 128(2), 71–75.

Schwarcz, J. (2015). Monkeys, Myths and Molecules. Separating fact from fiction, and the Science of Everyday. ECW Press.

Schwedt, G. (1998). Goethe als Chemiker. Springer, Berlin; Heidelberg; New York; Barcelona; Budapest; Hongkong; London; Mailand; Paris; Singapur; Tokio.

Schwietzer C.H. (1959/1960). Der eisenreiche Spinat… ? Medizin und Ernährung 1, 130–131.

Scott, J.M.D. (1923). Studies in Anaemia. I: The Influence of Diet on the Occurrence of Secondary Anaemia following repeated Haemorrhages in Rats. Biochemical Journal 17(2), 157–165.

Segar, E.C. (1919). The Thimble Theatre – "Over the Cliff". The Washington Times 23rd December p. 12.

Serger, H. (1906). Über den Eisengehalt des Spinats. Pharmazeutische Zeitung 51(33), 372.

Sherman, H.C. (1907). Iron in Food and Its Functions in Nutrition. Office of Experimental Stations Bulletin. May 25 1907, 185, 56.

— (1912). Chemistry of Food and Nutrition. The Macmillan Company, New York.

Sinios, A., Wodsak, W. (1965). Die Spinatvergiftung des Säuglings. Deutsche Medizinische Wochenschrift 90(42), 1856–1863.

Skrabec, Q.R. Jr. (2013). The green vision of Henry Ford and George Washington Carver. Two collaborators in the cause of clean industry. McFarland & Company Inc., Jefferson North Carolina London.

Smith, E.L. (1987). Eating for Health and Happiness. Keats Publishing, New Canaan, Connecticut.

Smith, J. (1968). Sometimes to err is Humor. Utica Observer-Dispatch 44(24), 24th May, p. 1.

Snell, K. & Moleschott (1842). Philosophische Beschouwingen der Natuur. H. Palier et Zoon, Te's Hertogenbosch.

Soskin, W. (1929). The funny pictures of the New Yorker and the Dangerous Life one lives with books. New York Evening Post 21st October 1929 p. 15.

Stahr, K., Fellmeth, U., Blume, H.-P. (2015). Emil Theodor von Wolff (1813–1896). Ein Pionier der Agrikulturchemie. In: Persönlichkeiten der Bodenkunde V. Beiträge zum 350. Jubiläum der Christian-Albrechts-Universität zu Kiel (Eds.: Hans-Peter Blume & Rainer Horn). Schriftenreihe des Instituts für Pflanzenernährung und Bodenkunde 103, 1–29.

Stockman, R. (1895). On the amount of iron in ordinary dietaries and in some articles of food. The Journal of Physiology 18(5–6), 484–489.

Strauss, H. (1909). Vorlesungen über Diätbehandlung innerer Krankheiten. 2. Vermehrte und verbesserte Auflage. Verlag von S. Karger, Berlin.

Sutton, M. (2010a). Spinach, Iron and Popeye: Ironic lessons from biochemistry and history on the importance of healthy eating, healthy scepticism and adequate citation. Internet Journal of Criminology, 1–34.

— (2010b). The Spinach, Popeye, Iron, Decimal Error Myth is Finally Busted. https://www.bestthinking.com/articles/science/chemistry/biochemistry/the-spinach-popeye-iron-decimal-error-myth-is-finally-busted

— (2016). How the spinach, Popeye and iron decimal point error myth was finally bust. HealthWatch Newsletter 2016; 101, 7

Terrell T. (2007). Straight Dope: http://boards.straightdope.com/sdmb/archive/index.php/t-373244.html

Teague, M. (1981). Mrs. L.: conversations with Alice Roosevelt Longworth. Doubleday, Garden City.

Teichmann, H. (1979). Alice. The life and times of Alice Roosevelt Longworth. Prentice-Hall Inc., Englewood Cliffs N.J.

Thachil, J. (2007). Carrots for the eyes, Spinach for the muscles. BMJ 335, 1288.

Thissen, S. (1995). Images of Light and Shadow: Spinozism bursts forth into Dutch cultural life (1854–1872) – Spinozism as an 'extra-cultural' phenomenon. In: Disguised and Overt Spinozism around 1700. Papers presented at the International colloquium, held at Rotterdam 5–8th October 1994 (Ed. Wiep van Bunge & E.J. Brill). Brill's studies in intellectual history. E.J. Brill, Leiden New York Köln.

