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The industry of butter made with pasteurised cream as a defence against Tuberculosis transmission

Alessandra Balestra
Ospedale Regionale Bellinzona e Valli – Sede Acquarossa. Department of Internal Medicine, Corzoneso Piano, Switzerland

Abstract. This paper presents the research conducted by Serafino Belfanti to assess the suitability of cream pasteurisation processes in industrial butter production in the Lombard dairy factories of the time. Belfanti's work focused on assessing whether those pasteurisation processes were enough to eliminate tuberculosis bacilli and whether they affected the quality of the butter compared to traditional methods. We can conclude that the pasteurisation process safely removes the bacilli and that the flavour of the butter is affected in a negligible way. Therefore, this process was recommended for commercial purposes.

Key words: Serafino Belfanti, tuberculosis, vaccine, pasteurisation

Introduction

Serafino Belfanti (Castelletto Ticino, 28 March 1860 – Milan, 6 March 1939) was an Italian medical researcher, immunologist, infectious disease specialist, and the founder of the Istituto Sieroterapico Milanese (1895) (1, 2). His role in the research and prevention of tuberculosis (TB) can be understood from one of his main works, carried out with doctor C. Coggi. This work dating back to 1902 provides such methodical and accurate data and conclusions that only an enthusiastic researcher can convey. This research, which was already conclusive and later inspired the work of other scholars, is still of great interest and importance in the long journey leading to the acquisition of concrete and effective means to fight tuberculosis. This paper describes the experiments carried out exactly as they were published in *Rendiconti del R. Istituto Lombardo di Scienze e Lettere* in March 1902.

While at the Congress on TB held in London in the early 1900s Robert Koch reassured everyone, denying that bovine tuberculosis could be transmitted to humans, the measures against infection from dairy products were not abandoned. Koch assured that infected meat and milk could be consumed without any worries, although there was no absolute certainty. In fact, the susceptibility of cattle to human tuberculosis was known among the scientific community. Many experiments had confirmed this possibility by inoculating cows, rams, and goats subcutaneously (but also orally or through intraperitoneal injection) with "*sputum of consumptive patients*" and verifying the occurrence of typical experimental tuberculosis in these animals (Delépine (3), Arloing (4), Santori-Faelli (5)). Furthermore, Lasar (6) had noticed the high incidence of tuberculosis verrucosa cutis (TVC) in butchers who handled meat infected with the bacilli. "*Therefore, the doubt or rather the conviction that, given certain factors, bovine TB bacilli can adapt to the human environment remains.*"

Belfanti concluded that maintaining and extending all measures that can limit the danger, even in the presence of the slightest doubt, is paramount.

As a result, it was suggested to proceed with the tuberculisation of animals and then eliminate the infected ones. However, this would have caused enormous economic loss and great damage to the cattle and dairy trade, which was fundamental for several regions.

Compensation payments to owners based on their cattle loss – a provision which was implemented in some rich countries (e.g. Belgium) – would have been extremely costly.

At that time, research focused on identifying a sterilisation method, such as boiling applied to milk, which could be used on other dairy products, such as cheese and butter. Belfanti focused in particular on butter.

Milk from infected cows could be boiled while milk from non-infected cows could be consumed raw. The tuberculin test was carried out in the small cowsheds of the Public Gardens and the Park, and in Milan at the Gambaloita Dairy of the Vittadini brothers.

Butter was not widespread in Italy, and it was mainly consumed by wealthy families. However, Lombardy produced and exported this product to various countries where it was widely popular, such as England.

Butter is made with cream, which is separated from fresh milk. Cream cannot be boiled, but it can be pasteurised (1).

Pasteurisation is a heat treatment applied to some foods to eliminate pathogenic non-spore-forming microorganisms. Unlike sterilisation, pasteurisation eliminates only vegetative cells, thereby allowing the complete removal of the most heat-resistant pathogen (*Escherichia coli*). The pasteurisation process gets its name from French chemist Louis Pasteur, who carried out the first pasteurisation test with Claude Bernard on 20 April 1862. In Italy, milk pasteurisation was introduced by Royal Decree in 1929. Liquid food pasteurisation occurs through a tubular, scraped-surface, or plate heat exchanger (the latter consists of stacked metal plates. The liquid to be treated runs on one side and the fluid heated at the required temperature on the other). The two fluids run in opposite directions an in a thin layer so as to make the heat exchange more efficient and ensure that the liquid food reaches the desired temperature. Pasteurisation is not used for large-scale sanitation of all foods, as it could affect their taste and quality. It is only used for liquids (especially milk, wine, beer, and fruit juices). *Low*-temperature pasteurisation occurs when the food is kept at 60-65°C for 30 minutes, which is the temperature range mainly used for wine and beer. *High*-temperature pasteurisation requires 75-85°C for 10-15 seconds and is mainly used for low-acidity products, such as milk and derivatives.

