considerable area. In temporarily uninhabitable areas food will not pose an immediate problem. Monitoring should be used as a guide in entering these areas and assessing the safety of the food found there.

Biological Warfare Hazards

Biological warfare may involve a twofold risk to a country's food supplies: a reduction in agricultural output due to infection of crops or livestock, and contamination of food that will involve a direct hazard to human health.

The conference reported that the hazards to food from biological warfare and bacterial contamination could best be reduced by (*a*) the full development of public health and similar services and the utilization of existing knowledge in detection and control; (*b*) the inclusion of instruction in the hygienic handling of food as part of civil defense training; and (*c*) the universal application of heat to all suspected foods.

Chemical Warfare Risks

Chemical warfare hazards through contamination apply both to agriculture and to man, the conference noted. The risk to the former is probably small, and the risk to man is considered to be most likely in terms of antipersonnel weapons. Where hazards to foods are involved, methods of identification, protection, and decontamination are the main defensive measures.

Concentration of Food

Although the dehydration industries have been severely curtailed since the last war, the conference reported renewed interest in dehydrated products for use by the armed services and civil defense. There is need for further research—including far more background research—into means of improving palatability, ease of reconstitution, keeping quality, and packaging.

Scientific Problems in Food Defense

By NORMAN C. WRIGHT, D.Sc., Ph.D.

It will be convenient to group the scientific problems of food defense under three broad heads: first, those concerned with the maintenance of an adequate and acceptable diet for all sections of the population, and specifically with meeting essential nutritional needs under emergency conditions; second, those involved in the reduction of the bulk and weight of essential foods, in their storage properties, and in their distribution in a convenient, attractive, and easily handled form; and third, those related to the protection of food stocks and to the salvage of damaged supplies.

Many of the problems falling under these three heads are closely paralleled by the wider problems of maintaining an adequate national food supply under war conditions. Moreover, they are relevant even in the more limited field of emergency feeding of the fighting services where specially concentrated ration packs are used. This is, indeed, the reason why the civil departments concerned with research and development in food science in the United Kingdom share with the services the responsibility for investigating the scientific problems involved in food defense—a partnership which has in practice proved of great mutual benefit.

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Maintenance of Adequate Diet

Basically, the adequacy of a diet is measured in terms of specific nutrients, that is, its calorie value and its content of protein, mineral constituents, and vitamins. In considering the long-term needs of a whole population under war conditions, all these must be taken into account. But for relatively short-term purposes, such as those involved in temporary emergency feeding, evidence indicates that it is the total calorie value of the diet which is of primary importance and which can be used as the best index of nutritional adequacy. This applies particularly to civil defense and essential industrial workers who have to undertake heavy physical tasks, frequently under conditions of stress. From the planning aspect, it is therefore essential that we possess a clear view of the levels of calorie requirements of different sections of the population under such conditions. We also need an indication of the probable effects of reduced calorie levels on physical efficiency, industrial output, and morale, particularly when the interruption of normal feeding is likely to be prolonged as in hastily evacuated industries or in areas cut off from normal supplies by enemy action.

Apart from the consideration of total food intake as measured in terms of calories, provision must also be made for safeguarding the health of the so-called vulnerable groups in emergency conditions—expectant and nursing mothers, infants, and invalids. The nutritional needs of these groups are well recognized. The technical problems involved are concerned rather with the provision of substitutes for essential foods, such as liquid milk, should normal distribution fail, and with devising packed rations for these special groups during evacuation or temporary isolation. A further group whose requirements under emergency conditions need to be assessed and met are those injured as a result of enemy attack, whether from shock, physical injury, or damage from special hazards such as radiation. These aspects of special dietary requirements under emergency conditions clearly form the indispensable basis of any emergency feeding plans.

But while a sufficient supply of essential nutrients is the prerequisite of an adequate diet, it is no less important that such nutrients should be furnished in an acceptable form. It cannot be too strongly emphasized that one of the most effective means of maintaining the morale of a population under stress is that their diet, and the foods which compose it, should deviate as little as possible from normal food habits. Thus, in the United Kingdom great stress was laid in the last war on the maintenance of daily deliveries of bread and of milk. In the same way such foods as are provided at emergency feeding centers should be those to which the people are accustomed and attracted; a sudden emergency is no time for introducing untried novelties. A typical example which may be quoted to illustrate this point is the provision of dried soups for emergency feeding. It is right and natural that nutritional experts should stress the importance of insuring that such soups have a high nutritive value, but it is at least equally essential that this should be combined with universal acceptability. Indeed, for short-term emergency purposes the first essential is that the foods supplied should be attractive to the consumer. The problem of the food scientists is how to incorporate into such an attractive dish the nutritive properties which furnish maximum sustenance.

Reducing Bulk and Weight

This principle is equally important in considering the second group of problems listed earlier: those involved in reducing the bulk and weight of essential foods and in improving their storage properties. For many foods, notably animal products—such as milk, eggs, and fish—vegetables and fruit, the most effective method of reducing bulk and weight is by eliminating the contained water. But it is found that the most acceptable of the resulting artificially dried products are those which on reconstitution most closely simulate the natural food.

Thus, milk powder manufactured by the spray drying process furnishes on reconstitution a product practically indistinguishable from liquid milk and has a ready sale. The present difficulties in reconstituting it into liquid form, however, still make it less acceptable to many housewives than, for instance,

canned evaporated milk. Dried egg powder, the uses of which as a substitute for shell eggs are more limited, only achieved popularity as a result of the serious shell egg shortage and after the housewife had gained considerable experience in its use. In spite of its ease of reconstitution, potato mash powder still has only a limited sale. Moreover, the trend of demand in the British fighting services is for dried potato slices rather than for mash—an indication of the general preference for a product which on reconstitution most closely retains its original appearance and properties. There is little doubt that the same general argument would apply to other dried vegetables (as it does to dried fruits) and to dried meat and fish if offered for sale to the public.