Thoms, H. (Editor) (1929). Handbuch der praktischen und wissenschaftlichen Pharmazie. Band VI, Zweite Hälfte, 2. Teil. Arzeimittel: Sanitas antiseptic lozenges – Zymphen. Urban & Schwarzenberg, Berlin Wien.

Tibbles, W. (1912). Foods – Their Origin, Composition and manufacture. Bailli`ere, Tindall and Cox, London.

Tiedemann, F., Moleschott, J. (1850). Die Physiologie der Nahrungsmittel. Ein Handbuch der Diätetik. Verlag Carl Wilhelm Leske, Darmstadt.

Toepke, G. (1904). Die Matrikel der Universität Heidelberg (5. Teil): Von 1807 – 1846. Heidelberg.

Trauner, D. (2015). Richard Willstädter und der Chemienobelpreis des Jahres 1915. Angewandte Chemie 127, 12078–12085.

Truman, M. (2007). The President's house – 1800 to the present. The secrets and history of the world's most famous house. Ballantine Books; Reprint edition – Special Young Adult Edition.

Truss, I. (2004). Eats, Shoots & Leaves. Thorndike Press, Waterville, Maine.

Twain, M. (1871). Memoranda. Galaxy 11, 159.

Ule, O. (1855). Die Chemie der Küche. 11. Der bürgerliche Tisch. Zweiter Artikel. Die Natur 4(50), 401–406.

— (1876). Die Chemie der Küche. Dritte, verbesserte Auflage. G. Schwetschke' scher Verlag, Halle.

Ury, E. (1913). Nesthäkchen und ihre Puppen. Reprinted in: Nesthäkchen Gesamtausgabe, Erster Band. (2016), Ed. Karl-Maria Guth. Verlag der Contumax GmbH & Co. KG, Berlin.

— (1925). Nesthäkchen im weißen Haar. Reprinted in: Nesthäkchen Gesamtausgabe, Zweiter Band. (2016), Ed. Karl-Maria Guth. Verlag der Contumax GmbH & Co. KG, Berlin.

Vierordt, H. (1906) Anatomische Physiologische und Physikalische Daten und Tabellen zum gebrauche fuer Mediziner. Verlag von Gustav Fischer, Jena.

Wallerstein, R.O, Mettier, S.R. (Eds.) (1958). Iron in Clinical Medicine. University of California Press, Berkeley and Los Angeles.

Wankmüller, A. (Ed.) (1980/1982). Studenten der Pharmazie und Chemie and der Universität Gießen von 1800–1852. In: Beiträge zur Württembergischen Apothekergeschichte. Band VIII. Buchdruckerei Chr. Gulde, Tübingen. p. 121–128.

Watts H. et al. (1868). A dictionary of chemistry and the allied branches of other sciences. Vol. 5. Quadrantoxide—Zymurgy. Longmans, Green & Co., London.

Wegele, C. (1911). Die Therapie der Magen- und Darmerkrankungen. G. Fischer Verlag, Jena.

West, J.B. (2015). Essays on the History of Respiratory Physiology. Springer, New York Heidelberg Dordrecht London.

Willstädter, R., Stoll, A. (1913). Untersuchungen über Chlorophyll. Methoden und Ergebnisse. Verlag von Julius Springer, Berlin.

Windeler, R. (1978). The films of Shirley Temple. Citadel Press, Secaucus, N.J.

Winkler, W. (2010). Mythen der Wissenschaft – Die große Spinat-Verschwörung. Süddeutsche Zeitung Online, 8th August, http://www.sueddeutsche.de/wissen/mythen-in-der-wissenschaft-die-grosse-spinat-verschwoerung-1.985098

Wolff, E. T. von (1851). Die naturgesetzlichen Grundlagen des Ackerbaus. Band 1 u. 2. Wiegand, Leipzig.

— (1858). Die Mineralstöffler und die Stickstöffler in der Landwirthschaft: nebst einer Beleuchtung der neusten chemischen Briefe des Freiherrn Justus von Liebig. J.G. Cotta'scher Verlag, Stuttgart.

— (1865). Die mittlere Zusammensetzung der Asche aller land- und forstwirthschaftlich wichtigen Stoffe. Nebst Nachweisung der Quellen und erläuternden Bemerkungen. Ein Hilfsmittel für die Statik der Forst- und Landwirthschaft. H. Lindemann, Stuttgart.

— (1871). Aschen-Analysen von landwirthschaftlichen Producten, Fabrik-Abfällen und wildwachsenden Pflanzen. Wiegandt & Hempel, Berlin.