The pasteurisation process – with temperatures ranging from 87°C to 110°C – eliminates pathogenic microorganisms, such as typhus agents, coliforms, mycobacteria, and brucella. (7)

During that time, pasteurisation was the routine in Sweden and Denmark, whereas in Italy and Germany, it was common belief that the process could affect the quality of butter and make it acquire "*a cooked flavour*". As a result, cream pasteurisation was either not carried out at all or carried out in a way that did not ensure the elimination of TB bacilli.

Belfanti's work aimed at establishing whether the industrial pasteurisation processes in use in Lombard dairy factories were enough to eliminate TB bacilli and whether they affected the quality of butter compared to traditional methods.

In the early 1900s, several researchers had already demonstrated how TB bacilli are incredibly resistant. Galtier (8), Jersin (9), Bang (10), Bitter (11), Förster (12), De Mann (13), and Bonhoff (14) had identified the following conditions to kill the bacteria:

- 55°C for 4 hours
- 60°C for 1 hour
- 65°C for a ¼ hour
- 70°C for 10 minutes
- 80°C for 5 minutes
- 90°C for 2 minutes
- 95°C for 1 minute

Martin (15) observed how the germ's resistance varies according to the biological liquid it is contained in: sputum, milk, organ extract, or pure broth cultures. Sormani (16) showed that the bacilli in a milk and sputum mixture were still alive after boiling at 90°C for 10 minutes. Beck (17) noticed that boiling at 80° C for 30 minutes was not enough to neutralise the bacilli, as milk infected with bacilli, however finely crushed, caused TB when inoculated in the test animal. However, according to Heim (18), that same temperature was enough to prevent the infection if the inoculum consists of sputum alone. Levy and Bruns (19) demonstrated the elimination of the bacilli contained in milk over a bain-marie at 65-70°C for 15-25 minutes.

Such variable results can be explained by the difficulty in heating the entire mass of a dense liquid, such as milk. In fact, Mann had recommended using capillary tubes to allow the liquid to reach the required temperature (13).

Therefore, Belfanti concluded that "*based on the latest experiments*," a temperature of 75°C can kill all the bacilli in milk; however, whether this temperature was enough to eliminate the bacilli also from a fat product, such as cream, needed to be verified because that's where it is believed that microorganisms acquire greater resistance.

Again, Belfanti listed discordant results from several other researchers. In 1889, Scala and Alessi (20) had observed how TB bacilli added to heated artificial butter were killed, whereas Rabinowitsch-Kempner (21) indicated that 30 minutes at 87°C for were not enough to eliminate them. On the other hand, Gottstein and Michaelis (22) ensured that 5 minutes at 87°C were enough to sterilise infected fat. In a series of experiments, Herr (23) showed that *"TB bacilli in cream die":*

- in 10-15 minutes at 65°C
- in 1-5 minutes at 70°C
- in 1-3 minutes at 74°C
- in 5 seconds to 3 minutes at 80°C
- in 5 seconds at 85°C or more

These data do not differ that much from the time required for milk sterilisation

Now, it was important to demonstrate that the results obtained in ideal laboratory conditions, with different means compared to those used in industries, and using a minimum amount of cream, could also be achieved in large dairy factories, where industrial machinery was used to sterilise tonnes of product at a time.

Large dairy factories used machines equipped with dual wall cylinders (like the *Triumph* pasteurising machine, Fig. 1) in which steam circulated at 112-114°C.

The cream was centrifuged in the cylinder at 35°C by a flapped beater moved by a pulley. This way the product was thrown against the cylinder walls by the centrifugal force and then moved up through a refrigerating pipe. The temperature of the cream would quickly rise in contact with the cylinder walls heated at 112°C. After a few seconds, every part of it would reach 80-85°C since the rotating layer was only a few centimetres big. When running up the pipe – which was kept cold by the running water circulating inside the walls – it quickly cooled down to 18-20°C, spreading inside the serpentines, and then falling into the containers for acidification. This way, the temperature of the cream would go from 35°C to 85°C, and down to 18-20°C again in 4 to 5 seconds.

This type of machine could pasteurise more than 1000 litres of cream per hour. The cream could reach a maximum temperature of 90-92°C. Low-fat milk could reach up to 102°C, thanks to the help of a second, smaller machine.

