Dyme (1950) has shown that a daily ration of 1331 Cal. with a protein: fat: carbohydrate ratio of 1: 1·3 : 5 requires an intake of 1000 ml. water to prevent dehydration. The R.A.F. emergency ration, Mk. V, which has a ratio of 1 : 2·5 : 5·1 and provides 1500 Cal. daily for 4 or 5 days, on extensive trials has been estimated to require about 1500 ml. The final step must be to assess the difference between a pure carbohydrate diet and the universal part of the Mk. V ration, with a ratio of 1 : 2·8 : 7·7, and providing 4771 Cal., in circumstances of a fluid water intake of the order of 560 ml. per head daily. The development of new processes for the desalination of sea water will affect the issue. At the moment an R.A.F. survivor would seem better placed with a ration suited to sea and land survival, even if not ideally perfect for the sea, than with a ration primarily suited to sea survival alone.

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Planning Food Supplies for Tropical Expeditions

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Special nutritional requirements in the tropics

'A tropical climate is an aggressive climate and must be met aggressively' (Macpherson, 1949). To be able to do this effectively the influence of a hot climate on man must first be understood and then, armed with the knowledge, it is possible to plan ahead to meet the special requirements of life in the tropics. In the present paper the manner in which a tropical climate affects man's dietary needs and habits, and the general principles guiding the planning of food supplies, are discussed. The precise requirements of food and equipment for any one expedition must of course depend on the number of individuals, the amount of transport, the availability of local supplies, and the location and duration of the expedition. Ideal requirements may have to be modified to conform to a 'cost ceiling'.

Men living in hot climates are under stress; the degree of stress depends on the heat load of the environment and on the state of the individual exposed to it. The climatic factors that contribute to the heat load of the environment are: air temperature, air humidity, radiant heat flux, and air movement. The effective temperature scale (Houghten & Yagloglou, 1923), modified to include the influence of radiant

heat (Bedford, 1946), combines the contribution from each of these variable factors into a single index of the physiological stress imposed by the environment. By using this index it is possible to compare the environmental heat stress in such widely differing types of climate as the hot-dry or desert type and hot-wet or jungle type.

The degree of strain experienced by different individuals when exposed to similar environmental heat loads is modified by many factors, some of the most important being: (1) Heat of metabolism. The increase due to physical effort under tropical conditions is of special importance in determining the limits of endurance. (2) Degree of acclimatization. During the first few days of exposure to a heat stress adaptive changes occur, and there is a progressive reduction in the physiological strain experienced. (3) State of health. The nutritional status of the individual and his psychological stamina and moral fibre are included, as well as the presence or absence of disease. When selecting personnel for service in the tropics attention should be paid to all these factors. (4) Clothing. In the desert clothing may help to reduce the radiant heat gain; in a hot-wet climate it should be reduced to a minimum to allow the maximum evaporation of sweat.

When man is exposed to a high environmental heat load certain physiological changes occur. They are primarily the result of adjustments to maintain the thermal equilibrium of the body, and their magnitude is a measure of the strain experienced. In addition certain changes may be a direct result of the strain itself. They include: (1) The production of sweat. (2) An increase in the rate of circulation of the blood and alterations in its distribution throughout the body, including a reduced visceral supply and an increased peripheral circulation. (3) Changes in skin and body temperatures. (4) A tendency to decrease the level of physical activity, thus reducing the heat of metabolism. (5) Anorexia. (6) Psychological changes.

Sweating is the vital mechanism for cooling the body at high effective temperatures, since by virtue of the latent heat of evaporation of water both the heat of metabolism and additional heat gained by conduction, convection and radiation from the surroundings must be eliminated.

Water is the most important single component of sweat but it also contains mineral salts, of which the chlorides of sodium and potassium are the most important, other mineral substances, small amounts of vitamins, and various organic compounds. The water intake required to replace sweat losses may be considerable, for example 12 qt. in 24 h for men marching in the desert (Adolph (and associates), 1947). Sweat losses exceeding 8 pt. in 4 h may be regarded as the upper limit for fit acclimatized young men; above that limit an increasing number of people will find the conditions beyond their endurance (McArdle, Dunham, Holling, Ladell, Scott, Thomson & Weiner, 1947). It is essential to replace water lost by sweating as rapidly as possible so as to avoid the serious effects of dehydration (Pitts, Johnson & Consolazio, 1944). Moreover, the need for water may outstrip thirst; 'it should be emphasized that during work men never voluntarily drink as much water as they sweat, even though this is advantageous for maintaining heat balance, but usually drink at a rate approximating about two-thirds of the water lost in sweat'

(Pitts *et al.* 1944). Over long periods, the best indication that enough water is being drunk is provided by the daily urinary output: 'some 700–900 ccs. per day must be recognized as usual and necessary' (Adolph (and associates), 1947). Thus, if urinary output falls below 1·5–2 pt./day, it is clear evidence that the fluid intake is insufficient.

