drodystrophic development has been observed also in the control groups, but exclusively during winter time and not exceeding 5 per cent.

The appearance of chondrodystrophy in chicken embryos is morphologically well understood. It resembles the human disease known as achondroplasia foetalis, and is characterized by abnormal shortening of the extremities and pathological changes of the skeleton. The etiology of this disease is unknown.

In the study of experimental chondrodystrophy, the following facts were taken into consideration. Landauer¹⁴ noted the shortening of bones and disorder of skeletal formation in embryos and hatched chickens following a deficient food regime of the egg-laying chicken. The development of chondrodystrophy in the experimental chickens, as well as in the controls, mostly takes place during the winter months. This fact leads to the assumption that the cause of the disease is connected with a deficient diet, mainly as it appears owing to a deficiency of vitamin D—the regulator of calcium metabolism. In fact, the yolk of the chicken egg is, during winter, five times poorer in vitamin D than during the summer; and in some cases it may be insufficient for the maintenance of a normal blood calcium level and for normal calcification of the skeleton.

Incidentally, stimulation of the parathyroid gland can lead to drastic inhibition of calcification, and to abnormal development of the skeleton. The effects of the parathyroid hormone on the skeleton of the growing organism are well understood. It is known that large doses of parathormone cause decalcification of the skeleton, inhibition of cartilaginous tissue development, and epiphyseal degeneration of the bones¹⁵. It is most probable that chondrodystrophy is due to increased function of the parathyroid gland, caused by D-avitaminosis in the embryo. The results obtained with anterior pituitary lobe transplants may be explained from this point of view. The transplantation of the pituitary gland stimulates the parathyroid gland. This effect was observed and investigated morphologically on a large scale⁶. The stimulation of the parathyroid gland causes a flow of calcium from the tissues into the internal media of the organism, producing impoverishment of calcium in the skeleton. During the summer, the large amounts of vitamin D contained in the yolk of the egg easily counteract this impoverishment, stimulating the flow of calcium in the reverse direction. During winter, the amount of vitamin D is insufficient to counteract the hormone excreted by the parathyroid gland. As a result, severe disturbance in the skeletal development takes place with its decalcification and deformation.

Studies of the interrelationship of the endocrine glands in the causation of experimental chondrodystrophy, taking into account the influence of the vitamin D balance, prove almost certainly the hypothesis of the humoral nature of this disease. On the basis of the evidence at hand, it is possible to conclude that the function of the endocrine glands during foetal life is insignificant only under the optimal environmental conditions in which the foetal organism develops. As soon as a deviation from the optimum occurs, the endocrine system can be mobilized as one of the most important regulators of vital functions in the organism. In certain cases, the endocrine apparatus re-establishes the disordered balance and secures normal development. In other cases, when the balance is severely disturbed, as for example in deficiency of vitamin D (never noted in

birds propagating during the summer), disorder in the normal development occurs with possible aberrations in morphogenesis.

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NUTRITIONAL VALUE OF BEER*

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FROM the days when prehistoric man first observed the 'ferment' liquor and experienced the after-effects of a possibly too-potent brew, alcoholic beverages have played an important part in social history. The desire for variety in what we drink manifests itself at an early age, as evinced by the child's preference for coloured and 'fizzy' drinks. As an adult he frequently acquires a taste for a drink which in Britain justifies the term 'national beverage', namely, beer. With social aspects we are not here concerned; as in a number of other cases, while moderation is harmless and even beneficial, excess is disastrous. None will dispute that the cause of true temperance, ably abetted by H.M. Commissioners of Excise, has made enormous strides.

As beer occupies so important a place in the national economy and is often a normal constituent of the diet, it is not surprising that it has attracted the attention of the nutritionist. In recent years the science of nutrition has made important advances, and it is not unprofitable to consider beer in their light.

