Palmieri's diagometer. A scientific instrument useful to detect adulteration in olive oil

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Abstract: "Il nuovo diagometro per gli oli e pe' tessuti" is a paper, written by Professor Luigi Palmieri, presented at the Reale Accademia delle Scienze Fisiche e Matematiche di Napoli in 1870. The described instrument aimed to test the quality of the olive oils. About 40 years earlier a certain Rousseau invented a similar instrument, considered by Palmieri to be imprecise and therefore of little use.
The "new" diagometer was instead provided with a bifilar electrometer to measure the electrical conductivity of oils. That allowed to classify the purity of the product and also to pinpoint any potential adulteration.
The Ministry of Agriculture and Industry commissioned the District Agricultural Commission to test Palmieri's instrument during the first Terni oil fair.
The Naples Chamber of Commerce decided to print out an operating manual of the diagometer, in order to make it suitable for olive oil trade.
Part of the instrument is exposed at the Museum of Physics of the University of Naples "Federico II".

Keywords: Luigi Palmieri, Diagometer, Bifilar electrometer, Olive oil adulteration.

1. Introduction

The Museum of Physics of the University of Naples Federico II has a collection of scientific instruments, dating back to the 19th century, designed and made by Luigi Palmieri, professor of Earth Physics and Meteorology at Naples University and director of the Vesuvian Observatory.

One of these instrument is a bifilar electrometer, mainly used to study atmospheric electricity, which presents on its wooden base the engraving: "*Diagometro Palmieri n. 30, 1872*". Since the instrument is an electrometer, what does the writing "diagometro" on it stand for? The presence of such engraving has led us to assume that the electrometer could be part of a more complex instrument. This hypothesis represents the starting point for the following study which aims to analyse the features and functioning of the abovementioned tool.

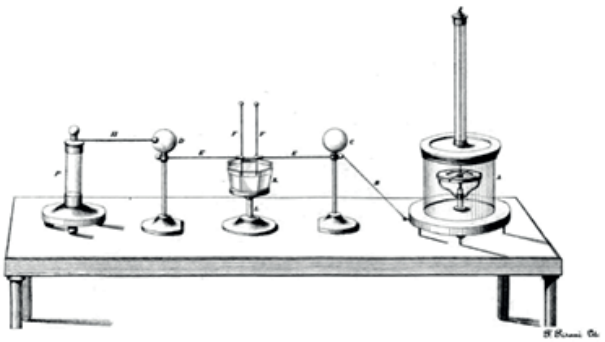

Fig.1. "New diagometer" (1870) by professor Luigi Palmieri, from Palmieri (1871a).

2. Unusual application of the bifilar electrometer

On November 12 1870, at the Royal Academy of Physical and Mathematical Sciences of Naples, Palmieri (1871a, pp.1-11) presented an interesting instrument that he called "nuovo diagometro", designed to test the quality of olive oil through physical measurements.

The oil was poured into a glass vessel c, in which dip two brass rods FF', called "reofori" (conductors). The points of these rods were kept at the same distance apart during the measurement and also at the same distance below the surface. By means of two arms EE', the *reofori* were connected with two insulated balls, C and D, the former of which was connected with a dry pile P, and the latter with a Palmieri's electrometer (Fig. 1) (Riccio 1878, p. 185). An instrument called "diagometer" (Fig. 2) (Rousseau 1823, pp. 587-590) had been already presented by "un certo Rousseau" (Palmieri 1871b, p 13) in 1823 to the Société de Pharmacie de Paris.

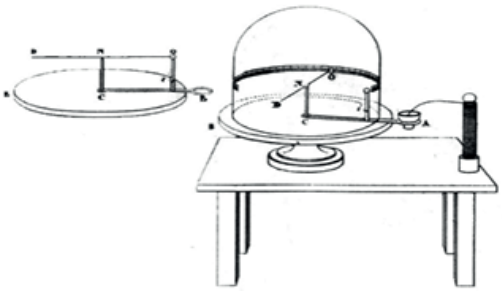

Fig.2. Rousseau's diagometer (1823), from Rousseau (1823).

It was designed to identify sophisticated olive oil through a scientific method. Therefore, Palmieri called his instrument "new diagometer". Some considered Palmieri's work a simple modification of Rousseau's diagometer. Palmieri disagreed on that because it consisted of an imperfect electroscope, incapable of measurements, while his instrument was equipped with a high precision electrometer (Palmieri 1871b, pp. 13-14), thanks to which he showed that the hypothesis and the method used by Rousseau were incorrect.

Rousseau's work was based on the great difference in electrical conductivity among various types of oils: low conductivity for pure olive oil, high conductivity, however, for seed oils.

