MILK PRODUCTION IN WAR-TIME

BY PROF. H. D. KAY, O.B.E.
NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

IF from the point of view of human nutrition in war-time the gravest problem is that of providing sufficient calories, the next in importance is undoubtedly that of maintaining at the highest possible level the daily inflow into the national larder of milk—with its unquestioned value in balancing and reinforcing, either for the young or the adult, a diet which may be short of calcium, vitamin A, riboflavin, animal protein, and fat. The adequate solution of the milk problem is dependent on many factors, agricultural, economic, administrative, etc. It is proposed to discuss a few of those in the first of these categories, mainly concerned with feeding and management of the dairy cow in war-time.

It is believed that of all farm animals, the modern dairy cow is the most efficient converter of farm feeding stuffs into human food. This, however, is true only for the animal of medium or higher yield, say, for present purposes, for the animal yielding not less than 500–600 gallons per lactation. It is again fortunate that, as a ruminant and by preference almost entirely a herbivore, the cow, unlike the pig and the hen, does not seriously compete directly with man for the kind of foodstuff he requires for his own diet. In the third place it is fortunate also that as a result of past research, a great deal is now known about the detailed nutritional needs of this highly specialized animal for efficient lactation, though this knowledge, particularly valuable in war-time, is effectively applied on far too small a proportion of our dairy farms.

Quantitatively, the dimensions of the problem of feeding the cow are greater in this than in the War of 1914–18. The dairy cow population at the outbreak of the present War was more than 20 per cent above that of 1914, and there has, if anything, been an upward trend in the last two years. In tonnage, the amount of food required for the dairy herd is not far short of that needed for the entire human population. The average dairy cow weighs about half a ton, and although she will provide each year say 500–600 gallons of milk, containing a dry weight of some 6 cwt. (that is, nearly twice her own dry weight) of first-class human food, she must have, if she is to remain a productive unit, not far short of four tons a year of foodstuff, estimated as dry matter. When this requirement is multiplied by well over three million (the exact number of 'dairy' cows depends on a rather arbitrary definition as between a 'dairy' cow and a 'beef' cow), the huge size of the problem—that of providing some twelve million tons (dry weight) of feeding stuff per annum to secure adequate milk production—is apparent.

It is not generally realized that as much as 80–85 per cent of the total food consumed by the dairy cow (estimated, of course, on a dry-matter basis) is, in peace-time, produced at home, from grazing and from other farm-produced foodstuffs such as hay, straw, roots, kale, silage, etc., these latter for the most part bulky foods with a relatively low energy and protein content and containing a large proportion of indigestible fibre.

For present purposes we may regard the essential food requirements for efficient lactation in the dairy cow as being a sufficiency of digestible nutrients in a bulk which does not exceed the assimilatory capacity of the animal. These nutrients have to provide (*a*) the animal's basal metabolic needs for energy, (*b*) her energy requirements for purposes of muscular movement, digestion and glandular activity, including the activity of the mammary gland and the relatively small amount of material necessary for the day-to-day repair of these tissues, and (*c*) the materials needed for the synthesis of the very considerable quantities of lactose, casein and lactalbumin, and fat secreted by the udder*. The war-time significance of this statement is that the food materials required for (*c*) are rather different in composition than those needed for (*a*) and (*b*). They are richer in protein, and belong mainly to the type of concentrates that was extensively imported from abroad in peace-time.

To obtain the necessary nutrients under (*a*), (*b*) and (*c*) from the ordinary, bulky farm foods is only possible if the yield of milk is small, say ½–1 gallon a day. The capacity and appetite of a high-yielding dairy cow do not allow her to eat sufficient of such bulky foods to maintain her milk yield for very long. She is, like nearly all modern farm animals, in a state of unstable biological equilibrium. Without adequate feeding of concentrated foods she may for a short time continue to secrete large amounts of milk at the expense of her own tissues, but this process will not continue and she will eventually rapidly fall off in yield.