The nutrients which may finally appear in beer must obviously derive from the materials of the malting and brewing process, and from the biochemical actions which occur. The most important materials are barley, from which the malt is made; malt adjuncts such as maize and rice, which mainly provide additional starch; hops, yeast, sugars and brewing waters.

The essential reactions which occur in the malting of barley and the mashing of malt are enzymic in character. The starch in barley is of vital importance to the brewer since it is the basis of his extract, and largely provides the material for fermentation. In malting and mashing, it is converted by the appropriate enzymes to soluble dextrins and sugars, and by a somewhat analogous process the proteins are also largely converted to soluble products. At the boiling stage, two important changes, among many, occur: the addition of hops provides important antiseptic substances; and a proportion of the nitrogenous substances are coagulated. In fer-

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mentation there is a loss of some 50 per cent of the solid material of the wort. The carbohydrates are largely fermented to alcohol and carbon dioxide; many of the simpler nitrogenous substances are lost to the yeast, being necessary for its satisfactory growth.

So far, then, as solid material is concerned, the story of the malting and brewing process is one of loss; but the loss is not absolute, since, for example, the sugars are converted to alcohol. Starting with an average barley containing some 60 per cent of starch and 10 per cent of protein, the finished beer may contain about 3 per cent of carbohydrate, 0.2 per cent of nitrogenous substances, and 3 per cent of alcohol.

The carbohydrates consist of degradation products of starch, and there is no reason to suppose that they are not digested in the normal manner. Their amount is not large, but they do provide nearly half of the energy value of the beer. The nitrogenous material is much smaller in amount, but this also is digested. Little information is available as to the precise nature of these substances; it would be interesting to know if they include any of the essential amino-acids. Such information may be forthcoming as the result of application of microbiological methods of assay of amino-acids.

Whereas beer as a whole may be regarded as a food since it contains four out of the five classes of nutrients, the alcohol which it contains may be regarded as a nutrient only in a strictly limited sense. It acts solely as a more or less immediate source of energy, and has none of the other functions ascribed to a nutrient. It is a substance foreign to the economy of the body, which eliminates it as soon as convenient. Thus, it is readily absorbed in the stomach, and provided the amount is not excessive, fairly rapidly oxidized in the cells. On an energy basis it can, of course, replace *pro rata* other energy-producing nutrients; but this seems a somewhat academic point, since beer is taken as a beverage in addition to the normal diet by most people.

As beer contains no fat, the calorie value may be calculated by multiplying the total solids (virtually carbohydrate and protein only) by 4, the alcohol content in grams by 7, and adding the two products together. It will then be found that the calorie value is derived, frequently to the extent of more than 50 per cent, from the content of alcohol, that it ranges from about 120 calories per pint for the mildest ales, to about 400 calories per pint for the strongest, and that it bears a close relationship to the specific gravity of the wort prior to fermentation—the 'original gravity'. For example, a beer of original gravity 1,033.2 (water = 1,000) would have a calorie value of $(1,033.2 - 1,000) \times 5.25 = 174$ calories per pint. The experimental value in this case was 177. Thus, by taking the excess of the original gravity over 1,000 and multiplying by the factor 5.2 or 5.3 (5.25 was chosen above as the mean of these two factors) a reasonably accurate estimate of calorie value may be obtained.

It is desirable to stress that this is the calorie or energy value and not the nutritive value of the beer. It is misleading and erroneous to compare different foods solely on an energy basis; all the nutrients in a food must be compared when assessing nutritive value.

Of the minor but essential constituents of the diet there remain the mineral salts and vitamins. Mineral salts derived from the waters, the materials and possibly the utensils used in brewing are present in the beer. It is a brewing commonplace that the

nature of the water plays an important part in determining the nature and quality of the resultant beer. It was largely by reason of the characteristics of the local waters that London and Dublin became famous for stouts and porters, and Burton-on-Trent for pale ales. There is a very complex interplay between the various salts present during the brewing process, and the nature of the salts found in the finished beer depends on a number of physico-chemical factors not all of which are clearly understood.