The measurement system was based on the use of a dry pile, whose "force" (electromotive force) was known, an electric conductor and the oil to be examined between them. If it was pure olive oil, no movement of the electroscope needle was observed, while if the oil was mixed with seed oils, the needle had a quick deviation. The conductivity of the oil was measured by the size of the needle's movement on the circumference of the electroscope and by the time needed to reach the maximum deviation.

Palmieri considered this method inaccurate because at the beginning the needle moved quickly and then considerably slowed down towards the end of the arc. Palmieri therefore assumed that the time taken to measure the maximum deviation provided a false value of the oil conductivity, which was inversely proportional to the time period. The time must be measured within the needle displacement interval of maximum 10° or 12°. Examining different oils, it was possible to observe how the needle's movement was the same at different time, vice versa at the same time the arcs were different.

3. Analyses of the oils

Using the new diagometer, Palmieri studied the properties of olive and seeds oils, he thus found solutions to unsolved problems until then. For a whole year he conducted experiments and several tests on all vegetal oils. He proved that:

- seed oils had their own conductivity unless they were rancid or tainted.
- in olive oils the conductivity varied according to the pressing, the ripeness of the olives, their origin and the relationship between olein and margarine.
- in the oils the conductivity was, moreover, influenced by the temperature, therefore all the comparisons must be made under the same temperature conditions.

Performing tests at different temperature ranges, he observed that:

- All the oil heated up to 40° had an increment in conductivity, but if they were brought back to starting temperature they reacquired the original conductivity.
- The olive oils warmed up between 60° and 70° and then brought back to the initial temperature were "more insulating" while the seed oils were "more conductive".

- The olive oils warmed up to 100° and then cooled down were slightly more "conductive" while the seed oils became "more insulating".

Palmieri therefore assumed that his instrument could certainly be commercially useful to recognize the purity and the quality among olive oils. In particular virgin olive oil (pressing only the pulp) was the most insulating, so the best one. While the oil of the last pressing (olive waste) was more conductive, so the worst one. Generally seed oils presented a very different degree of conductivity from olive oils. An exception was the oil of hazelnuts and pine nuts. They had a conductivity comparable with the best olive oils and they would have been perfect for sophistication if the high cost hadn't made them too expensive.

He concluded that the best oil for the adulteration of olive oil was peanut oil, similar to olive oil in terms of flavour, smell and colour. The presence of peanut oil, however, was detected by the "new diagometer" with no mistakes; this oil, in fact, had a higher conductivity than pure olive oil.

According to Palmieri, studies on oil blends were complex. In fact, the conductivity of olive oil changed with the variation of some parameters such as: pressing, olives' quality and rancidity. In contrast, seed oils were not all good conductors of electricity.

In light of these considerations, Rousseau's work was wrong. Therefore, Palmieri suggested taking a sample of oil and heating it up to 100°. Once that it was cooled down, its conductivity was then compared to the same unheated oil. It was observed that cooked oil was less conductive than raw oil. After 5 or 6 days, if the heated oil was pure olive oil, it became more conductive, if instead it was mixed with seed oils it remained more insulating. With this method, Palmieri thought he found a valid method for solving the problem of oil adulteration.

4. Applications of the new diagometer

In 1871, the Ministry of Agriculture, Industry and Commerce designed a Directive Commission to carry out experiments with Palmieri's new diagometer, during the first Terni oil Fair, and to draft a specific report.

The engineer Emiliano Carnaroli and the student engineer Carlo Cianconi submitted to diagometric measurements all the olive oils present at the fair and classified them according to the categories declared by the producers. On the results obtained from the diagometer, the value 1000 was attributed to the most insulating oil, which was chosen as the standard, and all the others were then reclassified in reference to this value.

The new classification highlighted how in many cases the category declared by the producers did not correspond to reality.

The Commission, established a comparison between the diagometric data and the opinion expressed by some experts on the basis of the organoleptic properties of the oils. Also in this case the results obtained were very positive. Then they examined mixtures in which a few drops of seed oils (flax and sesame) did not alter the smell and the taste of a first-class oil while increasing its conductivity twice. This was admirably detected by the diagometer.

Amazed by these results, Carnaroli and Cianconi (1871, pp. 19-27) expressed full favorable opinion on the validity and reliability of the new diagometer, pointing out its use in commerce. In fact, it was useful both for the producers and the customers.

The President of the Chamber of Commerce of Naples asked Palmieri to send the paper dedicated to the instrument of his invention, accompanied by appropriate modifications and instructions to facilitate its application (Cacace 1871, p. 4).

Palmieri accepted the invitation but rather than sending his previous paper, he preferred to write a detailed instruction, in order to facilitate the use of the instrument (Palmieri 1871c, pp. 5-14).

It was used several times by the Customs to solve issues related to imported oils.

