

## **The Combination Bread—Sugar as a Cause for Dental Caries.**

By

dr. techn. ARNE SCHULERUD.

616.314 002.02

The literature on dental caries, although very voluminous, has not as yet been able to give a definite answer to the problems of this disease. The numerous theories are pointing into two directions, "localists", based upon the chemical-parasitary theory of MILLER, and the "internists", seeing the resistance or disposition for caries as a consequence of correct or insufficient nutrition.

The localists, most typically represented by BUNTING and his school, see one specimen of bacteria, *B. acidophilus*, as the principal cause for caries. They have given evidence that the bacteria must be regularly present in the mouth if the teeth shall be attacked, and they find that the bacteria for its existence is dependant upon a regular supply of sugar through the food. A random portion of sugar is not important, only the daily use of sugar will make the mouth a proper milieu for this bacteria. They have further demonstrated a very high correlation between the presence or absence of the bacteria and the quantity of sugar in the diet on one side, and between presence of the bacteria and caries on the other. Cariesfree persons living on a diet rich in sugar usually do not show *B. acidophilus*, and they explain this as a natural immunity towards the bacteria.

The localists thus derive the origin of dental caries from one single matter (many will also include another industrial product, the white bread, in this connection). The internists, on the other hand, declare that caries is not derived from the sugar as such, but it is due to a reduced resistance because one or more neces-

sary products are removed from the food through the modern refining processes. They support their view through evidence that the dental status within several groups of persons has been markedly improved when a deficient diet is supplied through valuable matters. Many substances have been tested with a positive result, leading the different workers to consider for instance one of the vitamins B. C. D, or various mineral salts in the nutrition, as deciding for the prophylaxis. However, since so many substances have given results, one is not permitted to relate caries to one single substance. With certainty only this can be said, that any step from a deficient to a more complete diet will benefit the general health, and this in its turn will also improve the tooth status. The internist theory can under no circumstances give the full explanation of the caries problem, for numerous examples are known that tooth decay can develop rapidly even if the nutrition, up to our present knowledge, is satisfactory. On the other hand, we find many primitive peoples on rather poor diets showing excellent teeth, nay, some of them are even suffering under periods of real hunger almost every year without visible damages to the teeth.

The word "resistance", however, means an admittance that there must be a resistance against something, and thus a bridge is built over to the localists. Agreement seems established that this aggressive principle should be sought among the carbohydrate foods, but its character and its way of action is still debated. Dental caries has been called a culture disease, since it always will spread with a refined way of living. A study of the Egyptian mummies illustrated this clearly. At 4000 a. Chr., when food was still simple, the tooth state was excellent. The first signs of caries are found among the nobles and rich surrounding pharao and his court, while the rest of the population, having still their primitive diet, was sound. Since this diet gradually was replaced by more refined foods, caries is found in more and more widespread circles.

The modern culture gives a similar picture. Wherever it substitutes the ancient way of living, caries is introduced. Today, cariesfree populations are found in isolated areas only, among primitive tribes, and in Europe in hidden valleys, where the way of living is still based upon self-supply similar to the mediæval system. Among the civilized peoples a few cariesfree persons are found, seemingly unaffected by the general degeneration.

Many attempts have been made to solve the problem through studies of the nutrition of primitive peoples, but at the first look the picture given when all results are regarded simultaneously, is rather puzzling. It is comprehensible that a diet poor in carbohydrates is advantageous, but it is far more difficult to explain how all possible kinds of carbohydrates can be consumed without visible effect on the teeth. In some negro groups, even cane sugar forms the major part of the food without damage. On the other hand, if in stead of an aggressive we search for a protective principle, we generally find a higher intake of minerals and vitamins in the primitive diets than in the modernized, but one or more of the recommended protective foods such as milk, fruits and vegetables, fish, meat etc. are lacking in many of them. Hard food is said to be advantageous, since it aids the development of the dental arches, stimulates the blood circulation and nourishment of the teeth and helps to keep them clean. To this one may object that the teeth of many primitive peoples are anything but clean, and we know tribes who live largely on carbohydrates, taking nearly all their food in the form of porridge — and nevertheless they have very little caries.