To encourage individuals to drink adequate quantities of fluids at frequent intervals it is essential in equipping the expedition to provide suitable water containers. They should include large containers of from 5 to 50 gallons capacity for the main supply, and individual desert water-bags in which the contents are cooled by surface evaporation. Collapsible, lightweight canteens with a capacity of at least 2 qt. are ordinarily enough to supply men between meals even when marching under desert conditions. If surface water is likely to be used the expedition must take filtration pumps and water-sterilizing chemicals for the main supply, and each individual should carry a filtration bag and pocket sterilizing outfit.

After water the most important constituents of sweat are the chlorides of sodium and potassium. There are individual variations in the concentration of these salts in the sweat, and a decrease may occur with acclimatization (Lee, 1940; Dill, Jones, Edwards & Oberg, 1933; Talbott, Edwards, Dill & Drastich, 1933); the concentration is usually of the order of 0·1–0·2% (Adolph (and associates), 1947). In average tropical conditions the loss of salt through sweating will be covered by the dietary intake, provided enough salt is used in cooking and as a condiment, and regular, balanced meals are eaten. In exceptional conditions and during the first 2 or 3 weeks of acclimatization, from 15 to 20 g salt may be lost from the body each day, and it may then be advisable to supplement the dietary intake by tablets of salt or salinated drinking water. Both methods have drawbacks, the former frequently causes some degree of nausea and the latter may, by decreasing the potability of water, discourage adequate drinking.

There is some evidence that in tropical climates the dermal loss of iron is increased (Mitchell, Hamilton & Haines, 1949; Mitchell & Edman, 1951) and iron-deficiency anaemia is not uncommon. The use of iron kitchen utensils might, however, supply enough extra iron to meet such losses (Widdowson & McCance, 1943).

Estimates of the vitamin losses in sweat show a considerable range of variation (Mitchell & Edman, 1951), but they are generally small in comparison with the dietary intake. There would seem at the present time to be no satisfactory evidence for any benefit from taking vitamins in excess of the known requirements for temperate climates. The conclusion of workers who studied the nutritional requirements of troops in tropical climates during the second world war is of interest: 'We can give no support to the proponents of high vitamin intakes in the tropics when a healthy adult population is in question. It was our impression that morale, fitness and health of U.S. troops were not affected either adversely or beneficially by sporadic or regular use of vitamin pills' (Kark, Aiton, Pease, Bean, Henderson, Johnson & Richardson, 1947).

It has been suggested that the protein intake should be reduced because its high specific dynamic action will contribute to the heat load (Lusk, 1928). For a man

marching, the additional heat from specific dynamic action may be 5% of his total metabolism and, if the heat stress is such that his endurance is taxed to the limit, such an amount could prove critical (Johnson, 1943).

Foods comparatively rich in protein are, however, generally the more appetizing ones, and the amount of protein in the diet has been shown to determine appetite at levels well above the minimum requirements (Dole, Dahl, Schwartz, Cotzias, Thaysen & Harris, 1953). Since it is of paramount importance in the tropics to maintain a good appetite for food, there should be ample amounts of protein in the diet, and the quantities should not be less than those recommended for men in temperate climates.

The amount of fat in the diet may be less than is usual. There is not the need, as in the polar climates, for a concentrated source of energy, and dishes rich in fat are generally unacceptable in the tropics, although in extreme conditions foods that are easy to swallow have been found to be preferred, and oily preparations are then acceptable. Dishes of indigenous peoples in many tropical countries are often oily; it would be wise to indulge in such foods only at the end of the day.

One result of exposure to a hot climate, which has already been mentioned, is a reduction in physical activity which results partly from economy of body movement in everyday life and also from a more complete relaxation while resting (Hindmarsh, 1927).