The main problem of feeding for milk production

* The nutrients have also to provide, in most cases, for the growth of the fœtal calf. The main demand here, however, is late in lactation when the milk yield is falling off.

in war-time is to provide the type of concentrated protein-rich nutrients required for purpose (*c*), and that despite the facts that importation of concentrates from abroad is severely cut down, that the by-products of flour milling will soon be both less in quantity and in nutritive value since 85 per cent instead of 73 per cent of the wheat grain will go into flour for human consumption, that there is a shortage of skilled labour on the farm, and that a larger area of farm land is now being used for the production of human foodstuffs such as wheat and potatoes, the by-products of which are not very useful for purpose (*c*).

Without concentrated feeding stuffs, especially in winter, and adequate husbandry the dairy cow would fairly soon revert to a low-yielding animal producing most of her small output of milk from grass in the spring and summer months, and drying off completely in the winter. But alike with the good and the poor cow, feeding presents no problem at all if grass, which if of good quality will contain all the protein needed for purpose (*c*), is abundant. Up to four or even five gallons of milk a day can be produced without difficulty or damage to the cow, and without any supplementary feeding of concentrates, if such grass is available, and fields are grazed in rotation under reasonably efficient conditions of grassland management. In most parts of Great Britain, however, an abundant supply of grass rarely persists for more than three or four or possibly five months of the twelve. For the remaining months both bulky farm foods and concentrates containing sufficient protein are essential, in addition to what the cow can pick up from the pastures, if an average, or better than average, yield of milk is to be maintained. It is particularly in December, January and February, when natural environmental and war-time nutritional conditions both for the dairy cow and for man are at their worst, that human needs for a protective food like milk are at their greatest.

It has been suggested that the nationally most satisfactory war-time plan is for the dairy farmer to go in for summer milk production from grass, and winter his cows in a practically non-lactating condition. The large excess of milk not required for human nutrition during the summer months would then, it is suggested, be dried or "evaporated" and stored, for distribution during the winter season instead of liquid milk.

Even if the requirements of only three winter months were to be met, this scheme would entail treatment of some 240 million gallons of milk, that is, a large increase in our existing milk-drying and evaporating capacity (with plants very busy during the summer and idle during the winter), a very large supply of tin plate or other material suitable for making containers to store the 130,000 tons or more of processed milk, probably an organization to reconstitute the milk in numerous depots, and certainly a formidable change in food habits. Though milk dried or "evaporated" by modern methods and properly packed for storage loses very little of its nutritive value, it is very doubtful indeed whether any extensive change over to summer milk production is either feasible in war-time or advisable at any time.

In present circumstances, the only means by which milk yield may be maintained in winter are: (1) the switching over to the dairy cow of sufficient concentrated feeding stuffs, both those produced at home and those that continue to be imported, from less essential stock such as pigs and poultry, or (2) an increase in quantity and quality of the feeding stuffs grown on dairy farms at home, so that they not only provide all the maintenance rations needed for purposes (*a*) and (*b*) mentioned above, but also meet the higher protein requirements for purpose (*c*).

Alternative (1) is the foundation of the rationing system that was introduced half-way through the winter of 1940–41. By this system the greater proportion of the available concentrates were allocated to dairy cows: farm horses and one or two other categories of essential animals received a sufficient ration, beef cattle were reduced to about 50 per cent of their pre-war requirements, and the small amount left was allocated to pigs and poultry. Alternative (2) is clearly one which needs time to achieve. It means in the first place the improvement in quantity and quality of the grass produced on the farm, an improvement which had in fact begun, if only in a small way, before the War. This entails the ploughing up, appropriate artificial manuring, and re-seeding of worn-out or indifferent pasture, the general improvement of grassland by adequate dressings of lime and phosphates, the use of suitable seed mixtures and nitrogenous fertilizers on selected fields to produce grass one or two weeks earlier in the season and possibly to induce grass to linger for about the same length of time in the late autumn, with a corresponding economy in concentrates. It also means the making of silage in the spring from young grass (the younger the grass the higher the protein content) and particularly in the autumn from aftermath, or from special mixtures of cereals and pulses which have a high protein content, improvement in methods of haymaking, to ensure that losses of feeding value are minimal, the use of green 'soiling crops' such as mixtures of pulses and cereals, or, in warm districts, maize, to supplement the grass supply during the summer and early autumn, the growing of more cabbage and kale to provide green fodder during the winter months, an additional acreage of peas and beans to provide protein-rich fodder, an increased production of root crops such as swedes and mangolds for winter and early spring feeding, the production of a valuable food, of approximately the same energy value for the ruminant as good hay, from wheat straw (a material not normally used for feeding dairy stock, but which is increased in amount over pre-war quantities) by soaking it with dilute caustic soda solution, the intelligent use both of farmyard and artificial manures. These are all aspects of good dairy farming by which dependence on purchased feeding stuffs will be steadily lessened during the present year and in the future. Many dairy farmers, after the 1941 harvest, will already have achieved this objective of self-support, and the rationing scheme for dairy cows for this winter will undoubtedly be largely based on this fact.