— (1880). Aschen-Analysen von land- und forstwirthschaftlichen Producten, Fabrik-Abfällen und wildwachsenden Pflanzen. Zweiter Theil. Untersuchungen aus den Jahren 1870–1880. Verlag von Wiegandt, Hempel & Parey, Berlin.

Wolke, R.L. (2005). What Einstein Kept Under His Hat: Secrets of Science in the Kitchen. W.W. Norton & Company Inc., New York.

Wyman, J., Gill, S.J. (1990). Binding and Linkage: Functional Chemistry of Biological Macromolecules. University Science Books, Mill Valley (California).

Zacharias, R. (1960). Der eisenreiche Spinat…? Zeitschrift für Lebensmittel-Untersuchung und Forschung 113, 439–440.

Ziemann, M., Eren, Y., El-Osta, A. (2016). Gene name errors are widespread in the scientific literature. Genome Biology 17, 177.

Zinoffsky N. (1886). Ueber die Grösse des Hämoglobinmolecüls. Zeitschrift für physiologische Chemie 10:16–34.

Appendix 1: List of early newspaper articles that cited spinach is especially rich in iron:

Anonymous (1895a). Notes. Nature 52(1344), 325–327.

Anonymous (1895b). The therapeutic value of Iron. Modern Medicine and Bacteriological Review 4(6), 150–152.

Anonymous (1895c). Iron in Food. Geelong Advertiser (Victoria, Australia) 16th November p. 1.

Anonymous (1895d). Iron as Food. Australian Town and Country Journal (Sydney, NSW, Australia) 28th December p. 26.

Anonymous (1895e). The Best Way to Eat Iron. The Australasian (Melbourne, Victoria, Australia) 28th September p. 25.

Anonymous (1895f). Scientific & Useful. The Capricornian (Rockhampton, Queensland, Australia) 9th November p. 4–5

Anonymous (1895g). – Morning Bulletin (Rockhampton, Queensland, Australia) 9th November page 6

Anonymous (1895h). Notes – Mainly Personal. Dundee Evening Telegraph (Scotland, UK) 12th August 1895 page 2

Anonymous (1895i). Science Notes. Pall Mall Gazette 30th September page 1

Anonymous (1895j). Interesting and Entertaining. Exeter and Plymouth Gazette (Exeter and Plymouth, UK) 25th October page 8

Anonymous (1895k). Throw Physic to the dogs. Sunderland Daily Echo and Shipping Gazette (Sunderland, UK) 13th August page 3

Anonymous (1895l). Iron in Food. Lincolnshire Chronicle (Lincolnshire, UK) 13th August page 3

Anonymous (1895m). Iron in Food. The Yorkshire Herald (York, UK) 30th November page 12

Anonymous (1895n). Throw Physic to the dogs. The Northern Daily Mail and South Durham Herald (Hartlepool, UK) 13st August page 1

Anonymous (1895o). Iron in Food. The Manchester Weekly Times (Manchester, UK) 8th November page 7

Anonymous (1895p). Chips. North-Eastern Daily Gazette (Middlesborough, UK) 2nd October page 4

Anonymous (1895q). Iron in Food. Lincolnshire Chronicle (Lincolnshire, UK) 16th August page 3

Anonymous (1895r). Iron in Food Substances. The Whitstable Times and Herne Bay Herald (Kent, England) 24th August page 6

Anonymous (1895s). Iron in Food Substances. The Leeds Times (Leeds, UK) 24th August page 6

Anonymous (1895t). Important facts. The Nottingham Evening Post (Nottinghamshire, UK) 10th August page 2

Anonymous (1895u). – Portsmouth Evening News (Portsmouth, UK) 29th August page 2

Anonymous (1895v). – Dundee Courier (Dundee, UK) 7th August page 3

Anonymous (1895w). Iron in Foods. Northern Daily Mail (Hartlepool, UK) 19th October page 3

Anonymous (1895x). – Luton Times and Advertiser (Luton, UK) 9th August page 6

Anonymous (1895y). Iron in Food Substances. Derbyshire Courier (Derbyshire, UK) 24th August page 6

Anonymous (1895z). News Items from our latest exchanges. The Colonist (Nelson, New Zealand) 7th December page 4

Anonymous (1895aa). The best Way to eat iron. New Zealand Herald (Auckland, New Zealand) 12th October page 1

Anonymous (1895ab). News Items from our latest exchanges. The Colonist (Nelson, New Zealand) 18th October page 4

Anonymous (1895ac). Items. Oamuru Mail (Otago, New Zealand) 7th December page 4

Anonymous (1895ad). Iron in food. Spinach contains more of it than eggs or beef. The Virginia Enterprise (St. Louis County, Minnesota, USA) 29th November page 3