Another pasteuriser suitable for small dairy factories and recommended for small owners was the

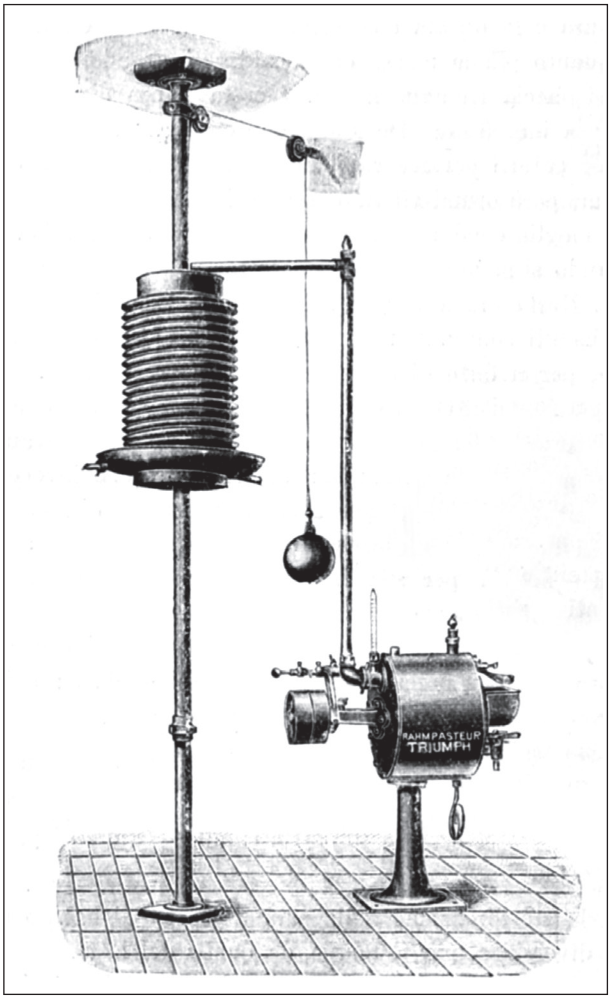

Figure 1. *Triumph* pasteurising machine. This type of machine could pasteurise more than 1000 litres of cream per hour (see description in text).

Lister machine (Fig. 2), which Belfanti used for the experiments described in this paper. Its operation was similar to the *Triumph*'s. The only difference was that the beater was moved by a steam-driven turbine. The product would take 15 to 20 seconds to travel from the inlet to the outlet. This machine could pasteurise about 100 litres of product per hour.

Both machines used *Schmidt* refrigerating systems, which, however, had a downside: the serpentines along which the cream ran were not protected; therefore, the product would come into contact with air. This inconvenience could be solved by a special casing (Fig. 3).

Belfanti highlighted how the temperature range used by the machine was enough to eliminate the bacilli. Then, he proceeded with the experiments as follows.

"First of all, we verified the virulence of the TB bacilli we had been cultivating in the laboratory." To this end, Belfanti inoculated 10 guinea pigs with an emulsion consisting of the film extracted from the culture broth contained in a small *Erlenmeyer* flask[1], obtaining reassuring results (Tab. 1).

Belfanti conducted the experiments first with milk and then with cream.

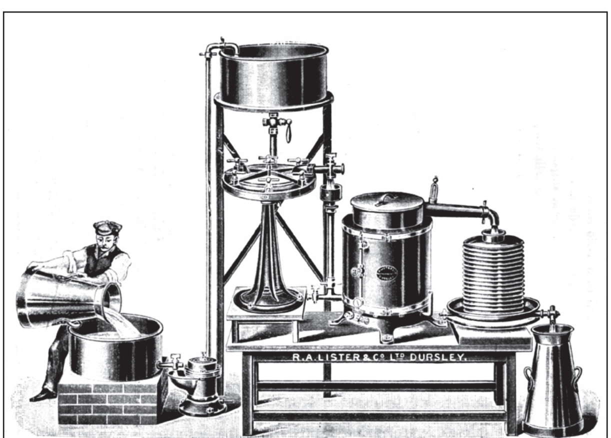

Figure 2. The *Lister* machine, suitable for small dairy factories and recommended for small owners, which Belfanti used for the experiments described in this paper. Milk fresh from the cow would be poured into the skimmer, which separated it from the cream. The cream was then conveyed to the pasteurising machine and, from there, to the refrigerator.

[1] A conical laboratory flask.