In this observation, however, a possibility is given to explain the development of dental caries. The decay always begins where a retention of food particles can take place, and since fat and protein can form no acids the carbohydrates must be responsible. All kinds of carbohydrates will produce acids when mixed with saliva and placed in an incubator, and the rate of formation is not very different. Acid forming bacteria thus always are present, and whether BUNTING is right, that *B. acidophilus* is the one responsible, or if there may be a sort of symbiosis between various bacteria and the types of yeast very commonly present in the mouth shall not be discussed here, since many of these organisms, above all the yeasts, are insufficiently examined.

But, if BUNTING's theory is right, that *B. acidophilus* is the chief actor and for its existence depends on a regular supply of sugar, then the mass of seemingly contradictory observations can be brought into order, if another point is regarded at the same time:

*If the food has such a consistence that retention cannot take place, then there will be no caries, even if the mouth is full of B. acidophilus.*

It is astonishing that in the literature no attempt has been made to explain dental caries out from this simple and logical

thought. The only observation approaching the point is a notice by WAUGH on the effect of certain types of ship biscuits on the teeth of Alaskan Eskimos. The case is discussed by ROSEBURY (1), who postulates three conditions of the food to provoke caries, namely hardness and compactness, allowing the food to be tightly pressed into pits and fissures, and a high content of carbohydrates for acid formation. However, the thought has not been followed to its full consequences.

Carbohydrate foods giving an opportunity for retention are largely bread types, and not only the hard ones, while soups, porridges and probably potatoes require so little chewing work that they are not likely to be pressed into fissures and pockets. On the other hand, bread need not do any harm if the other factor, *B. acidophilus*, is not present at the same time, determined by the use of sugar.

If this is held in mind, it is an easy task to divide the caries-free populations into definite groups after their way of living, sharply distinguished from the civilized, carious peoples. A quantitative evaluation is too difficult, since the frequency by various authors is expressed partly in terms of per cent carious teeth, partly as the number of individuals attacked, and because the nutrition in most cases is incompletely described. We note, for the first, that caries is somewhat more extended where carbohydrates form the major part of the food — among African tribes 5—6 % carious teeth is reported against 1 % or less among the meat-eaters. Secondly, caries has always existed, it has been observed to small degrees from ancient times. Consequently, in the following table, "cariesfree" does not necessarily mean 100 % caries-free, but such populations are mentioned where the frequency is markedly lower than the common average. In this way, the cariesfree can be divided into four groups:

- 1) Fat and protein food, with little or no carbohydrates.
- 2) Mingled food with soft carbohydrates, porridge and potatoes, boiled cereals.
- 3) Mingled, with bread, no sugar.
- 4) Mingled, with sugar, no bread.

The other part, the carious, is not divided into groups, since the simultaneous use of bread and sugar is a characteristic of modern nutrition upon the whole.

## Cariesfree.

Population	Food
<i>Gr. 1. Fat and protein food, with or without fruits and vegetables.</i>	
Alaskan Eskimos	Fish, meat, berries, herbs, roots, fat
Greenland Eskimos	Fish, meat, fat and liver, herbs, sea weeds
Canadian Indians	Meat and fish, a little herbs, roots and berries
Lapps of northern Norway, 17—1800	Reindeermeat and milk, berries, herbs and roots
Masai negroes	Meat, blood, milk
Neurs (PRICE)	Meat and sweet water fish, fruits, vegetables
South African negroes (LENNOX)	Meat, milk, fruits and vegetables
South Ocean islands	Fish and shellfish, fruits and vegetables
Australian Aborigines	Roots, leaves, berries and seeds, peas, insects, fish and meat
Diabetics on diet	Civilized food with little bread, without sugar
<i>Gr. 2. Mingled food with soft cereals, porridge and potatoes.</i>	
The Hebrides	Fish and fish liver, porridge and cakes of oats
Tristan da Cunha	Fish and potatoes, milk, a little meat
Mexican half bloods	Porridge of maize, milk and dairy products, some vegetables
Chamula Indians	Porridge of maize up to 90 %, vegetables, spices
Amazon Indians	Fish, meat, porridge of maize, fruits, vegetables
Egyptians 4000 a. Chr.	Meat, milk, porridge of crushed grain, fruits
Baitu negroes (PRICE)	Porridge of maize, milk, fruits and vegetables
Kikuyu » »	Porridge of maize, sweet potatoes, fruits and vegetables.
Wakamba » »	Fish, cereals, sweet potatoes
Bahema- and Wanandas	Maize and beans, sweet potatoes, bananas
Dinkas	Fish and cereals
Uganda negroes	Fish and meat, bananas, sweet potatoes
South African negroes (LENNOX)	Porridge of maize up to 75 %, vegetable foods
Inkas of Peru	Meat, fish, maize and beans, potatoes
Malays (MEYER)	Fish, meat, maize and rice, fruits, vegetables