Anonymous (1895ae). Iron and Food. Spinach Contains More of It Than Eggs or Beef. Evening Star (Washington, D.C., USA) 12th November page 2

Anonymous (1895af). Iron in Food. Spinach Contains More of It Than Eggs or Beef. Highland Recorder (Monterey, Virginia, USA) 27th December page 3

Anonymous (1895ag). Iron in Food. Spinach Contains More of it Than Eggs or Beef. Dakota Farmers' leader (Canton, South Dakota, USA) 24th January page 6

Anonymous (1895ah). – The Ottawa Journal (Ottawa, Canada) 24th August page 6

Anonymous (1895ai). Vorurtheile ueber den Eisengehalt der Nahrungsmittel. Der Fortschritt (New Ulm, Minnesota, USA) 26th September page 10

Anonymous (1895aj). Iron in Food. Scientific American 73(11):171

Anonymous (1895ak). Iron in Food Substances. St Andrews Citizen (Fife, Scotland) 2nd November page 2

Anonymous (1895al). Iron in Food. The Yorkshire Herald (North Yorkshire, England) 30th November page 12

Anonymous (1895am). General News. St. Andrews Citizen (Fife, Scotland) 17th August page 3

Anonymous (1895an). Iron in Food. The Youth's Instructor 43(42):336

Anonymous (1895ao). Iron in Food. The Ohio Chronicle 28(5):4

Anonymous (1895ap). The best way to eat iron. Patea Mail 8(123) 24th October 1895 page 2

Anonymous (1895aq). Iron in Food. Spinach Contains More of It than Eggs or Beef. Estherville Daily News (Estherville, Iowa, USA) 12th December page 15

Anonymous (1895ar). Scientific Miscellany. The Hickory Press (Hickory, North Carolina, USA) 29th August page 6

Anonymous (1895as). Iron in Food. The Chatham Record (Pittsboro, North Carolina, USA) 19th December page 1

Anonymous (1895at). Iron in Food. Cassville Republican (Cassville, Missouri, USA) 19th September page 1

Anonymous (1895au). Trans-Atlantic Topics. The Nebraska State Journal (Lincoln, Nebraska, USA), 15th Sept page 9

Anonymous (1895av). Iron in Food. The Abbeville Press and Banner (Abbeville, South Carolina, USA), 11th December page 1

Anonymous (1895aw). Iron in Food. Punxsutawney News (Punxsutawney, Pennsylvania, USA), 18th December 1896, p. 3.

Anonymous (1895ax). --. Democrat and Chronicle (Rocherster, New York, USA), 21st August 1895, p. 3.

Anonymous (1895ay). Iron in Food. Spinach contains more of the substance than either eggs or beef. The Buffalo Commercial (Buffalo, New York, USA), 14th November 1895, p. 4.

Anonymous (1895az). Iron and Food. Alton Evening Telegraph (Alton, Illinois, USA), 14th December 1895, p. 3.

Anonymous (1895ba). --. Cork Constitution (Cork, Ireland), 2nd October 1895, p. 5.

Anonymous (1895bb). --. Cork Constitution (Cork, Ireland), 12nd August 1895, p. 5.

Anonymous (1895bc). --. Cardiff Times (Cardiff, Wales), 10th August 1895, p. 1.

Anonymous (1895bd). --. Pontypool Free Press (Gwent, Wales), 27th September 1895, p. 7.

Anonymous (1895be). --. Shepton Mallet Journal (Shepton, Somerset, UK), 16th August 1895, p. 8.

Anonymous (1895bf). --. Worcester Journal (Worcester, Worcestershire, UK), 10th August 1895, p. 6.

Anonymous (1895bg). --. Bridgnorth Journal and South Shropshire Advertiser (Bridgnorth, UK), 28th September 1895, p. 6.

Anonymous (1896a). Iron in Food. Warwick Argus (Queensland, Australia) 19th December page 6

Anonymous (1896b). Iron as Food and Medicine. Northern Star (Lismore, NSW, Australia) 11th April page 6

Anonymous (1896c). The best way to take iron. The Wells Journal – Somerset and West of England Advertiser (Somerset, England) 18th June page 3

Anonymous (1896d). Facts of Science. The Lichfield Mercury (Staffordshire, UK) 3rd July page 6

Anonymous (1896e). Science Notes. Otago Witness (Dunedin, New Zealand) 16th January page 48

Anonymous (1896f). Household helps. The Scranton Tribune (Scranton, Pennsylvania, USA) 11th July page 11

Anonymous (1896g). Iron in Food. Spinach Contains More of It than Eggs or Beef. Juniata Sentinel and Republican (Juniata County, Pennsylvania, USA) 26th February page 1

Anonymous (1896h). Iron in Food. Spinach Contains More of it Than Eggs or Beef. Dakota Farmers' leader (Canton, South Dakota, USA) 24th January page 6

Anonymous (1896i). Ueber den Spinat. Altonaer Nachrichten (Hamburg, Germany) 5th March p. 2.