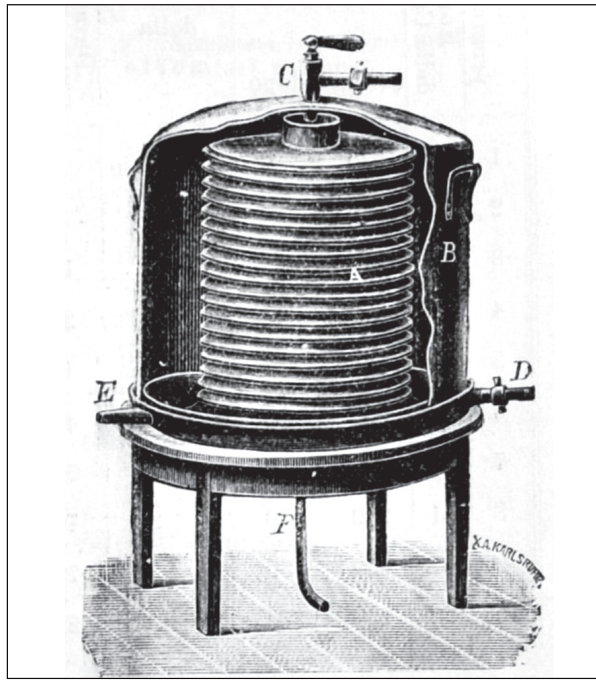

Figure 3. Serpentine protection casing. This special casing protect the cream, that ran along the serpentines, form the contact with air.

Table 1. Diffuse Tuberculosis has been found in gross necropsy of 9 out of 10 guinea pigs inoculated with an emulsion extracted from the culture broth of the TB bacilli.

6 maggio 1901.

Num. progressivo	Num. della Catena	Peso in gr. prima	Peso in gr. dopo	Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
1	100	375	—	7 maggio	1	Negativo	morta
2	77	275	—	11 „	5	„	„
3	98	365	—	22 „	16	Tuberc. diffusa	uccisa
4	25	250	310	28 „	22	„	„
5	15	230	280	21 giugno	46	„	„
6	76	300	380	21 „	46	„	„
7	2	300	480	23 luglio	78	„	„
8	51	250	370	23 „	78	„	„
9	67	290	480	23 „	78	„	„
10	28	230	320	27 „	82	„	„

He mixed a small amount of milk with the aforementioned tubercular emulsion; then he took a control sample from this mixture. He took a second sample after the pasteurisation process was completed. Both samples – which were of the same size as the sample used during the previous experiment to test the virulence of the bacilli – were inoculated in 8 guinea pigs through intraperitoneal injection. The results are summarised in Tab. 2.

The experiment was repeated for a second time with equally reassuring results. Belfanti then carried out a third experiment using only the pasteurised milk sediment after centrifugation. Again, this product proved to be harmless for the animals.

The experiments with the cream were carried out mixing 10 litres of cream with 30 cc of the usual TB emulsion. Samples were taken before and after, and then butter was made in the laboratory but without

Table 2. 8 Belfanti inoculated 8 guinea pigs with milk mixed with tubercular emulsion and not pasteurized. In gross necropsy 5 of these showed diffuse tuberculosis, 1 leukocyte cluster in the peritoneum and in the lymph nodes and 1 enlargement of the retroperitoneal lymph nodes. Only one was completely free of infection. A second sample of mixed milk was inoculated after the pasteurisation process; gross necropsy shows no infection in all 8 Guinea pigs

11 maggio 1901 (latte non pastorizzato).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	1	300	—	19 maggio	8	Ammassi leucocitari nel peritoneo e nelle ghiandole.	morta
2	16	310	—	19 „	8	Ghiandole retroperitoneali ingrossate.	„
3	8	550	520	28 „	17	Tuberc. diffusa	uccisa
4	9	320	290	28 „	17	„	„
5	66	420	330	31 „	20	„	„
6	88	460	—	9 giugno	29	„	„
7	85	650	610	21 „	41	Negativo	„
8	59	600	580	21 „	41	Tuberc. diffusa	„

11 maggio 1901 (latte pastorizzato).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	42	370	—	18 maggio	7	Negativo	morta
2	33	320	260	28 „	17	„	uccisa
3	44	600	570	28 „	17	„	„
4	86	500	400	31 „	20	„	„
5	52	480	450	20 giugno	40	„	„
6	38	320	300	20 „	40	„	„
7	12	580	520	21 „	41	„	„
8	69	550	670	21 „	41	„	„

Table 3a. Endoperitoneal injection with non-pasteurized cream butter: 4 out of 5 guinea pigs show diffuse tuberculosis.