Three Essentials

These examples have been quoted to show that, in devising methods of reducing bulk and weight, at least three essentials must be taken into account: first, the product must be capable of reconstitution into a form to which the consumer is accustomed; second, the method of reconstitution into this form must be simple and rapid; and third, the product must be capable of storage for relatively long periods without deterioration in flavor or texture. If these conditions could be met, such dried products could, from the standpoint of civil defense, be of real value. In the first place they would form an attractive variant in emergency meals or in the supplies used for the initial feeding of evacuated populations—or indeed for temporarily isolated populations who can only be fed by airlift operations. In the second place, if the housewife were once accustomed to their use in the home, they would form a valuable item in household larder stocks to meet temporary or emergency shortages. For both these purposes it is, however, essential that the products be sufficiently attractive to find a market under peacetime conditions so that in an emergency they would not be considered simply as undesirable substitutes for the genuine product. They must, in brief, possess sufficient advantages to stand on their own merits.

The production of artificially dried foods of improved acceptability constitutes one desirable technical development in this field. There are, however, a number of other directions in which science should be able to increase the availability of foods for emergency purposes. Bread constitutes the main basis of all Western diets, but at present we are completely dependent on static or, in an emergency, mobile bakeries for our day-to-day supplies. While the bulk of a nation's bread will always need to be freshly baked, it might well be desirable to have available an alternative long-keeping product for which local baking facilities and fuel supplies are not needed. Canned bread and foil-wrapped bread provide two methods of meeting this need. Another alternative is the more extended use of antistaling and antimold agents. While the use of such agents is probably not desirable as a national policy in peacetime, it ought clearly to be given consideration as a possible emergency measure. The same comment applies to antioxidants, which are capable of delaying the development of oxidative rancidity and tallowness in the long-term storage of fat-containing foods.

Fields for Study

Any assessment of the effectiveness of such special measures, and of the possible risks which they might entail to the consumer, must be based on scientific investigations of a relatively fundamental nature. Systematic studies are, however, equally necessary in solving many of the more practical problems involved in emergency feeding. Thus, the selection of equipment for the preparation and serving of meals at emergency feeding centers necessitates careful tests of their suitability and reliability. This applies not only to such considerations as the effectiveness of the insulation of containers designed to hold hot beverages, but even to such subjects as the heat conduction of beverages in relation to their "thickness" (or viscosity) and their rate of "settling"—factors which have been shown to influence to a marked degree their heat-retaining properties. Again, when emergency equipment has to be procured in very large quantities (e. g., individual feeding utensils) it is essential that the choice of the various items should

be based on systematic studies of their design, robustness, and ease of stowage.

The problems so far discussed have been concerned mainly with the production and properties of foods suitable for civil defense feeding. A no less important field of study is the problem involved in the packaging and transport of food, whether for general civilian feeding, emergency feeding, or the supply of food to the fighting services.

Packaging and Transport

As regards packaging, the outstanding problem in the United Kingdom is the acute shortage of packaging materials, particularly of tin plate and of the fibrous materials required for sacks and wrapping. This shortage can only be met by the development and use of substitutes which have the necessary properties of impenetrability to moisture and air and which are sufficiently robust to withstand prolonged storage and subsequent handling. One incidental advantage of the use of such substitutes is, however, that they may lead to the adoption of packaging methods which have certain advantages over those used during the last war. Thus, foil-wrapping and the use of synthetic materials, such as pliofilm, are capable of substantially reducing the weight of, for instance, emergency ration packs—a point which is of importance both for civil defense purposes and for the fighting services.

As regards transport, it is now well recognized that the efficient conduct of a war places a most severe strain on a nation's road and rail services. Experience in the last war showed that one of the limiting factors in securing the optimum use of these services and facilities was the time taken in handling freight, which in turn is influenced by the size, shape, weight, and nature of the packages to be handled and by the extent to which freight handling can be mechanized. The existence of an emergency in any given locality due to enemy action, in which, for instance, one sector of the transport system has been badly disorganized, combined with a probable shortage of available manpower in such an affected area, would intensify the need for the greatest efficiency in all freight handling operations.

Protection and Salvage

Finally, there is the third general group of problems, namely, the measures needed for the protection of food stocks from deterioration or damage, and for their disposal if they are unfit for human consumption. The prevention of deterioration is, of course, a wide problem which affects the whole policy of stockpiling on a national basis, but it involves special difficulties when applied to the local storage of food supplies for emergency purposes, since such local stocks may on occasion have to be stored in hastily improvised premises.

Moreover, damage to food stocks resulting from direct enemy action clearly falls within the province of the civil defense services. In the last war such damage was limited to the direct and indirect effects of blast and fire, and much information is available regarding both the nature and extent of the damage likely to be caused by these hazards and the means of minimizing their effects. The development of new hazards resulting from radiation and from bacteriological and chemical contamination has, however, opened up a fresh series of problems on which scientific investigations and guidance will be required. These problems involve not only the determination of the nature and severity of the contamination, but an assessment of the risks involved in consuming the contaminated food. Indeed, the safe disposal of such food may itself involve a very real problem, quite apart from the practicability of salvaging operations.