Anonymous (1896j). Iron in Food. Spinach Contains More of it Than Eggs or Beef. Blount County News-Dispatch (Blountsville, Alabama, USA), 6th February 1896, p. 4.

Anonymous (1896k). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Eutaw Whig and Observer (Eutaw, Alabama, USA), 30th January 1896, p. 4.

Anonymous (1896l). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Vernon Courier (Vernon, Alabama, USA), 20th February 1896, p. 3.

Anonymous (1896m). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Citizen-Examiner (Hayneville, Alabama, USA), 30th January 1896, p. 4.

Anonymous (1896n). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Choctaw Alliance (Butler, Alabama, USA), 10th March 1896, p. 3.

Anonymous (1896o). Iron and Food. Our Southern Home (Livingston, Alabama, USA), 2nd January 1896, p. 1.

Anonymous (1896p). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Advocate and Democrat (Marysville, Kansas, USA), 14th February 1896, p. 6.

Anonymous (1896q). Iron and Food. The Democrat-Reporter (Linden, Alabama, USA), 23rd April 1896, p. 1.

Anonymous (1896r). Iron in Food. The Coosa River News (Centre, Alabama, USA), 10th January 1896, p. 2.

Anonymous (1896s). Iron and Food. The Coosa River News (Centre, Alabama, USA), 3rd January 1896, p. 3.

Anonymous (1896t). Iron in Food. Spinach Contains More of it Than Eggs or Beef. Estherville Daily News (Estherville, Iowa, USA), 27th February 1896, p. 2.

Anonymous (1896u). Iron as a Medicine. The Marshall Messenger (Marshall, Texas, USA), 26th June 1896, p. 8.

Anonymous (1896v). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Daily Tribune (Wisconsin Rapids, Wisconsin, USA), 25th January 1896, p. 3.

Anonymous (1896w). Supplying salt and iron. Fort Worth Daily Gazette (Fort Worth, Texas, USA), 1st March 1896, p. 11.

Anonymous (1896x). Iron in Food. Spinach Contains More of it Than Eggs or Beef. The Chilliwack Progress (Chilliwack, British Columbia, Canada), 22nd January 1896, p. 4.

Anonymous (1897a). Iron in vegetable Food. The Literary Digest 14(17):524–525

Anonymous (1897b). Iron in Food. Petersburg Times (SA, Australia) 24th December page 7

Anonymous (1897c). The best way to take iron. The Clutha Leader (Balcutha, New Zealand) 28th May page 3

Anonymous (1898a). Iron in Food. The Muswellbrook Chronicle (NSW, Australia) 9th July page 3

Anonymous (1898b). Iron in Food. The Murrurundi Times and Liverpool Plains Gazette (NSW, Australia) 9th July page 6

Anonymous (1898c). Iron in Food. Queanbeyan Age (NSW, Australia) 6th August page 3

Anonymous (1898d). Iron in Food. The Braidwood Dispatch and Mining Journal (NSW, Australia) 2nd July page 2S

Anonymous (1898e). Interesting Items. Clarence and Richmond Examiner (Grafton, NSW, Australia) 16th July page 7

Anonymous (1898f). Virtues of Spinach. Dundee Evening Telegraph (Scotland, UK) 15th August page 4

Anonymous (1898g). Nature's Iron Tonics. Hampshire Telegraph (Hampshire, UK) 1st January page 12

Anonymous (1898h). Spinach. Manchester Weekly Times (Greater Manchester, UK) 12th August page 7

Anonymous (1898i). Iron in Food. Lake Wakatip Mail (Otago, New Zealand) 4th November page 5

Anonymous (1898j). Horticulture – Vegetables as Medicine. The Progressive Farmer (Winston, North Carolina, USA) 4th October page 1

Anonymous (1898k). About the House. The Neihart Herald (Neihart, Montana, USA) 19th November page 2

Anonymous (1898l). Health Hints. The Chronicle (Mount Vernon, N.Y.) 4th February p. 7

Anonymous (1898m). Eine Gemüseplauderei. Deutsche Correspondent (Baltimore, Maryland, USA). 17.April.1898, p. 2.