13 agosto 1901 (Injezione endoperitoneale)
(Burro di panna non pastorizzata).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	75	430	430	14 agosto	1	Negativo	morta
2	24	500	490	15 sett.	33	Tuberc. diffusa	uccisa
3	10	450	435	15 „	33	„	„
4	5	500	500	2 ottobre	50	„	„
5	82	550	450	2 „	50	„	„

Table 3b. Endoperitoneal injection with pasteurized cream butter: 5 out of 5 guinea pigs are negative for infection.

(Burro di panna pastorizzata).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	11	390	390	14 agosto	1	Negativo	morta
2	68	500	550	15 sett.	33	„	uccisa
3	74	620	660	15 „	33	„	„
4	3	490	520	2 ottobre	50	„	„
5	56	410	470	2 „	50	„	„

acid fermentation. Next, the melted butter was injected into the guinea pigs both via the peritoneal and subcutaneous route, obtaining the same results as the experiments with milk (Tab. 3a-d).

Conclusion

"Our results coincide with Mr Herr's"; therefore, the methodology allowed for the safe elimination of the bacilli (1).

Table 3c. Subcutaneous injection with unpasteurized cream butter: 1 Guinea pig out of 5 is negative for infection. The remaining 4 show: a small tuberculous nodule at the inoculum site with enlarged and caseified inguinal lymph nodes; a scar at the inoculum site with swollen inguinal lymph nodes and tuberculous nodules in the liver and spleen; a small abscess in the inguinal region; scar tissue at the inoculum site and tuberculous nodules in the liver and spleen.

15 agosto (Injezione sottocutanea)
(Burro di panna non pastorizzata).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	28	420	—	16 agosto	1	Negativo	morta
2	79	520	650	21 dicemb.	128	Piccolo nodulo tub. al punto d' innesto con ghiand. ingrossate all' inguine e caseificate.	uccisa
3	15	350	440	21 "	"	Cicatrice al punto d'innesto con ghiandole ing. ingr.: noduli tub. al fegato ed alla milza.	"
4	69	430	470	21 "	"	Piccolo ascesso alla regione inguinale.	"
5	84	385	400	21 "	"	Tessuto cicatriziale al punto d' innesto: fegato e specialmente la milza con noduli tub.	"

Table 3d. Subcutaneous injection with pasteurized cream butter 5 out of 5 guinea pigs are negative for infection.

(Burro di panna pastorizzata).

Num. progressivo	Num. della Catena	Peso in gr.		Data della morte	Durata dell'esperienza in giorni	Reperto necroscopico	Osservazioni
		prima	dopo				
1	20	490	670	21 dicemb.	128	Negativo	uccisa
2	53	310	450	21 "	"	"	"
3	98	380	580	21 "	"	"	"
4	9	345	420	21 "	"	"	"
5	67	410	640	21 "	"	"	"

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As for whether cream pasteurisation affects the butter's characteristics, Belfanti reassured producers by mentioning the excellent results concerning quality control published by Weigman in the *Chemiker Zeitung* (243). Moreover, according to Herr's experiments, the butter acquired even finer characteristics, even if the cream had somewhat of a "*cooked flavour*" if treated at higher temperatures or for longer (hence the possibility of using higher temperatures for the process).

Evaluations conducted at the cooperative dairy factory in Casalpusterlengo showed that the butter had *"superior characteristics compared to so-called sweet ones with regards to flavour and (…) shelf life."*

Indeed, the *"cooked flavour"* of the cream could be removed through an acidification process, widely used in Denmark. This process consisted in adding lactic ferments grown in low-fat milk to the cream after the pasteurisation process. The mixture was then left to acidify at 18-20°C before being churned. In Italy, however, this acidification process was not particularly widespread, and when it was applied, it did not give good results.

However, the excellent results obtained even without this process led Belfanti to recommend pasteurisation for commercial purposes. But he also stressed that, although infected milk could be used to make butter, it could NOT be used for direct consumption. He also reassured those who believed that butter alone could not ensure enough profits by reminding them that its production process allowed obtaining low-fat milk and its by-products, i.e. lactose and casein. This way, the revenues would compensate the loss due to infected raw milk.

Belfanti suggested a process that, on the one hand, avoided any damage for producers and, on the other was "*hygienically safe for consumers, who have the right to protect their health, which is too often threatened by avoidable infectious diseases.*"(1).

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Correspondence:
Alessandra Balestra
Ospedale Regionale Bellinzona e Valli – Sede Acquarossa
Department of Internal Medicine
Corzoneso Piano, 6716 Acquarossa, Switzerland
E-mail: alessandra.balestra@eoc.ch