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The Effects of Soil and Diet on Disease

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SUMMARY

In South Africa there is a high incidence of esophageal cancer. An intensive study in the Transkei, a Province of South Africa, has shown the incidence of the disease to vary depending on location. These people do not share the diet of other racial groups in South Africa who do not have the same high frequency of the disease.

Many factors point to diet playing a major role in the carcinogenic process. These factors may, however, be the interaction of multiple factors one upon the other.

Diet is determined by the soil in which there may be abnormal metals, deficiency of essential elements, and increased silica and quartz. Diet can influence the tissue directly by containing potent carcinogens or weak carcinogens which may be potentiated by factors in the diet, acting directly by causing irritation, or indirectly by lowering the resistance of the body to disease.

There is still a great deal of work to be done which, although centering on diet, has many facets. One must of necessity keep the holistic approach until each factor is thoroughly investigated and the puzzle is eventually unraveled.

The investigation in the Transkei is primarily an epidemiologic one. This is, however, hard to divorce from an etiologic search. So many potential carcinogens can be found if one looks hard enough that, when no very outstanding factor of cause and effect is evident, it is well to look at the broad principles involved and study more closely the interaction of the multiple factors upon one another.

There is a high incidence of esophageal cancer in the Transkei where it is unevenly distributed over an area of 16,440 square miles (8). This high incidence has only been evident since the late 1940's and is slightly higher in males than females (5:4). The latter form a static population which subsists on the produce of their own farms, supplemented at times by refined goods, e.g., sugar, tea, and flour from the local Trading Store.

GEOLOGIC CONSIDERATION

One of the earliest correlations with the disease was a geologic one where 89% of disease-rife areas were found on Beaufort Sediment and 64% of the disease-free areas were on dolerite (4). These geologic correlations could not be ignored in spite of the skepticism voiced at the time. It was agreed that the correlation could hardly be a direct one but might be related to the natural poverty of the soil, deficiency of trace elements, and further depletion by bad farming practices with resulting soil erosion, etc.

The significance of the fact that Beaufort Sediment has up to 70% available silica whereas dolerite only has about 10% will be considered later.

TRACE ELEMENTS

An investigation of these disease-prevalent areas confirmed the presence of complex trace element deficiency greater in the gardens of cancer sufferers than in the gardens in cancer-free areas. Experiments carried out by leaf injection on maize, beans, and pumpkins showed deficiencies of molybdenum, copper, boron, zinc, manganese, and iron. (2).

Essential trace elements act as catalysts for the proper functioning of enzymes in the tissues of plants and animals; for example, cobalt is necessary for vitamin B_{12} synthesis in ruminants, and molybdenum for the synthesis of nitrogen in plants. A number of diseases among animals have been traced to deficiencies in the soil. For example, in the everglades of Florida, the tendency to bone fracture in domestic animals disappeared when copper, found deficient in the soil, was added to their diet.

Roach, when at East Malling (7), reported that both manganese and iron deficiencies led to abnormalities in leaf content in respect to numerous compounds, including members of the amino acid and phenolic fractions. Not only were there compounds in the normal half of the leaf that could not be detected in the abnormal half, but there were also compounds in the deficient half of the leaf that could not be detected in the normal half. It would seem that deficiencies in the soil cause abnormal metabolism in plants which, when eaten by man, may prove to be toxic.

The toxicity of plants under varying soil conditions is at present under investigation. Evidence of changed morphology under different soil conditions is demonstrated by the *solanum nigrum* in the Transkei. This plant is closely related to the deadly nightshade of Europe, and yet the berries are relished by all sections of the South African population and the leaves are popular with the Bantu as a spinach and even dried for winter use. We have collected 5 different morphologic types. The difference in morphology depends on where the plant is found, whether in fertile gardens, forests, or old soil eroded gulleys. Dr. Schütte (11) grew the seed of *S. nigrum* and found a lush growth in the molybdenum-deficient media, whereas that grown in a fully nutrient medium was somewhat smaller and straggling.