The valuable salts of calcium are present in beer in very variable amount according to type and conditions of brew. In a number of analyses recently examined, the lowest content appeared to be of the order of 25 mgm. of calcium per pint, the highest about 270 mgm. per pint. The ratio calcium/phosphorus appeared to average unity for a wide range of beers and stouts, and this ratio may be regarded as satisfactory. On the basis of a daily requirement of 800 mgm. of calcium, it will be seen that one pint of beer might provide about 10 per cent of this.

At the present time it is not possible to say what proportion of calcium and phosphorus in beer is absorbed by the body. It is known that beer contains phytic acid derived from the grain, and investigation is proceeding whereby an accurate assay of this substance may be made. The estimation of the various fractions of organic phosphorus—hexose phosphate, phytic acid, etc.—is not at present on a satisfactory basis, and until accurate methods are available it would be invidious further to discuss the phytic acid question. Phytic acid is not itself absorbed by the body, and in addition it takes up a certain proportion of calcium (and iron) which is similarly lost. In the absence of quantitative data, it is nevertheless reasonable to point out that not all the calcium and phosphorus in beer is necessarily absorbed.

Of the other nutritionally important minerals, copper in small amount, and manganese are known to be present in beer. Sodium chloride and potassium salts also make in this way a useful contribution to the diet of heavy workers, or workers in heated atmospheres who tend to lose abnormal amounts of these salts by perspiration or excretion.

The story of vitamins in beer is a somewhat chequered one. It starts in the early days of vitamin history and at a time when the complex nature of vitamin B was not realized. Examination of barley and malt led to the belief that although vitamin B might be present to a small extent in these products, the amount in the finished beer was so small that it could be disregarded. It is interesting to note that at this time vitamin C was found in germinating cereals and pulses, and was thus present in barley on the germinating floor of the maltster. It does not, however, survive the subsequent kilning and brewing processes, and is not a constituent of beer, although claims to that effect were made so recently as 1935.

Following the earlier disappointing results, interest in vitamins in beer waned, and it is only quite recently that it has revived, threatening at one time to become 'a seven days wonder' in the popular Press. In the intervening period, the complexity of vitamin B had been realized, and at the present time there are not one or two, but ten or eleven members of the group, and still more are likely to be established. Moreover, the accurate assay of the various members of the complex has been a primary objective for many laboratories in Great Britain and the United States. The methods employed are three in type:

biological, microbiological and physico-chemical. Each has its difficulties and is being subjected to intensive study by teams working in collaboration. Although results in some cases leave something to be desired, important advances have been made, and it is now possible to assay with some degree of accuracy the most important members of the complex.

The application of such methods to brewing materials and processes is a recent development, and it is now known that several members of the vitamin B complex are to be found in beer, in amounts which may have some dietary significance. Detailed investigation has so far been devoted to aneurin, riboflavin and nicotinic acid. Other members of the vitamin B complex are under examination, and findings are likely soon to be published. These include pantothenic acid, pyridoxin and biotin; but their position with reference to human nutrition in general still needs some clarification.

In the case of aneurin, there is some loss when barley is malted, but little change in mashing and boiling. In fermentation, however, a remarkable change takes place, most of the aneurin in the wort being taken up by the yeast at the expense of the beer, which cannot therefore be regarded as a very good source of the vitamin. The amounts reported, in $\mu\text{gm.}$ per pint, range from about 7 to 35, and contents as high as 85 have been found in certain strong ales.

With regard to riboflavin, there is increase both in malting and in fermentation, many yeasts having the power of synthesizing riboflavin, with the result that the beer contains appreciable amounts and the yeast crop is greatly enriched. The riboflavin content of beers ranges from 200 to 800 $\mu\text{gm.}$ per pint, the higher limit being attained only by some strong ales.