Population	Food
<i>Gr. 3. Mingled food with bread, no sugar.</i>	
Stone age peoples	Hard bread of crushed grain, milk, fish and meat, herbs, roots and berries
Alp valleys	Rye bread, porridge of barley meal, potatoes, dairy products, meat, partly vegetables
Valle, Norway	Bannock and porridge of whole meal barley, dairy products, meat, berries, potatoes
Mösstrand, Norway	Bread, barley porridge, potatoes, dairy and meat
Muhima negroes	Bread (kind not described), milk, meat
<i>Gr. 4. Mingled food with sugar, no bread.</i>	
Kanakas and negroes on sugar plantations	Sugar-canes essential food
Timor	Porridge, sugar-canes, a little fish, fruits and vegetables

#### Carious.

##### *Mingled food with sugar and bread:*

All civilized European and American peoples  
 Modernized nutrition in the Alp valleys and in Valle, Norway  
 The Hebrides, port with shop and bakery  
 Laplanders on modern food  
 Indians and Australian Aborigines on civilized food in reservations  
 Eskimos, Indians, negroes in contact with civilization

Practically all the cases described in the literature will suit into the above scheme. An exception can be noted in the caries-free group 1, namely the African Elmolo tribe, living chiefly on fish and tortoises. Their nutrition is insufficiently described, but is said to be deficient, especially in vitamin C. The tribe is dying out, suffers much from tuberculosis, caries, arthritis etc. Another exception forms the isle of Pitcairn, where the food is said to be similar to that of Timor, but nevertheless caries is frequent in the first place, rare in the last. However, the informations on Pitcairn foods are so incomplete that no conclusions can be drawn.

Among the carious, some exceptions are also found. It is, for instance, not unusual that in internates the teeth may be better than in their surroundings, even if the food is not visibly different. This is the case with a couple of orphanages in Oslo, being under control for several years. In one of these, the children intention-

ally have been given sugar on the bread and candy at bedtime, and yet they have practically no caries. This is not in conflict with the author's theory, however, since *B. acidophilus* is very sparsely present.

The theory leaves open the question of the mechanism through which the attack on the enamel is performed. It only gives an explanation why tooth decay has increased so extremely in the last fifty to hundred years, and also why caries is spreading so rapidly when civilized foods are breaking their way into formerly intact districts. In ancient Egypt the teeth originally were excellent. With the increased use of a more refined food, very typical in the ptolemaic age, followed an enormous increase of caries. We shall never know if they had *B. acidophilus*, but they used sweets liberally, and we have quite a good knowledge of their bread.

The same process, in a very accelerated tempo, takes place in our days when a closed locality, say an Alp valley, is opened for traffic. Sugar is one of the first things to be introduced, and associated with the shop is usually a commercial bakery. In a few years tooth decay is growing rapidly. Or look at the "civilized" Greenland Eskimos. Their sugar intake is very high, bread is highly appreciated, and their teeth spoiled. It does not alter the situation that the bread is made from whole meal.

The examples given are quite a weighty evidence for the theory. However, the author is fully aware that an experimental test ought to be made, especially to see how an exclusion of bread or sugar would act when combined with common civilized nutrition. The test might be carried out like this:

- 1) Control group, usual food with bread and sugar.
- 2) Group with bread, no sugar.
- 3) Group with sugar, starchy foods as porridge, potatoes etc., no bread. Care should be taken that the food was if possible identical but for the quality of the carbohydrates, while the quantity should be the same. Groups 2 and 3, then, ought to give an arrested or at any rate retarded caries, while the control group should give a "normally" progressive caries. Under the present conditions the author has not been able to have such a test established, but evidence for group 2 can be extracted from BUNTING's experiments (2). Here it is reported that in American internees a restriction of sugar in the diet has lead to a marked decrease in caries frequency.

In the light of the new theory, it seems that all measures proposed against caries may to some extent moderate the evil, but it is not mastered and hardly can be. An improved nutrition in many cases has given good results, and such an improvement is for several reasons to be recommended. For the purpose of giving a more sufficient food, whole meal bread may be of value, but concerning the direct action in the mouth, dark or white bread has but minor importance, as stated by the author's earlier work in this field (3, 4). However, stickly, unelastic bread, resulting from poor flour or careless baking, can do considerable harm because of its increased adherence to the teeth. Such bread is not at all seldom, especially where rye bread is prevalent.

