

On the Rôle of Mucin in the Pathogenesis of Caries.

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As a political fugitive in Sweden I was offered an opportunity in the Serafimer Lazarette, Stockholm, to carry out some experimental studies on the etiology of caries.

Among other things, a method was worked out for titration of small amounts of dissolved or undissolved carbohydrate in oral lavage. This is obtained by washing the mouth and teeth by means of a strong atomizer — if necessary, together with the employment of a probe or dental floss. In this way a fairly accurate measure is obtained for the carbohydrate retention under various conditions, especially in examination of the milk teeth. Thus we are enabled to estimate the amount and ratio of dissolved and undissolved carbohydrate, for instance, after intake of various sorts of bread or after bread + »sweets», and to compare the “carbohydrate status” of the mouth immediately after a night’s sleep with the corresponding condition immediately before the onset of sleep. Furthermore, the cleansing capacity of various fruits and vegetables as well as the effectivity of the tooth-brushing and various tooth-pastes may be tested experimentally in this way.

In the elaboration of this method the mucus of the saliva, mucin, a glycoprotein, caused a good deal of difficulties, as after acid hydrolysis it has a reducing effect and is difficult to separate from the carbohydrates. At the same time, however, mucin was found to present certain properties which, the writer thinks, may be of etiological significance in the caries problem, and which

from the literature accessible appear not to have been dealt with previously under this angle. Hence, perhaps, it may be appropriate for a non-odontologist briefly to set forth the following points of view for a possible critical discussion or further elucidation of the problems involved.

It is a well-known fact that when fine-ground flour is made into a dough and baked, it undergoes a 1' degree of pasting. Under its treatment in the mouth, this "paste" forms a sort of compound — mostly of physical character — with the salivary mucin, resulting in an intensely puddled, pasty mass of mucin-carbohydrate that fills every space where there is a chance of retention. According to several authors — *e. g.* Pickerill — bread appears to induce the secretion of a saliva particularly rich in mucin.

The question then arises as to the possibilities of lowering the retention of this mucin-carbohydrate paste in the innumerable spaces between approximal surfaces of the teeth, in fissures, in gingival pouches, etc.

Such possibilities are partly of mechanical nature, partly chemical.

In the chewing of "native", untreated, food a thorough interaction takes place between various mechanical processes of cleansing. For the shredded or firmly cohesive consistence of the native food — often due to non-heat-treated cellulose structures — counteracts its retention, no matter whether this food is of animal or vegetable origin. Furthermore, the self-cleansing capacity of the native food is greatly supported by the mechanism of chewing — for instance, by the underpressure in the oral cavity every time the rows of teeth are separating, simultaneously with the pressure of the cheek against the teeth. In the mastication of carrots, for instance, a whole lot of small carrot fragments — with sharp edges and grooved surfaces — will be crowded in the buccal fold. When now the two rows of teeth separate, the underpressure in the oral cavity and the musculature of the cheek will force all these tiny fragments against the necks of the teeth, lift them up along the surface of the teeth, especially in the intervals between the teeth, while the pressure against the teeth is increasing gradually, as the fragments pass up along the increasingly projecting crown till finally they are deposited on the masticating surface! It is no inconsiderable amounts of retained food elements that

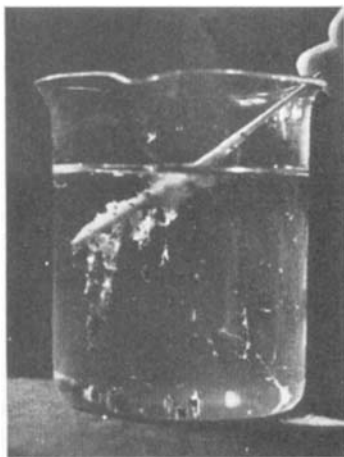


Fig. 1. A large mouthful of saliva and some fragments of black-coloured bread are poured into a glass of water, whereafter a little vinegar or fruit juice is added. The mucin is precipitated and envelops the bread particles with a network of membranes and threads.

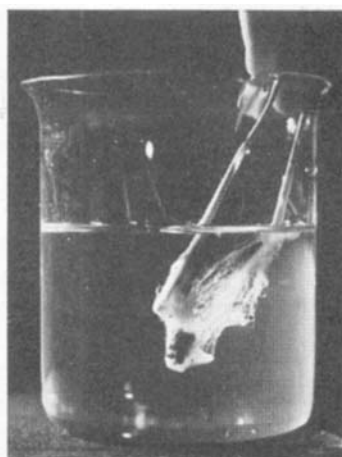


Fig. 2. Even after energetic stirring, the threads of precipitated mucin still have a good hold on the bread particles.

are carried along by these masses of sharp-cut small carrot fragments from the intervals between the teeth or are forced directly into the oral cavity, supported by the oral underpressure. Besides, most native food has tendency to stimulate an abundant production of thin, ptyalin-containing saliva, rich in minerals.