The lighter clothing worn in the tropics (Gray, Consolazio & Kark, 1951) and the decrease in the basal metabolic rate (Quenouille, Boyne, Fisher & Leitch, 1951) also may contribute to lowering metabolism. The voluntary dietary intakes of soldiers engaged on the same general duties in widely differing climates have been shown to be correlated with environmental temperature (Johnson & Kark, 1947). To compute calorie requirements for hot climates it has been tentatively recommended that 'for every 10° departure in mean annual temperature from the reference temperature of 10° C., requirements should be adjusted by 5 per cent of requirements at the reference level, the 5 per cent being subtracted for higher temperatures and added for lower temperatures' (Food and Agriculture Organization of the United Nations: Committee on Calorie Requirements, 1950, p. 32). The food requirements can, therefore, be expected to be a little below those for a similar mode of life in a temperate climate.

Loss of appetite, and even distaste for food (anorexia), are manifestations of the physiological strain of hot climates, especially during the period of acclimatization (Lee, 1940); they become marked if the fluid intake is insufficient to replace the water lost by sweating (Adolph (and associates), 1947). The chief nutritional problem, therefore, is likely to be not how much and what the individuals ought to eat, but what and how much they are willing to eat. Irregular habits of feeding, which are all too easily adopted in the field, and the desire to avoid the extra work of cooking and preparing proper meals, can accentuate this problem and lead to malnutrition. The solution is to adopt a strict discipline with regard to meal-times, and to provide a varied and appetizing diet of high nutritive value. A low food intake with a loss of body-weight is very common during the first few weeks of exposure to tropical

conditions. After the initial period, changes in weight provide one of the best objective criteria of satisfactory nutrition.

Choice of foods

The physiological reasons for special nutritional requirements in the tropics having been discussed, the choice of victuals and equipment for an expedition can be briefly considered. The energy value and nutrient content of individual foods can be determined by means of tables; values for foods commonly used in the tropics have been published (Platt, 1945). There are specimen dietaries available which indicate the relative proportions of each foodstuff (Platt, 1946; Berryman & Chambers, 1943), and if they are used as a basis for planning the food supplies the omission of essential items will be avoided. In choosing individual items the merits and drawbacks of unprocessed compared with processed foods must be carefully weighed; certain foods must be taken in processed forms to ensure their preservation in tropical conditions, and with others the saving in weight and bulk of carrying compressed and dehydrated products is a great advantage. Some foods are much less appetizing when processed than when fresh and several of the vitamins may be lost in processing, preservation or cooking. Manufacturers are, however, well aware of such risks, and the food technologist, who should be consulted about the vitamin content of particular products, has applied himself in recent years to securing foodstuffs in which the vitamin content is preserved (Bate-Smith & Morris, 1952).

One of the main reasons for complaints about the unattractiveness of dishes prepared from processed foods, especially from certain dehydrated products, is in the faulty methods used for reconstituting, cooking and serving them. If they are taken on an expedition the cook must know their limitations and learn beforehand how best to use them. Too much emphasis cannot be placed on the importance of skilled cooking; the best of catering can be ruined by bad preparation and presentation, and it is surprising how many cooks can uniformly achieve a sameness of flavour no matter with what ingredients they begin.

In selecting the foods to be taken on an expedition consideration should be given to the likes and dislikes of the members. In reviewing the food requirements it is helpful to classify the individual items as follows: (1) cereals and their products; (2) starchy roots, tubers and similar products; (3) pulses and oilseeds; (4) meat, fish, milk and dairy products; (5) fruit and vegetables; (6) fats and oils; (7) 'menu value' foods such as flavourings and beverages.

(1) The aristocrat of tropical cereals is rice; it should be provided in the parboiled form, of which elegant preparations are available, on account of its keeping qualities and its good protein and content of B-vitamins. Suitably packed wheat flour is useful, and bread-making is no longer impracticable now that excellent dried, live yeast preparations can be got. Biscuits are always useful and are easily packaged. Blocks of dried cereal preparations have been made which reconstitute well and make acceptable breakfast dishes.

(2) Most tropical countries have some flours made from starchy roots or tubers, such as yams and cassava, or from fruits like plantains. Dried potato meal is obtainable and properly prepared makes a satisfactory dish as creamed potato.

(3) Pulses, nuts and oilseeds, including groundnuts and coconuts, have a useful place in the menu and provide a good source of protein. A fresh vegetable dish can be prepared from some of them after sprouting.

(4) Meat, fish, eggs, milk and other animal products are available in a variety of processed forms suitable for tropical conditions; they can be used to supplement game and other local sources of supply. Skim-milk powder is a useful preparation and there is a variety of tinned, concentrated milk products and processed cheeses. There are available moulded blocks of egg and cheese, egg and meat, and sugar and milk which can be used for custard.