Comm. Bozzoni, head of the Naples Maritime Arsenal, performed experiments with the new diagometer on behalf of the Ministry of the Navy. Bozzoni believed that the new diagometer was the most reliable tool to discover frauds on olive oils for steam engines and weapons. So he ordered its use in all arsenals (Palmieri 1883a, pp.1-4). This experience had international resonance, as can be seen from what was published in the *Revue Maritime and Colonial* of 1872 (Ministère de la Marine et des colonies 1872, pp.375-379).

5. The refinement of the new diagometer

Some scientists at that time believed that the pile of the diagometer was strongly affected by the hygrometric conditions of the environment and that it showed variable charge or even that it was inert in some conditions.

Palmieri replaced the old dry pile with one he invented, described in the 1883 *Nuove lezioni di fisica sperimentale e di fisica terrestre* (Palmieri, 1883b, pp. 276-277).

The new pile, in fact, could maintain a constant electromotive force thanks to the introduction of silk laces which kept it separated and insulated from the glass case and also absorbed the moisture.

He also made other changes such as replacing the “reofori” with metal wires, ending with 2 small cones, introducing two levers instead of globes.

He presented in 1883 to the Royal Institute of Encouragement of Naples a note in which he described these important improvements made to the new diagometer.

Once eliminated the problem of the pile, the diagometer was suitable for measurements even in extremely humid environments: Palmieri in fact used it between the dense clouds and the strong humidity that surround the old Vesuvius Observatory.

The simplicity of use and the extreme precision made the diagometer the best tool available at the time to solve the problem of oil counterfeiting. This explained the national and international interest aroused by the instrument, which was the subject of numerous scientific and economic articles, for about 10 years, as for example *La Provincia di Pisa* (1871), *La Provincia dell’Istria* (1872), *American Scientific* (1878), *Feuilleton de la Presse* (1880).

7. Conclusion

The study on Palmieri's "new diagometer" revealed that this instrument was recognized as an official measuring tool used by various national and international organizations operating in the commercial sector. It also highlighted the skill and foresight of Luigi Palmieri in applying his theoretical studies on conductivity in order to benefit of the economic community. In the second half of the nineteenth century, the scientist gave a serious contribution to the birth of "applied research" which will have its maximum development in the following century.

References

Cacace T. (1871). *Lettera al Sig. Professore Luigi Palmieri*, in *Istruzione pratica per usare il Diagometro di L. Palmieri pubblicata a spese della Camera di Commercio di Napoli*. Napoli: Stabilimento Tipografico dell'Unione, p. 4.

Cianconi C., Carnaroli E. (1871). "Relazione intorno agli esperimenti eseguiti col diagometro degli oli presentati alla prima Fiera olearia di Terni". *Atti dell'Accademia delle Scienze Fisiche e Matematiche. Società Reale di Napoli*, 5 (4), pp. 19-27.

Feuilleton de La Presse, Causerie Scientifique, 21 avril 1880.

La Provincia. *Giornale degli interessi civili, economici, amministrativi dell'Istria ed organo ufficiale per gli atti della società agraria istriana* (1872), Anno VI, n. 13, 1010.

La Provincia di Pisa. *Giornale politico ufficiale per gli atti giudiziari e amministrativi*, 15 ottobre 1871.

Ministère de la Marine et des colonies. *Revue maritime et coloniale* (1872). Paris: Challamel Ainé, pp. 375-379.

Palmieri L. (1871a). "Il nuovo diagometro per gli oli e pe' tessuti". *Atti dell'Accademia delle Scienze Fisiche e Matematiche. Società Reale di Napoli*, 5 (4), pp.1-12.

Palmieri L. (1871b). "Appendice alla memoria intitolata nuovo diagometro per gli oli e pe' tessuti". *Atti dell'Accademia delle Scienze Fisiche e Matematiche. Società Reale di Napoli*, 5 (4), pp. 13-18.

Palmieri L. (1871c). *Istruzione pratica per usare il Diagometro di L. Palmieri pubblicata a spese della Camera di Commercio di Napoli*. Napoli: Stabilimento Tipografico dell'Unione, pp. 5-14.

Palmieri L. (1883a). "Importante perfezionamento arrecato al diagometro Palmieri". *Atti del R. Istituto d'incoraggiamento*, 2 (6), pp. 1-4.

Palmieri L (1883b). *Nuove lezioni di fisica sperimentale e di fisica terrestre*. Napoli: Giovanni Jovene libraio-editore, pp. 276-277.

Ricco A. (1878). "Professor Palmieri's diagometer". *American Scientific. Weekly journal of practical. information, art, science, mechanics, chemistry, and manufactures*, 39 (12), p. 185.

Rousseau (1823). “Sur un diagomètre électrique propre à reconnaître la sophistication de l’huile d’olive”. *Journal de pharmacie et des sciences accessoires*, 12 (9), pp. 587-590.