Bread and sugar both play such an important part in our nutrition that one cannot seriously think of letting one of them go in order to fight caries, but luckily results can be hoped for in other directions. Much is still undone concerning the mechanism of tooth decay, such as the aggressivity of various acids towards enamel and dentine, the saturation of saliva with Ca and P ions etc. The activity of acidophilus strains in symbiosis with different yeasts of the mouth, although morphologically almost identical can give a very different rate of acid formation. In this field, an explanation may be found for the variable individual susceptibility towards dental caries. The greatest problem, however, lies in the question why some persons have a natural immunity towards *B. acidophilus*. When this question is answered, the fight against dental caries may pass into its deciding phase.

### Summary.

The studies of the food of primitive people who are free from dental caries apparently give a confused picture as all kinds of foodstuffs, including sugar cane, are eaten without harm: there can even be a shortage of different kinds of protective foodstuffs and the teeth can remain undamaged even if the food is eaten in a soft state such as gruel.

According to BUNTING's theory, dental caries is dependent on acidophilus "B", the presence of which in the mouth depends on a regular consumption of sugar. This theory can account for the appearance of dental caries if, at the same time, one has in mind another point of view which one has not thought of before. *When the foodstuff is of such a consistence that nothing can be left*

*on the teeth, dental caries cannot be produced even if the mouth is full of acidophilus "B".*

Based upon the foregoing, the people who are free from dental caries can be divided into four groups according to their nutriment, namely: (1) foodstuffs containing fats and protein and a small quantity of carbon hydrate, (2) foodstuffs mixed with soft and boiled hydrates, potatoes and gruel, (3) the same with bread but without sugar and (4) with sugar but without bread. As fats and protein do not produce acid, the first group is not attacked. In group 2 the soft hydrates cannot penetrate into the crevices of the teeth and therefore have no time to acidify. In group 3, acidophilus "B" does not exist on account of the non-existence of sugar and in group 4, where the bacteria exists there is, on the other hand, no possibility of retention. Civilized countries where dental caries is very prevalent, show, in general, a simultaneous use of bread and sugar.

There are very few exceptions in this classification. A further attempt at experimenting cannot be made for the present but the numerous examples in literature give an excellent possibility of judging the exactitude of the theory. One can therefore explain why dental caries develops so rapidly when, for example, a closed valley in the Alps opens up for modern foodstuffs. Sugar is one of the first commodities to be introduced and a bakery soon follows.

Bread and sugar are not harmful as such and one cannot think of excluding them from nutriment. To a certain extent one can expect a reduction in dental caries from nutriments of a higher value. But more promising in reality are the studies made of certain individuals who, from nature, have a greater power of resistance against acidophilus "B" and dental caries and the experiments to transfer this immunity to other people.

### Zusammenfassung.

Studien über die Ernährung der kariesfreien, primitiven Völker geben scheinbar ein verwirrendes Bild, indem alle Arten von Nahrung, ja sogar Rohrzucker, ohne Schaden verzehrt werden können. Verschiedene Stoffe der »Schutznahrung« mögen fehlen, die Zähne können dennoch geschützt sein, auch wenn die Kost weich, in Breiform, gegessen wird.

BUNTINGS Theorie führt die Karies auf die Tätigkeit der B.

acidophilus zurück, deren Vorkommen im Munde von regelmässigem Zuckerverbrauch bedingt ist. Diese Theorie kann das Entstehen der Zahnfäule erklären, wenn man ein anderes, bisher nicht beachtetes Moment erinnert: *Wenn die Nahrung eine solche Konsistenz hat, dass keine Reste in den Zähnen festgehalten werden, kann keine Karies entstehen, wenn auch der Mund voll von B. acidophilus ist.* Hiernach kann man die kariesfreien Völker nach Art ihrer Nahrung in vier Gruppen einteilen, nämlich 1) Fett- und Proteinnahrung mit wenig Kohlehydraten, 2) Gemischte Kost mit weichen, gekochten Kohlehydraten, Brei und Kartoffeln, 3) Desgl. mit Brot, ohne Zucker, und 4) Dasselbe mit Zucker, ohne Brot. Da Fett und Protein im Munde keine Säure bilden wird Gruppe 1) nicht angegriffen. In 2) werden die weichen Kohlehydrate beim Kauen in die Zahnfurchen nicht eingepresst und erhalten so keine Zeit zu säuern. In 3) gedeihen die gefährlichen Bakterien nicht infolge fehlenden Zuckers, und in 4), wo die Bakterien wohl vorkommen, fehlt wieder die Retention. Als Gegenstück kommen die zivilisierten Länder mit viel Karies, wo der gleichzeitige Gebrauch von Brot und Zucker gemeinsam ist.