(5) Fresh fruits and vegetables can almost always be got in the tropics, but to give variety fruits and vegetables not available can be taken in many processed forms; they include a remarkable range of tinned fruits and vegetables, tinned jams, sun-dried fruits such as figs, dates and raisins, and many dried vegetables.

(6) Tinned fats can be had for cooking, but dried butterfat, often locally available as ghee, is a good general purposes fat; it reconstitutes well and will keep in tropical conditions.

(7) Particular attention should be paid to substances in the 'menu value' group. They include flavouring agents, sauces, curry powders, spices, salt, and materials for beverages, including tea, coffee and dried lemonade powders.

Preservation and packaging of foods

Almost as important as the choice of the foods themselves are the methods adopted for their preservation and packaging. For those foods in which preservation depends on a barrier between the product and the atmosphere, for example dehydrated products in tins, many small containers rather than single large ones should be used. Correct packaging and accurate labelling with descriptions of the contents on the outside of each crate are obviously quite essential. The technique of packaging for tropical conditions is highly developed and useful hints and general principles are given in '*Recommendations for Preservations and Packaging for Tropical Theatres of War*' (British Standards Institution, 1943). The expedition's cook should be consulted about the type of equipment he wishes to use; for small expeditions with transport, excellent petrol-fuel stoves are available, and solid fuels are useful in individual packs. A refrigerator should be included in the equipment if transport facilities permit and its value in increasing the potability of drinking water and improving the palatability of the diet cannot be overstressed.

Transporting the food and its packaging, the kitchen equipment, mess kits, fuel, and the additional weight of the personnel to run the catering of a large expedition which aims at being self-sufficient, is a major problem.

Some idea of the weight that might be allowed for each component item in a large expedition and the average weight per head can be obtained from Table 1.

Table 1. *Weights of food and equipment required to cater for* 1000 *troops of the U.S. Army for* 5 *days (after Berryman & Chambers,* 1943)

Item	U.S. Field Ration A (lb.)	U.S. Field Ration B* (lb.)
Food and all packaging	34,200	24,450
Kitchen equipment	10,000	10,000
Mess kits	1,000	1,000
Fuel	1,200	1,200
Subsistence personnel	8,000	6,000
Subsistence for subsistence personnel	2,189	1,310
Refrigeration space (cu. ft.)	322	0
Total weight	56,589	43,960
Weight/man/day	11·32	8·79
Total weight/1000 Cal.	3·06	2·38

*In Field Ration B all perishable foods are replaced by non-perishable, processed or canned varieties.

Summary and conclusions

1. The physiological basis for special dietary requirements in the tropics is discussed.

2. To maintain maximum efficiency fluid must be replaced hour by hour, for which purpose it is recommended: that each member of the expedition should understand the basic physiological principles of man's water requirements in the tropics, and that cool, potable water should be made available for drinking at all times and in all circumstances by the provision of appropriate water containers.

3. Except in extreme conditions the salt lost in sweat can be adequately and most satisfactorily replaced at meal-times.

4. Anorexia can lead to an inadequate or unbalanced intake of nutrients. To avoid the difficulty certain steps can be taken. The food chosen for an expedition should permit of a varied and appetizing menu of the dishes the individuals are accustomed to eat. A strict discipline should be maintained in the preparation and consumption of regular meals. It is of great importance that a skilled cook should be selected; if dehydrated or other special processed foods are taken, the cook must have been trained in the art of reconstituting and cooking them.

5. Particular attention should be paid to the simple criteria of adequate nutrition, a urinary output of not less than 2 pt./day and the maintenance of body-weight.

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Himalayan Rations with Special Reference to the 1953 Expedition to Mount Everest

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Himalayan rations usually consist of a combination of bulk stores taken out from England or obtained in India and of foodstuffs purchased locally in the Himalayas. Rice, potatoes, *tsampa* (coarse flour made from roasted barley), *dhal* (a kind of lentil), eggs, chickens and meat are the chief foods available locally; fresh fruit and vegetables are seldom, if ever, obtainable.

The earlier Everest expeditions took with them a great variety of bulk stores. Later expeditions have come to depend increasingly on local food supplies, limiting their bulk stores to essential items not procurable locally, such as tea, powdered milk, sugar, jam, biscuits and butter.

Experience gained on expedition to Cho Oyu, 1952

On the expedition to Cho Oyu in 1952, which may be taken as typical of British postwar expeditions, a survey was made of nutritional and dietary problems. Measurements of the oxygen consumption of members of the party climbing at their normal pace at various altitudes made it possible to construct an approximate