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SYMPOSIUM ON 'MILK—ITS PRESENT AND FUTURE ROLE IN NUTRITION'

A history of milk in the food industry

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Milk in antiquity

If the food industry is described as being concerned with the processing of food for distribution and sale, then such an industry has co-existed with the earliest historical records and it is probable that some form of it was in being long before that. The general pattern of the archaeological record of, for example, the Middle East, is consistent with the assumption that trading in grain and bread existed in one form or another from the time of the earliest settlements that were large enough to be called cities, dating from around 8000 B.C. The development of agriculture also is generally believed to date from this period although the gathering of wild forms of wheat and barley in the Middle East probably came rather earlier. There is good evidence that the domestication of animals had began with sheep and goats about 11 000 years ago. (Higgs & Jarman 1969; Reed, 1969). The first evidence of domesticated pigs is from around 9000 years ago (Tannahill, 1973) and cattle, it seems, came last—a mere 8000 years ago (Perkins, 1969). While we shall never know for certain, it is likely that goats' milk and sheep's milk were used long before that of the cow.

The art of writing dates from about 5500 years ago and there is therefore a gap in the record of civilization of about two and a half thousand years between the domestication of cattle and the first written records. However, from about 4000 years ago (Leonard, 1974*a*) clay tablets were recording in detail the economy of herds of cattle. For example, one of these reveals a year by year entry showing that over a ten-year period the writer increased his herd five-fold and that his yields of butter and cheese followed accordingly. The reference to butter and cheese is interesting, indicating as it does that the invention of these foodstuffs was earlier than 4000 years ago. We have further indications of these from early carvings. An Elamite seal of 4500 years ago depicts a goat being milked before a fertility goddess

(presumably to encourage the animal to higher yields) while a Sumerian frieze of about the same period vividly illustrates processes of milking and butter-making (Leonard, 1974*b*).

By biblical times the domestication of cattle was a well-established practice and the importance of dairy products to the economy of the day is shown by about 150 general references to cattle, milk, butter and cheese in Holy Writ (from Cruden's Concordance). By the Roman period (Brothwell, 1969) the use of cheese was widespread in all levels of society; gourmet cheeses were sought after and smoked cheeses were especially appreciated. As well as having their own specialities, the Romans also imported foreign varieties. Clearly, the art of cheese-making was already well developed. Clark & Goldblith (1975), quoting the works of Columella, show that the Romans recognized the need to use fresh milk in cheese-making. They also knew about the action of rennet (which they called *coagulum*) obtained from a lamb or kid and about the need for warmth to speed up its action. Columella writes also on the rectification of cheese-making faults such as overdryness, oversaltiness and holes in the finished product.

Cheese is an indirect way of "preserving" milk, but by the twelfth century, Marco Polo, the great Venetian traveller, was describing the use of dried milk and its reconstitution in the Tartar army (Wright, 1904) as follows:

"They boil the milk, and skimming off the rich or creamy part as it rises to the top, put it into a separate vessel as butter; for so long as that remains in the milk, it will not become hard. The latter is then exposed to the sun till it dries. Upon going on service they carry with them about ten pounds for each man, and of this, half a pound is put, every morning, into a leathern bottle, . . . with as much water as is thought necessary. By their motion in riding the contents are violently shaken, and a thin porridge is produced upon which they make their dinner".

The nineteenth century

Despite inventions of this sort, by the beginning of the nineteenth century, milk technology had progressed only in detail from the methods of 2000 years previously. Appert (1810) published his famous monograph on food preservation which established the techniques of canning on an empirical basis. Contemporary accounts (Drummond, 1939) indicated that he successfully preserved milk for use by the French navy by heat sterilization. In Appert's time it was believed that putrefaction of food was caused by air and that even the smallest trace, beyond the limits of physical exclusion, would cause deterioration. It was thought that heating food chemically "fixed" the entrained air. Appert's process worked, and therefore this thesis must be correct. Forty-seven years later Pasteur published his short paper "Mémoire sur la fermentation appelée lactique". In his biography of Pasteur, René Dubos (1961) categorizes this paper as "the beginning of scientific microbiology and one of the most important landmarks of the biochemical and biological sciences". One of the many consequences of that paper was the insight it offered into the mechanism of the Appert process. Taken with his later work on

the preservation of wines and beers, it reported the basic understanding which later brought into existence the process which associates Pasteur's name with milk and milk products to this day. From then on the scientific development of milk technology became possible and Pasteur himself is reported as having remarked "There is no such thing as pure and applied science—there are only science, and the applications of science".

From Appert's time onwards, the accelerating pace of the industrial revolution brought its own pressures on the primitive dairy industry. In great cities like London, milk could only be supplied by keeping cows in the town and bringing feed to them. Kept in crowded conditions in filthy cow-sheds, many of the cattle became diseased and often the milk must have been heavily infected before it was drawn from the udder. Byng (1847) describes the cowsheds in Golden Square, London, which lies a hundred yards east of Regent Street:

"Forty cows were kept in them, two in each seven feet of space. There is no ventilation, save by the unceiled tile roof, through which the ammoniacal vapours escape . . . Besides the animals, there is at one end a large tank for grains, a store-place for turnips and hay, and between them a receptacle into which the liquid manure drains, and the solid is heaped . . . the stench then arising [is] insufferable".