DIET

It may be significant that esophageal cancer has its highest rates among peasant farmers in areas like China, Calvados in

France, and Karzagestan in Russia, where people have subsisted on the produce from the same soil for generations. Esophageal cancer in Africa appears to be confined to the East along the lines of migration south of the Sudan. According to Schütte (10), 80% of agricultural land in Africa carried crops that suffer from nutritional disturbance, and the people from Egypt to South Africa suffer from Kwashiorkor (protein deficiency) which is generally considered to be a deficiency of essential amino acids.

The staple diet in the Transkei is maize, containing the protein zein with a biologic value as low as 54 and a deficiency in two essential amino acids–tryptophan and lycine. This protein is supplemented with beans and pumpkins, in good seasons only, and edible weeds (the value of which is as good as the ground upon which it is grown). Meat and milk, protective first class proteins, are less available than previously, and eggs are never eaten by women, rarely by men.

There is evidence to support the view that resistance to disease, especially tuberculosis, is decreased in protein-deficient diets (5).

TOXIC PLANTS

Plants used as food and medicine play an important role in the lives of these people and warrant investigation. At present the investigation has hardly progressed further than a collection of data. We have collected over 500 plants used by these people. One hundred and fourteen species of 35 families are eaten as food; the rest are used medicinally–internally or externally, as drops, inhalations or plasters. Because the people believe they have been poisoned when they are ill, emetics and enemas form the greater part of their pharmacopoeia. If the emetic is strong, the medicine is good; if it is foul tasting and burns, it must be effective. What better way of ridding oneself of evil spirits, which are the cause of all ills, than by burning them away? Thus red chillies are drunk in tea to cure pulmonary infections. If chillies are unobtainable, then zinc *Capsicum forte* is brought from the local store or chemist for the same effect.

Senecio. Schoental and Head (9) have found the pyrrolizidine alkaloids of the senecio plants not only toxic to the liver but hepatogenic.

There are some 300 species of senecio widely distributed throughout South Africa (13). We have collected and identified 19 species which are used medicinally or as food in the Transkei. Batten and Bokelman (1) report the presence of 11 others in the Eastern Cape; Watt and Breyer-Brandwijk (14) report two more used in the Transkei.

Of these 32 species 8 are cooked as pot herbs, 2 are mixed with tobacco and used as snuff, 11 are taken internally, and 8 are applied externally. The root, juice, seeds, and leaves are all used in various forms, *viz.*, poultices, decoctions, emetics, enemas, snuff, washing, and tattooing. The uses range from weaning babies, curing madness, and "curing" cancer in horses to washing away bad luck.

Cycads. Cycasin, the alkaloid obtained from cycads, has been found to consist of a highly toxic moiety related to the nitrosamines.

A number of species of cycad grow along the Transkeian coast, and it is likely that they are more commonly used than is generally supposed. Poisoning with the seeds has been reported by Steyn and Verdoorn (12) in the Transvaal in 1948. Some of the known uses of cycasin in the Transkei are as follows:

The bark of *Encephalartos altensteinii* is cut up, boiled, and drunk as an emetic to cure coughs. It is also used to wash away bad dreams. The same uses are reported for the bark of Stangeria, which also allegedly cures fevers. Women with small babies wear a necklace of Stangeria roots, and when the babies are ill the women bite off a piece, chew it, and then give it to the baby as an emetic.

TOBACCO

Tobacco is extensively used in the Transkei. Two varieties are home grown–one mild, the other strong. Both, however, appear strong to the outsider. Tobacco is used in several ways: (*a*) For smoking in long home-grown pipes with reinforced metal bowls. (*b*) As snuff, mixed with a senecio that is dried and ground with the tobacco, or with charred aloe leaves which contain benzpyrene. (*c*) The dottle from the stem of the pipe is relished by some, often by females who procure it from their menfolk when tobacco is scarce. The dottle is placed between the gum and lip and sucked for hours. Beauty-conscious girls put it on their lips. (*d*) Some people suck the tobacco juice left over in the bowl of the pipe.