But with the thorough industrial and culinary treatment to which our food evidently must be submitted, it implies such a great possibility of retention that even the mechanical cleansing of the teeth, for instance, by chewing a carrot or a slice of whole-grain bread now and then is not enough to overcome the retention. No doubt, moreover, this retention is highly promoted by the poorly developed jaws and the resulting sad position of the teeth which we gradually have acquired.

Indeed, one of our earliest and strongest instincts, the "chewing instinct" — which replaces the sucking instinct about at the time of dentition — meets with our concerted efforts to suppress it: at the time of dentition we give the children gruel, mush and mashed vegetables; we become irritated when the child bites his rattle instead of shaking it; and as the child grows, we scold if in his need of chewing — and in want of anything better to

use his teeth on — he gnaws on the bars of his crawling-bin or breaks his toys with his teeth!

With the poor position of the teeth and the great possibilities for food retention presented by our mouth, it is obvious that the only thing able to get in everywhere must be chemical substances in solution. Here we meet with a fact that is bound to be of great importance, namely: the *striking capacity of mucin for precipitation in acid milieu* — not at very weak nor very strong acid reactions as, for instance, in the stomach, etc. — but just at the acidity of most fruit acids if only they are present in a sufficiently high concentration.

Take, for instance, a glass of diluted fruit juice, or a glass of water with a little vinegar, and pour into it a large, markedly mucinous lump of sputum. This lump will then be seen almost instantaneously to precipitate as long and tough threads or — if it is not stirred about — as vesicular, membrane-like, masses that gradually contract, more and more, and finally assume the form of a small, firm, elastic ball. Then chew a small piece of bread, mixing it with a good deal of saliva, and place it in the dilute fruit juice. Now this lump of starchy paste, soaked with — and enveloped in — mucin, becomes entangled in the precipitated tenacious shreds of mucin and is dragged along.

During the mastication of a fruit-containing diet this process takes place also in the deep intervals between the teeth; the mucinous-starchy mass is precipitated, and the long projecting threads of mucin are caught by the rough tongue or by coarse food particles, and thus the starchy paste is pulled out from its place of retention! If this is not accomplished at once, there is a never-ceasing supply of mucin that keeps oozing into the crevices, enveloping the starchy paste, precipitating and trying again to drag the starch out — and so on, as long as the treatment of the fruit-acid food in the oral cavity takes place.

At first the description of these processes may perhaps seem somewhat speculative. But on employment of dilute fruit juice to wash the mouth or brush the teeth with one feels unmistakably that these processes actually take place to some extent. The idea then suggests itself that the conditions here described are of the greatest importance to an effective cleansing of the teeth, especially of the most deleterious substances in the places least accessible.

It may be added that also other substances in our food articles

possess a similar mucin-precipitating property — *e. g.* tannic acid (and perhaps this may be why the Chinese are said to wash their mouth before and after meals with their green tea?).

In passing it may be mentioned that the writer thinks that the conditions here described are bound to play a considerable rôle also in gingivitis and alveolar pyorrhea, in which the pocket retention is a most important etiological factor. A complete cleansing of these pockets from bacteria and food remnants, suspended in — and permeated by — saliva to the very bottom of the pockets, is almost impracticable with the ordinary mechanical or disinfecting measures of cleansing — at any rate if it has to be done daily (every evening).

Another obvious idea is that this property of mucin — precipitation at slightly acid reaction — implies also a noxious quality. The lactic acid or pyroracemic acid formed by bacterial enzymes beneath or within the starchy-mucinous lump will at once precipitate a layer of mucinous membranes round all the small foci for their formation that undoubtedly will impede the process of diffusion through the mucin. The process here involved is illustrated very well by the following small experiment: Into a glass of saliva a drop is poured of sodium hydroxide, hydrochloric acid and lactic acid, respectively, coloured with bromothymol blue: a regular capsule formation will take place round the drop of lactic acid, preventing its diffusion into the saliva. Perhaps it is due to this very fact that the required acidity may be established in a quite localized small area on an enamel surface — and this might perhaps explain why a salivary milieu is so important, for instance, to the production of caries *in vitro*.