Little has been said about the effect of war-time conditions on milk quality. In general, quality is rather more stable to environmental changes than is yield. If yield falls, then there is normally a small increase in milk fat percentage, as was in fact observed last winter. Insufficient feeding of concentrates, in addition to its depressing effect on yield, is sometimes associated with a diminution in the percentage, of solids other than fat in the milk. On the whole, however, it may be said that the war-time diet of the milking cow will only have quite small effects on the composition of her milk.

Second only in its effects on milk yield to a shortage of feeding stuffs, and much more drastic in its effects in reducing the nutritional quality of milk than any other factor, is udder disease. Even in the sub-clinical stages mastitis produces a marked fall in the compositional quality, and therefore in the nutritional value of milk, together with an appreciable drop in total quantity secreted, and the changes become more serious as the disease progresses.

In peace or in war, until this disease—or group of diseases—is taken in hand on the national scale, these largely avoidable losses will continue to be suffered. Some authorities are of opinion that there has been an increase in udder disease during the last two or three years. This may well be, as with the unskilled labour that has on many farms replaced the pre-war skilled cowman—a process which began before the outbreak of war—early symptoms of the disease are easily overlooked and veterinary treatment delayed until irreparable damage has been done to the udder tissues. An animal even at this stage may continue to secrete a little poor quality milk without requiring supplementary concentrates in her diet, but since the food required for maintenance of a poor or indifferent animal is little if any less than that required for maintenance of a high-yielding cow, the former animal is wasting food if the criterion of milk yield divided by total food consumption is applied. At the other extreme, the very high yielder in war-time is difficult to handle successfully, as she requires highly skilled management and in some cases special foodstuffs, neither of which may be available. The desirable dairy cow in war-time is an animal giving a good, but not an immense yield.

In war-time as in peace-time, culling of the inferior yielder pays. It is possible to cull without losing milk at all if the foodstuff virtually wasted on the poor yielder is distributed among the better yielders, and—an important proviso in war-time—if rations of concentrates are provided on a basis of milk produced and not on a basis of numbers of cows. Even in war-time, a scheme for the control and treatment of mastitis, associated with a culling policy for getting rid of incurable chronic cases, would be greatly beneficial to the national milk supply.

The fall in milk-yield that was evident in the winter of 1940–41 was probably as much the result of climatic conditions highly adverse to milk production as to local shortages of feeding stuffs. The uncertain climatic factor renders any prediction as to the probable total milk yield during the mid-winter months of 1941–42 very hazardous. The yield in the winter of 1940–41 was some 7 per cent below that of 1939–40, which was itself only about 2 per cent below that of the winter of 1938–39, a winter of record output. Will this fall become greater in the most critical months of 1941–42 ? There are good reasons for hoping that it may not. Under next winter's rationing scheme, with absolute priority for the dairy cow in supplies of concentrates, and with the strenuous efforts that many dairy farmers have been making during the past twelve months to make their farms more nearly self-supporting as regards feeding stuffs for milk production and not merely for maintenance, the dairy cow should be adequately, though not generously, provided for during the forthcoming winter. Though culling of poor yielders is being officially encouraged, the national herd has not diminished. The hay crop, on which much depends, has been on the whole a fair one, with hay of good quality. Grass has been plentiful in most parts of the country, which means that the reserves of feeding stuffs for summer use have not as yet been consumed. The loss of milling by-products resulting from the increased rate of extraction of flour from wheat should be more than offset by the increased production of oats and mixed corn during the present harvest.