Tobacco has been used in Africa for many hundreds of years. However, smoking habits may have changed recently, or changes in the soil may have changed its composition.

MYCOTOXINS

Deficiencies in the soil, besides their effect on the nutrition or toxicity of plants, lead to a poor plant resistance to infection, as has been demonstrated by Roach in his Molybdenum-deficient plants in the Transkei (2).

Methods of storing grain and making beer would lead to a further growth of fungi present on the cobs and may even produce the optimum conditions of temperature and humidity for the development of toxins. Some 20 fungi, all of which are toxic, have been isolated from our maize. Among these are *Fusarium roseum,* gibberella, *and Diplodia zeae.* Food infested with the *F. Roseum*, fed to ducklings, caused death in 9 days, and the isolated toxin caused massive necrosis of the liver of rats–more marked even than that caused by aflatoxin. (Dr. I. Purchase, C.S.I.R., Pretoria, personal communication).

A cytologic investigation of gullet swabs (of persons with and without cancer) showed a number of hyphae and pods of fungi, which were apparently normal inhabitants of the gullet. However, when we tried to culture fungi from the gullet, we were singularly unsuccessful. Only four growths of fungi, *viz.* penicillium, aspergillus, and cladosporium were isolated, and these were considered to be contaminants. As a result, we felt it better to tackle the problem from another angle, and a full-scale investigation into the toxicity of fungi isolated from foods in the Transkei is being carried out by the Council for Scientific and Industrial Research under the direction of Drs. Theron and Purchase of Pretoria, who have also instigated a biologic feeding experiment in East London.

PLANT IRRITANTS

The fact that cancers of the mouth, pharynx, and gullet form the most common group of cancers in the Transkei leads one to suspect a commonly ingested carcinogen. Yet the position of the cancer in the gullet makes one suspicious of an irritant possibly playing a role, if only in determining the location of the cancer.

The most common site of cancer is the mid-third, an area crossed by the aorta and bronchi and the site of the hilar glands, which are very often enlarged, fibrotic, and acantholotic from chronic lung disease. It is hard to believe that this area of the esophagus is not involved in these changes in the glands which are so close.

Apart from postulating a possible narrowing of the mid-third of the esophagus from surrounding disease, the method of eating and drinking in a semireclining position would favor a longer time for food to reach the stomach than the normal 9 seconds, as the greater pressure gradient from negative in the chest to the increased positive pressure in the abdomen would have to be overcome.

We mentioned earlier that more disease areas were found in Beaufort soil than dolerite and that there was more available silica, as well as quartz in the former than the latter. This brings two factors to mind. One is that maize is ground on an ever-wearing stone. This ground mixture contains innumerable particles of quartz. Maize is also prepared by stamping and the air is filled with the chaff. Both these procedures of preparing corn have been incriminated in the silicosis found in young women in the Transkei (6). The second factor which may have a more direct bearing on our esophageal cancer is the fact that most plants, some more than others, e.g., graminaceae, absorb silica from the soil and deposit it as opal in the epidermis of the leaves. This substance is also used for reinforcing stems and thorns of plants. These silicaceous bodies have definite shapes and are called phytoliths. (Wilting of plants which again is increased when there is a deficiency of Zinc or boron in the soil, increases the concentration of these bodies in the epidermis.)

We ashed a number of commonly eaten weeds at 450°C and treated the residue with nitric chromic acid. We were left with a number of phytoliths, diameter ± 15-20μ. The thorns themselves, a good size larger, were intact. After chewing it is not inconceivable that these sharp spicules in a bolus of food could scarify a narrowed gullet. Whether this effect is one of continual chronic irritation on a mucous membrane below par from dietary deficiencies, or an active one of the action of salicic acid on the cells causing hypoxia by interference with cytochrome-*c*-oxidase (3) remains to be determined.

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