Anonymous (1898n). Virtues of Spinach. The Sun (Chanute, Kansas, USA), 18th December 1898, p. 2.

Anonymous (1898o). Virtues of Spinach. Argus-Leader (Sioux-Falls, South Dakota, USA), 10th November 1898, p. 7.

Anonymous (1898p). Virtues of Spinach. The Los Angeles Times (Los Angeles, California, USA), 21st October 1898, p. 12.

Anonymous (1899a). Nature's Iron Tonics. The Coburg Leader (Victoria, Australia) 4th February page 3

Anonymous (1899b). Science Notes. The Sydney Mail and New South Wales Advertiser (NSW, Australia) 2nd September page 569

Anonymous (1899c). Value of Spinach. Falkirk Herald (Stirlingshire, Scotland) 29th November page 2

Anonymous (1899d). Virtues of Spinach and Onions. Dundee Evening Telegraph (Angus, Scotland) 3rd January page 4

Anonymous (1899e). Gossip on Men and Things. Hampshire Advertiser (Hampshire, England) 2nd December page 2

Anonymous (1899f). Value of Spinach. Kent & Sussex Courier (Kent, England) 29th November page 3

Anonymous (1899g). Nature's Iron Tonics. The Bruce Herald (Milton, New Zealand) 17th March page 3

Anonymous (1899h). Now, the Spinach fad. Kansas City Journal (Jackson, Missouri, USA) 19th February page 5

Anonymous (1899i). A healthful fad. Spinach is now called the most precious vegetable. Evening Star (Washington, D.C., USA) 12th April page 13

Anonymous (1899j). Spinach in Spring – Physicians and Chemists Recommend It for "That Tired Feeling". Kansas City Journal (Kansas City, Missouri, USA) 20th March page 7

Anonymous (1899k). Girls, Remember This. The Houston Daily Post (Houston, Texas, USA) 30th March page 3

Anonymous (1899l). Uses of Spinach. Homely Vegetable has wonderful Medicinal Properties. The Saint Paul Globe (St. Paul, Minnesota, USA) 15th April page 8

Anonymous (1899m). Eat spinach. Launceston Examiner (Tasmania, Australia) 1st April page 3

Anonymous (1899n). Virtues of Spinach. The homely vegetable is said to possess wonderful Medicinal Properties. The Columbian (Bloomsburg, Pennsylvania, USA) 27th April page 8

Anonymous (1899o). Eat spinach. The Wisconsin horticulturist. 4(4):8 (June 1899)

Anonymous (1899p). Food better than Tonics. Los Angeles Herald 320 25th August 1899

Anonymous (1899q). Why one should eat spinach. The Week (Brisbane, Qld., Australia) 2nd June p. 5

Anonymous (1899r). Virtues of Spinach. Geneva Daily Times (Geneva, N.Y., USA) 9th May p. 7

Anonymous (1899s). Nature's own Tonic. Geneva Daily Times (Geneva, N.Y., USA) 10th October p. 8

Anonymous (1899t). Spinach for Spring. The Daily Leader (Gloversville, N.Y., USA) 26th May p. 3

Anonymous (1899u). Nature's own Tonic. The Northern Tribune (Gouverneur, N.Y., USA) 25th October p. 3

Anonymous (1899v). Health Hints. The Daily Palladium (Oswego, N.Y., USA) 16th March p. 7

Anonymous (1899w). Eat Spinach in the Spring. Geneva Daily Gazette (Geneva, N.Y., USA) 31st March p. 4.

Anonymous (1899x). Spinach for Spring. An Excellent Substitute for Medicine When One is Not Quite Well. Wyoming Democrat (Tunkhannock, Pennsylvania, USA). 28.April.1899, p. 1.

Anonymous (1899y). To be healthy, eat spinach. Specialists have discovered that the plant is unusually wholesome. The Daily Herald (Delphos, Ohio, USA). 10.July.1899, p. 6.

Anonymous (1899z). Virtues of Spinach. The homely vegetable is said to possess wonderful medicinal properties. Reno Gazette-Journal (Reno, Nevada, USA), 5.Sept.1899, p. 2.

Anonymous (1899aa). -- . The Seattle Star (Seattle, Washington, USA), 29.May.1899, p. 2.

Anonymous (1899ab). Virtues of Spinach. The Daily Republican (Monongahela, Pennsylvania, USA) 18th January 1899, p. 2.

Anonymous (1899ac). Virtues of Spinach. Poughkeepsie Eagle-News (Poughkeepsie, New York, USA), 22nd March 1899, p. 7.