The labour situation is unlikely to become more serious, as experienced male agricultural workers are not being called up, and more Women's Land Army recruits are being trained for work on dairy farms. The present very high prices paid for dairy cows indicates that even if certain farmers are turning over from milk production to other less-exacting types of farming that appear to be giving, for the present at least, equally good returns, their dairy animals will not be lost from the national herd. What is less certain is whether the slight trend towards summer milk production shown during the past twelve months will be accentuated. If autumn calvings are markedly fewer in 1941 than in 1940, then there will be an increased shortage of liquid milk during the critical mid-winter months. If they are not, the winter milk yield of 1940–41 is very likely to be maintained during the forthcoming winter.

THE "HOROLOGIUM OSCILLATORIUM" OF CHRISTIAN HUYGENS

By A. E. Bell
St. Marylebone Grammar School, London

THREE great works laid the foundation of modern mechanics: Galilei's "Discourses on Two New Sciences" (1638), Huygens's "Horologium Oscillatorium" (1673), and Newton's "Philosophiæ Naturalis Principia Mathematica" (1687). Of these, the second is certainly the least well known, and least accessible to the English reader[1]. Yet it is more rigorous in the treatment of its subject-matter, more strictly mathematical in style than the others, and it certainly deserves more recognition than has ever been conceded to it. From Huygens's original intention to publish a work on the construction and scientific principles of his pendulum clock (employing a cycloidal pendulum), the work grew and grew over a period of about fifteen years, and finally issued forth in 1673 with much accumulated around its central theme. Unlike most of Huygens's other writings, the work is singularly free from all Cartesian influences. Huygens himself hoped that it would be in direct line with the great work of Galilei, and his hopes were not disappointed. Newton wrote to Oldenburg, the indefatigable secretary of the Royal Society, of his "great satisfaction" with the work, and said he found it "full of very subtile and usefull speculations very worthy of ye Author". Newton especially admired Huygens's mathematical style, and considered him "the most elegant writer of modern times".

Part 1 of the "Horologium Oscillatorium", "Containing a Description of the Clock", describes in detail how the various wheels and pinions of the mechanism are put together. The description is of great interest to the student of the history of clocks because in all except one particular Huygens's clock was based on the old balance clocks dating back to the thirteenth century. This particular was, of course, the pendulum, the adaptation of which (setting aside the slight claims of Galilei) was first successfully worked out in 1656; with small differences the pendulum was used in the same way in 1673, except that Huygens had in the interval discovered (1658–59) that the cycloid is the tautochrone and that consequently a cycloidal pendulum is isochronous for arcs of all magnitudes. To make the pendulum bob execute the correct curve the flexible part of the suspension hung between metal plates or 'cheeks', themselves later found to require the cycloidal form (see below). Huygens owed much indirectly to Pascal and Wren for his discovery of the tautochrone. "I am sure that geometers will value this refinement infinitely more than all the rest of my mechanical inventions", he wrote of the cycloidal pendulum. About the same time as he made this discovery, he started on theoretical researches which led to the first general solution of the problem of determining the centre of oscillation of a compound pendulum. In Part 1 the only reference to this, however, is a purely practical one: the clock could be adjusted to measure the mean solar day by moving a rider on the pendulum rod on either side of its middle position.

Huygens hoped much from the use of his pendulum clock, suitably suspended, to determine longitudes at sea. The matter is discussed optimistically in Part 1, but no dependable results were ever obtained with regularity on the various trials carried out during his lifetime. Bifilar pendulums and many others all proved unsuitable. Huygens invented a spiral spring regulator in 1665, and brought out a clock employing this ten years later. Clearly, it was only the lack of the necessary workmanship which stood between this principle and a successful chronometer. The spiral spring regulator does not enter the pages of the "Horologium", however, and this is accordingly a digression. Huygens, in fact, put his faith in the cycloidal pendulum clock equipped with a *remontoire* for greater exactness. Such clocks he con-