Man kann nach der neuen Theorie erklären, warum die Karies so schnell verbreitet wird, wenn z. B. ein geschlossenes Alpental der neuen Ernährungsweise eröffnet wird. Brot oder Zucker sind einzeln nicht schädlich, und es ist wirtschaftlich unmöglich, sie aus der Ernährung auszuschliessen. Besserung des Karieszustandes kann gewissermassen durch eine verbesserte Nahrung erwartet werden, aber die Lösung des Problems ist eher in der Immunitätsforschung gegenüber *B. acidophilus* zu suchen.

### Résumé.

Des études sur la nourriture des peuples primitifs exempts de carie dentaire donnent apparemment une image confuse vu que toutes sortes de nourritures, même des cannes à sucre, sont mangées sans dommage. Il peut y avoir pénurie de différentes sortes de nourritures «protectrices» et les dents peuvent être intactes bien que la nourriture soit mangée à l'état mou, comme une bouillie.

La théorie de BUNTING reporte la carie dentaire à l'*acidophilus B.* dont la présence dans la bouche dépend d'une consommation de sucre régulière. Cette théorie peut expliquer l'apparition de la carie dentaire à condition que l'on ait en même temps sous

les yeux un autre point jusqu'ici assez délaissé: *Quand la nourriture possède une consistance telle que la rétention ne puisse avoir lieu, aucune carie dentaire n'arrive à se produire même si la bouche se trouve pleine d'acidophilus B.*

En se basant sur ce qui précède les peuples exempts de carie dentaire peuvent, d'après leur nourriture, être divisés en 4 groupes, à savoir 1) Nourriture de graisse et de protéine avec peu d'hydratés de carbone, 2) Nourriture mélangée d'hydratés moux et bouillis, pommes de terre et bouillie, 3) idem avec du pain, sans sucre, et 4) avec du sucre et sans pain. Comme la graisse et la protéine ne donnent pas d'acide le groupe 1) n'est pas attaqué. Dans le groupe no. 2) les hydratés moux ne peuvent pas être poussés dans les sillons des dents et n'ont pas le temps d'aigrir. Dans le groupe no. 3) l'acidophilus B. ne subsiste pas à cause de la pénurie de sucre, et dans le groupe no. 4), où la bactérie existe bien, il n'y a d'autre part aucune rétention. Les pays civilisés avec beaucoup de caries dentaires ont tous en commun l'usage simultané de pain et de sucre.

Il y a très peu d'exceptions à ce classement. Un assai ultérieur expérimental ne peut être fait en ce moment, mais le grand nombre d'exemples dans la littérature donnent un bon point d'appui pour l'exactitude de la théorie. On peut ainsi expliquer pourquoi la carie dentaire progresse si vite quand par exemple une vallée fermée des Alpes s'ouvre pour laisser entrer la nourriture moderne. Le sucre se trouve parmi les premières marchandises introduites et une boulangerie suit bientôt.

Le pain ou le sucre à l'état seul ne sont pas nuisibles et l'on ne peut pas penser à les exclure de la nourriture. Dans une certaine mesure on peut s'attendre à une amélioration des caries dentaires au moyen d'une nourriture de haute valeur. Or, plus promettant sont en effet des études faites sur certaines personnes qui dans leur nature sont réfractaires à l'acidophilus B. et à la carie dentaire et les essais de faire communiquer l'immunité à d'autres personnes.

The author wishes to express his gratitude towards professor, dr. I. REICHBORN KJENNERUD of the dental University of Oslo for his valuable advice during the performance of the manuscript.

**Literature.**

1. ROSEBURY, J. D. Res. 1939, 343.
  2. BUNTING et al., J. D. Res. 1934, 97.
  3. ERICHSEN and SCHULERUD, Odont. Tidsskr. 1941, 326.
  4. ERICHSEN and SCHULERUD, Odont. Tidsskr. 1942, 221.
- 

Address:

Kristiania Brödfabrik,

*Oslo,*

Norway.