Anonymous (1900a). Virtues of Spinach. The Mountaineer (Katoomba, NSW, Australia) 9th February page 3

Anonymous (1900b). Virtues of Spinach. The Wingham Chronicle and Manning River Observer (Wingham, NSW, Australia) 3rd February page 4

Anonymous (1900c). Iron in Food. Taranaki Herald (Taranaki, New Zealand) 13th January page 3

Anonymous (1900d). Eat spinach. The Pacific Commercial Advertiser (Honolulu, Hawaii, USA) 20th April 1900 page 4

Anonymous (1900e). Eat spinach. The Pacific Commercial Advertiser (Honolulu, Hawaii, USA) 20th April 1900 page 4

Anonymous (1900f). Virtues of spinach. The Dubbo Liberal and Macquarie Advocate (NSW, Australia), 3rd Feb 1900

Anonymous (1900g). Farm Notes. West Gippsland Gazette (Warragul, Vic, Australia) 9th January p. 4

Anonymous (1900h). Are good medicines. Watertown Re-Union (Watertown, N.Y., USA) 25th April p. 7

Anonymous (1900i). Spring Diet. The Brooklyn Daily Eagle (Brooklyn, N.Y., USA) 2nd June p. 13

Anonymous (1901a). Nature's Iron Tonics. The Muswellbrook Chronicle (NSW, Australia) 16th February page 5

Anonymous (1901b). Nature's Iron Tonics. Riverina Recorder (Balranald, Moulamein, NSW, Australia) 20th February page 2

Anonymous (1901c). Natures Iron Tonics. The Braidwood Dispatch and Mining Journal (NSW, Australia) 16th February page 2

Anonymous (1901d). Virtues of Spinach. Sandy Creek News (Sandy Creek, N.Y., USA) 6th June p. 2

Anonymous (1901e). How to make puree of Spinach. The Coeymans Herald (Coeyman, N.Y., USA), 19th June p. 1

Anonymous (1901f). Domestic hints. The Sun (Fort Covington, N.Y., USA) 9th May p. 2.

Anonymous (1901g).

Anonymous (1902a). Spinach for the Complexion. Sunday Times (Sydney, NSW, Australia) 3rd August page 6S

Anonymous (1902b). Natures Iron Tonics. Balmain Observer and Western Suburbs Advertiser (NSW, Australia) 25th January page 7

Anonymous (1903a). Medical and Sanitary. Geelong Advertiser (Victoria Australia) 13th June page 4

Anonymous (1903b). Sunday Times (Perth, WA, Australia) 24 May p. 6

Anonymous (1903c). Why you should eat Spinach. The Sacred Heart Review (Boston, Massachusetts, USA) 14th February p. 15

Anonymous (1904a). --- Yates County Chronicle (Penn Yan, N.Y., USA) 4th May p. 6

Anonymous (1904b). A few useful hints. Geneva Advertizer-Gazette (Geneva, N.Y., USA) 26th April p. 4

Anonymous (1904c). --- Yates County Chronicle (Penn Yan, N.Y., USA) 15th June p. 6

Anonymous (1904d). A few useful hints. Geneva Advertizer-Gazette (Geneva, N.Y., USA) 31st May p. 4

Anonymous a.k.a. Maureen (1905a). Why you should Eat Spinach. New Zealand Tablet (Dunedin New Zealand) 21st December page 37.

Anonymous (1905b). The virtues of Spinach. Alton Evening Telegraph (Alton, Illinois, USA), 14th January 1899, p. 12.

Anonymous (1906a). The Virtues of Spinach. Darling Downs Gazette (Darling, NSW, Australia) 1st October page 7

Anonymous (1906b). The Virtues of Spinach. Maryborough Chronicle, Wide Bay and Burnett Advertiser (Queensland, Australia) 20th October page 7

Anonymous (1906c). The values of spinach. The Express and Telegraph (Adelaide, SA, Australia) 15th September page 6

Anonymous (1906d). Kalgoorlie Miner (WA, Australia) 25th August p. 8

Anonymous (1906e). The Evening Star (Boulder, WA, Australia) 10th September p. 1

Anonymous (1907a). Health and Diet. The Western Champion and General Advertiser for the Central-Western Districts (Barcaldine, Queensland, Australia) 27th April page 15

Anonymous (1907b). Health and Diet. The Gosford Times and Wyong District Advocate (NSW, Australia) 19th April page 4

Anonymous (1907c). Health and Diet. Manilla Express (NSW, Australia) 6th April page 7