The development of the railways, coupled with an outbreak of cattle plague in 1863–5 gradually led to the reduction in the number of town cattlesheds. By 1863, London was already receiving over two million gallons of milk annually by rail. This large trade seems to have encouraged fraud by the watering of milk. A simple hydrometer was introduced to counter this but the dairymen soon found that while added water decreased the reading, the reading could be restored to the normal range by removing some of the cream. Thus fraud gave a double profit and it was not until the introduction of the Beckmann freezing point test in 1894 that an effective curb was placed on this practice. From 1870, the time was ripe for the beginnings of modern dairy science and milk technology.

The events of the second half of the nineteenth century are summed up in the form of a chronology.

1844 Rail carriage of milk to Manchester introduced.

1850 Factory production of cheese begun in the United States by J. Williams, near Rome, Oneida County, New York.

1856 Gail Borden patents the preparation of condensed milk by evaporation under reduced pressure (USP No. 15 553, 1856). The patent was exploited commercially by the Anglo-Swiss Co. (later Nestlé) from 1866 onwards in Switzerland and elsewhere thereafter.

1863–67 Outbreak of cattle plague in London cowhouses accelerates existing trend to transport milk by rail to London from the Home Counties. Pioneers in this new trade were Sir George Barham and a Mr. Freeth. Mr. Freeth's son, a certain Captain Freeth, was a former Hon. Secretary to the Society of Dairy Technology.

1870 Factory cheese-making techniques introduced to England at Derby by C. Schermerhorn (USA).

1875 Commercial preparation of "Standard Rennet" by C. Hansen, who had a

laboratory in Copenhagen in 1874. In 1878 Hansen opened a factory in New York to produce his product.

1878 Introduction of cream centrifuges by Gustav Laval in Sweden and by Neilsen in Denmark.

1880 Heat-treated milk offered for sale in Berlin.

1883 J. G. Kjeldahl technique for nitrogen determination introduced.

1887 Hailwood (UK) exhibits the first plant for in-bottle sterilization of milk by heating for 20 min in boiling water.

1889–91 Early attempts to mechanize milking.

1890 First systematic preparation of butter starter cultures by Professor Storch who also advocated pasteurization before inoculation with a proved pure starter. His technique provided the foundation for the modern trade in Danish butter.

1890 First pasteurization holding plant, using a process calculated to destroy typhoid and tubercule bacilli, designed by Bitter.

1893 First city pasteurization plant built in New York by Nathan Strauss.

1895 Pulsating milking machine successfully designed by Shields. His methods were the forerunner of all modern milking machines.

1899 Mark Ekenberg took out the first patent for roller drying.

1902 Just-Hatmaker introduced drum drying of milk and the Merrel-Soule company began spray-drying.

(This table has been compiled from a combination of the sources listed in the references, and in particular from Round (1971), Capstick (1950), McLachlan (1975) and Drummond & Wilbraham (1939).

The twentieth century

By the turn of the century, the basis of the modern dairy industry had been laid. However, the Milk and Dairies Amendment Act of 1922, together with Orders made under it, resulted in a flurry of engineering activity and invention to produce effective pasteurisation equipment. While the old holder process, which required milk to be held for 30 min at a temperature between 145° and 150°F, was simple in principle, it had to be made semi-continuous or continuous to meet the production needs of the large dairies already in existence. The invention of the plate heat exchanger by Richard Seligman in 1923 (Seligman, 1950) was to transform pasteurization methods by using the incoming milk to cool the finished product leaving the pasteurizer. The holder technique was to reign unchallenged for nearly twenty years although it was well known during this period that a higher temperature would do the job much better and with a dwell time of only a few seconds. Clearly the Seligman heat exchanger was well adapted to such a process (in principle only the operating temperature had to be raised to make a pasteurizer of it) but the idea lay fallow until 1941 when the UK government legislated in favour of high-temperature, short-time processes.

The following year saw the opening in Cambridge of the first commercial centre for artificial insemination (AI) of cows. AI started hesitantly but 300 cows a year

were being treated by 1945. Twenty years later the figure was rising towards two million (Smith, 1969), and the expectations of the pioneers in this field have been fully justified by the continuous improvements in our dairy herds ever since.

An observer of the dairy scene in the year 2028 may well look back on the second half of the twentieth century as a turning point in the development of further uses for milk, lactose, casein, milk fat and whey within other branches of the food industry and for a wider variety of purposes. However, events are too close for more than the voicing of a suspicion, a hint that in future the sharply defined dairy industry will grow to even greater importance as it gradually and almost imperceptably merges into the food industry as a whole.

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