Nicotinic acid is also present in appreciable quantity; derived like the others from the original barley, there is some increase in malting, after which the subsequent processes involve slight losses. Yeast appears neither to synthesize nor take up significant amounts of the vitamin. Finished beers contain from 2 to 11 mgm. per pint, with an average of 5 or 6 mgm.

The three vitamins discussed above are known to have important relations to carbohydrate metabolism in that they are constituents of enzymes concerned. It should be remembered in this context that the carbohydrates (and nitrogenous substances) in beer make their own demands on these vitamins, and only after such demands are met will the balance of the vitamins make a positive contribution to the general diet. It is difficult accurately to assess such contribution; but it is safe to suggest that a moderate consumption of beer increases the vitamins generally available, at least so far as riboflavin and nicotinic acid are concerned.

The antiseptic and other constituents of hops, while important as agents which give beer some of its pleasing characteristics, are of no direct nutritional significance; but it should be mentioned that the presence of these substances and the conditions of manufacture render beer, from the microbiological point of view, one of the safest of our beverages.

There would seem to be a case for a systematic study of the constituents of beer in relation to modern views on nutrition. While the results of this would be interesting and even important, it has to be admitted that in this case—as in many others—the public consumes the product primarily because it likes it.

OBITUARIES

Dr. F. W. Lanchester, F.R.S.

DR. F. W. LANCHESTER died at his home in Birmingham on March 8, and the world of engineering lost a figure of the type which is perhaps only just beginning to be appreciated—a great physicist who applied his knowledge and critical mind to engineering problems. He was born on September 23, 1868, was educated privately and received his scientific training at the Royal College of Science, South Kensington. His earlier days were devoted to the automobile world, and he is generally credited with having produced the first motor-car driven by an internal combustion engine in 1895–96. He certainly founded the Lanchester Motor Co., Ltd., in 1899, and the firm's first product contained many unique features typical of his genius and unorthodox views. He was afterwards associated with the Daimler and B.S.A. companies, and then took up the compression ignition engine with Messrs. Beardmore, which activities lasted up to 1930.

Since 1930, Lanchester has been a free-lance consultant, and has often surprised those who were privileged to know him by the breadth of his interests. Unfortunately, he was attracted only by the academic interest of problems, and it usually fell to others to reap both the credit and the financial rewards of his original thinking. Lanchester had too big a mind to allow this to deter him, although the unfairness of it sometimes led him into controversies that have often caused him to be labelled 'difficult'. It has been said of him that "his brilliance blinded those around him and some never recovered from their blindness". An extremely sensitive nature made it impossible for him to fight even for his just rewards, still less to accept anything that carried a suggestion of charity, and consequently he died really poor.

Lanchester's name will be honoured, perhaps more than anywhere else, in the world of scientific aeronautics. He presented papers to the Birmingham Natural History and Philosophical Society in 1894, and to the Physical Society in 1897 on the subject of aerofoil theory, the concepts of which are to-day firmly established as the theory of lift and drag. His two volumes, "Aerial Flight, Aerodynamics and Aerodynamics", published in 1907, laid the foundations of the theory of flight that remain uncontradicted and accepted everywhere to-day. This work, afterwards elaborated by Dr. L. Prandtl of Göttingen, is to-day known as the Lanchester-Prandtl theory, and this circulation theory is accepted universally as the basis of modern aerodynamic science. In 1916 he published a book entitled "Aircraft in Warfare", which was a reprint of a series of articles contributed by him to *Engineering* before the outbreak of the First World War. Many of the precepts that he laid down there have since become the commonplaces in warfare. Some of these, notably the airborne torpedo and the use of the naval aircraft carrier, only received their full recognition and development in the Second World War. During late 1939 and early 1940, *Flight* published what was probably some of his last scientific writing, entitled "Exhaust Efflux Propulsion", laying down a scientific basis of jet and rocket propulsion. The trend of development in these matters is already showing that his pioneering thought upon this subject is likely to prove as fundamentally correct as his other aerodynamic work.

In addition to the writing of books and articles, Lanchester was a member of the original Advisory