Anonymous (1907d). Health and Diet. The Wingham Chronicle and Manning River Observer (NSW, Australia) 20th April page 9

Anonymous (1907e). Health and Diet. Liverpool Herald (NSW, Australia) 6th April p. 10

Anonymous (1907f). Health and Diet. The Burrowa News (NSW, Australia) 5th April p. 1

Anonymous (1907g). – St. Tammany farmer (Covington, Louisiana, USA) 30th March page 6

Anonymous (1907h). – Macon Beacon (Macon, Mississippi, USA) 16th March page 4

Anonymous (1907i). Health and Diet. Narandera Argus and Riverina Advertiser (NSW, Australia), 19th April p. 7

Anonymous (1907j). The values of spinach. Barrier Miner (Broken Hill, NSW, Australia), 19th Jan p. 6

Anonymous (1907k). Health and diet. Liverpool Herald (NSW, Australia) 6th April p. 10

Anonymous (1907l). Health and diet. The Dubbo Liberal and Macquarie Advocate (NSW, Australia) 6th April p. 7

Anonymous (1907m). Health and diet. The Western Champion and General Advertiser for the Central-Western Districts (Barcaldine, Qld., Australia) 27th April p. 15

Anonymous (1907n). Foods containing iron. The Catholic Journal (Rochster, N.Y., USA) 19th April p. 6

Anonymous (1908a). Useful vegetables. The Northern Miner (Charters Town, Queensland, Australia) 14th August page 3

Anonymous (1908b). Virtues of Spinach. The Beds. Advertiser and Luton Times (Bedfordshire, UK) 20th November page 3

Anonymous (1908c). Useful vegetables. Gympie Times and Mary River Mining Gazette (Queensland, Australia) 11th July page 6

Anonymous (1908d). Useful vegetable. Auckland Star (Auckland, New Zealand) 26th September page 1

Anonymous (1908e). How nature provides. The Durango Wage Earner (Durango, Co, USA). Page 4

Anonymous (1909a). Household notes. The Pacific Commercial Advertiser (Honolulu, Hawaii, USA) 11th July page 13

Anonymous (1910a). Talk about nerves. The Port Jefferson Echo (Port Jefferson Long Island, N.Y., USA) 2nd April p. 3

Anonymous (1910b). Talk about nerves. The Corrector (Sag-Harbor, N.Y., USA) 9th April p. 3

Anonymous (1910c). Vegetable Foods. The Ogdensburg Journal (Ogdensbrg, N.Y., USA) 24th June p. 4

Anonymous (1910d). Vegetable Foods. The Madrid Herald (Madrid, N.Y., USA) 23rd June p. 4

Anonymous (1912a). Importance of Iron in Blood. The Ogdensburg Journal (Ogdensburg, N.Y., USA) 31st July p. 4

Rhan-Steglitz, C. (1913). Das Eisen in der Ernährung der Tiere. Praktische Mitteilungen – Beilage zum Pusterthaler Bote 29:1–2

Anonymous (1915a). Do you know the value of foods? The Post-Star (Glens Falls, N.Y., USA) 1st June p. 7

Anonymous (1916a). Foods for Children. South New Berlin Bee (South New Berlin (Chenanogo County) ,N.Y., USA) 19th August p. 7

Anonymous (1917a). Lesson Talks and Answers to queries. The Evening World. (New York, N.Y., USA) 12th March p. 15

Anonymous (1917b). The garden a medicine chest. Commercial Advertiser (Potsdam Junction, N.Y., USA) 31st July p. 2

Anonymous (1917c). The garden a medicine chest. South Side Signal (Babylon, N.Y., USA) 13th July p. 3

Anonymous (1917d). The garden a medicine chest. Commercial Ad-vertiser (Potsdam Junction, N.Y., USA) 4th Sept p. 6

Anonymous (1917e). Nourishing vegetables. The Evening World (New York, N.Y., USA) 4th June p. 15

Anonymous (1917f). The garden a medicine chest. The Suffolk County News (Sayville, N.Y., USA) 7th Sept p. 2

Anonymous (1917g). The garden a medicine chest. Penn Yann Express (Penn Yan, N.Y., USA) 10th October p. 4

Anonymous (1919a). Man's System Demands Iron. The Evening World (New York, N.Y., USA), 5th November p. 26

Peterson, F. (1919b). Child Health Alphabet. The Evening World (New York, N.Y., USA) 11th February p. 21

Anonymous (1921). Health value of fruits and vegetables. Le Meschacébé (Lucy, Louisiana, USA) 16th p. 6

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