It may be, however, that the entire question is to be considered under another — though to some extent congruous — angle, namely: that the precipitated mucinous membranes enter into the formation of the so-called plaques, and that the acid production is of a more chronic character, taking place under adsorption to or beneath these plaques. Still, perhaps, this is less probable, for instance, in caries of the milk teeth, which most often arises in the middle of a masticating surface, where plaques are not likely to be present, whereas a few bread crumbs nearly always are seen to lie quite loose in the hollow between the cusps for half an hour or longer after intake of bread. Here too, then, caries arises simply on the site of choice for retention. Most likely it is in particular — or exclusively? — the *nocturnal retention* that is the

decisive factor, and then the bread crumbs may readily remain in this open place. It is not to be wondered that this caries, strictly speaking, does perhaps not commence on the masticating surface proper but rather deeply in the fissures between the cusps where the bread paste naturally is forced down continually; and it can be explained equally well whether we reckon the fissure as closed chronically from the outside by a plaque or merely blocked temporarily by a mucinous membrane due to acid production »from the inside«. At any rate, as soon as the cavity has become manifest externally and the fissure thus is open, it will be difficult to imagine a plaque formation covering the cavity in the middle of a masticating surface. (But the process of caries keeps progressing at a very rapid rate, quite independent of any plaque formation — practically from night to night!)

But, even though a particularly important rôle may be assigned to the fissures as especially good sites of retention, they are hardly so deep — nor their content of bread paste so firmly packed — that the fruit acids cannot ooze down in them and precipitate the mucin. It is conceivable that possibly the bread is not always pulled out of the fissures together with the mucin — just as in other places where it may be packed very firmly. But it may be of great importance that it no longer is emulsified in a mucinous milieu that is ready at once to precipitate a wall round every one of the small acid-producing foci as soon as any acid is produced. On the other hand, the mucinous membranes and shreds precipitated by the fruit acids supplied from *the outside* are situated more by chance; they run through the bread mass “planlessly” and will not give rise to the strongly localized, systematic, enclosure just of the foci of the acid production. And the new supply of saliva will not enter into such an intense — and hence such a potent — combination with the firmly pasted bread lump as the first saliva it was kneaded with.

It seems reasonable to imagine the processes here mentioned as pronounced *micro*-processes with a great variation in the formation of the multitudinous small foci for acid production. The acid is formed round the bacteria or yeasts which continually are present in the oral cavity. Very likely these micro-organisms are found especially on the sites of retention, where the enamel surfaces are quite approximal, or in commencing caries cavities; so here too the foci for acid production often lie close against an enamel surface. Thus it often happens that the capsule formed round the focus

does not extend in between the focus and the enamel surface but — to the contrary — “solders” the focus to the enamel.

For the present, of course, the considerations here advanced are rather speculative. They are to be taken merely as an attempt to explain the peculiar fact that our organism produces a substance as mucin, which is an important and perhaps indispensable factor in the pathogenesis of caries, while at the same time it appears to be of the greatest importance to the self-cleansing processes in the oral cavity. Furthermore, *these two diametrically opposite activities are due to one and the same quality of mucin: its capacity for precipitation by weak acids, e. g. fruit acids.*

To the writer this fact appears to indicate that a quite particular significance ought to be attached to fruits and fruit acids in the general prophylaxis of caries.

Summary.

Some theoretical considerations are presented on the rôle of mucin in the pathogenesis and prophylaxis of dental caries.

Particular emphasis is laid upon a striking property of mucin: its capacity for precipitation as a strong tenacious network enveloping and carrying along all solid particles — *e. g.*, remnants of food, bacteria (see photos).

Such a pronounced precipitation of mucin takes place at once on contact with fruit acids in the concentrations in which these are present in all kinds of fruit. Experimental quantitative studies on the influence of this phenomenon on the retention of carbohydrates are now being carried out in the laboratory of the Danish College of Odontology.

Zusammenfassung.

Es werden gewisse theoretische Erwägungen vorgelegt über die Rolle des Muzins für die Pathogenese und Prophylaxe der Zahnkaries.

Besonders wird eine auffallende Eigenschaft des Muzins betont: seine Fähigkeit, in Form eines festen und zähen Netzwerks ausgefällt zu werden, das alle soliden Partikel, z. B. Speisereste und Bakterien, umhüllt und mitschleppt (siehe photographische Aufnahmen).

Solch eine ausgesprochene Ausfällung von Muzin findet bei Berührung mit Fruchtsäuren in den in allen Arten von Früchten vorliegenden Konzentrationen sofort statt. Experimentelle quantitative Untersuchungen des Einflusses dieser Erscheinung auf die Zurückhaltung von Kohlenhydraten finden z. Z. in dem Laboratorium des Dänischen Odontologischen Instituts statt.

Résumé.

L'auteur présente quelques considérations théoriques sur le rôle de la mucine dans la pathogénèse et la prophylaxie de la carie dentaire.

Il souligne une propriété très particulière de la mucine: sa faculté de précipiter sous forme d'un réseau solide et adhérent enveloppant et entraînant toutes les particules solides, par exemple les restes d'aliments, les bactéries (v. photographie).

Une précipitation abondante de mucine se produit immédiatement au contact des acides de fruits à la concentration existante dans les diverses sortes de fruits. Au Collège Odontologique Danois, en poursuit actuellement des recherches quantitatives sur l'influence exercée par ce phénomène sur la rétention des hydrates de carbone.

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