SEPTEMBER 16, 1968 ROBERT A. KEHOE

This is a story—a true story—of a strange set of circumstances which threatened to destroy a multi-million dollar industry in the United States, and to deprive a large number of our citizens, especially the children, of a source of great personal gratification. This came about in 1935-36, when billion dollar industries were not so common, even in the United States, as to be every day affairs, when also the memory of a serious economic depression and financial panic was fairly fresh in the minds of the people generally and of industrial managers in particular. The threat had its origin outside the country-through the medium of an essential raw material of a widely distributed edible product, which, almost by chance, had been found to contain a potentially dangerous concentration of a chemical substance which had caused numerous toxic epidemics elsewhere in the distant past, having acquired thereby an extremely bad although not wholly deserved reputation as a deadly poison. It was not known, through any prior experience, whether this poisonous substance had been present in this raw material for some time in the past, or, indeed, whether it might not be a natural constituent thereof. No one had looked for it previously, and only because the agents of the Federal Food and Drug Administration had been scrutinizing and analysing, at random, numbers and varieties of food products and their ingredients, had it been encountered. Incidentally, this continuous effort has unearthed a great many sources for the contam-ination of foods and food products through the years.

The imported product of the jungles of Mexico, Honduras and Guatemala, on the Yucatan peninsula—chicle, the principle gum of chewing gum, was the raw material involved, and samples of this product had been found to contain unusual amounts of lead. This had stimulated further sampling of the chicle then being imported into the United States, which had demonstrated the fact that much of it contained highly significant quantities of lead. Whereupon, all of that being

imported was being impounded until such time as it could be sampled and analysed. By March or April of 1936, virtually an entire year's supply of chicle had been impounded at several ports on the East Coast of the United States, and in New Orleans, thus creating a shortage on the market that promised to stop, promptly or at an early date, the production of chewing gum by a number of manufacturers, and ultimately to bring a complete halt to the entire industry. The largest of the manufacturers had something like a year's supply of chicle in storage, but even this, when analysed, might well be found unsuitable for use. Most of the others had been purchasing their requirements, on short term, from a large importing company in New York City, which, along with the one large manufacturer, had supplied the capital required for the production of chicle in the jungle and for the intermediate steps of its preparation for shipment to the United States. These two organizations, together, purchased and imported about 90 percent of that which came into the United States. The remainder was imported by a number of brokers, who deal in this product periodically as opportunity presents itself, along with other commodities from the same area. The total quantity of chicle imported into the United States annually, in and around this period (1935-36), was of the order of eight to ten million pounds. Since chicle enters into finished chewing gum to the average extent of about 30 percent by weight, the annual production of chewing gum in the United States, in the middle nineteen thirties, may have approximated twenty-five to thirty million pounds. What it may be in the nineteen sixties is another matter, now that the specific threat posed in the earlier period of this story has been met and vanquished. This, no doubt could be ascertained from appropriate sources, but it is not germane to this account, and it may be set aside as a matter for a bit of speculation, in relation to the "domestic manners of the Americans" in this period of their relative sophistication. It should be added, for the sake of completeness, as well as for the appreciation of the necessity of extending an investigation into distant parts of the earth, that certain desirable physical

properties of chewing gum, such as "chewiness" and elasticity, had been found to require the addition to the basic chicle of some far eastern gums in appropriate proportions. Once it had been found that commercial chewing gum, manufactured within a period of two or three years prior to the discovery of lead in chicle, contained appreciable quantities of lead, it was hardly prudent to conclude that this was the sole source of its lead content. The immediate threat to the industry had to be resolved in toto and at the earliest possible time, lest it should be found, belatedly, that all of the somewhat related raw gums were being impounded because of their content of this same potentially toxic ingredient, and that the problem had failed of solution in time to make available to manufacturers a satisfactory supply of raw materials. Only by learning the facts and acting on them promptly, could the wheels of this industry avoid grinding to an abrupt stop.

It may be that some misanthropic people would regard this occasion with amusement, while others might even feel a degree of satisfaction or relief on hearing of the death knell of, to them, an essentially useless commodity, or the elimination of an objectionable practice. A very large segment of our population, however, would disagree with such views, while the owners and managers of this industry, and the not inconsiderable numbers of its employees and beneficiaries would rise up in wrath at their very expression, whether in critical words or through action or lack of concern on the part of governmental authorities. Within the industry, there was dismay bordering here and there on panic. Several defensive measures were proposed, one being that, since chicle came directly from the jungle, the lead most certainly was a natural ingredient, and as such could not be dealt with under a law that applied to adulteration and contamination. Another suggestion had it that the dilution of chicle by sixty-odd percent of other ingredients would probably reduce the lead to insignificant proportions. Still another idea was that since chewing gum was chewed for some time, after which

the residuum was discarded, little of the lead would be swallowed.

Fortunately, there were wise heads within the industry, who recognized the necessity of procuring the facts, and of presenting a solid front and a considered and agreed upon policy in dealing with the legally constituted agency of the government. Accordingly, scientific consultants were engaged to aid in the development of a program of investigation, and legal counsel was procured to advise the group and to confer with the relevant governmental agency. The latter, a man of impressive physique and resounding voice, with a shock of snow-white hair and an histrionic diction, was, in himself, an imposing front of virtue embattled against undeserved misfortune. His first act within the group was to proscribe the use of the dread word "lead" in speech and correspondence, designating it as "X". The fear of the public reaction to even the suspicion of danger from a marginal food product was strong in him, and he spoke mightily and effectively, both to the industry and to representatives of the government.

Since time was of the essence, six men of experience in the chicle camps in the jungle were dispatched to visit those then operating in Yucatan, in two areas in the Mexican territory of Quintana Roo, into an area of eastern Yucatan known as "El Cuyo", and into three areas in the Mexican State of Campeche. These men were instructed in detail as to the types of observation which they should make in relation to possible sources of contamination of chicle with lead, and were given an elaborate questionnaire to direct their observations toward specific details of the work of gathering, transporting and boiling down the latex or sap, from which the chicle for export to the United States was prepared. They were also instructed to gather samples of the latex and of all containers and other materials with which it came in contact from tree to final destination. They were provided with suitable lead-free containers for these collected materials. Some three months later, these men returned with detailed

reports of their observations, and a virtual flood of samples of the widest variety and quantity imaginable arrived in the United States, and were forwarded for the most part to the Kettering Laboratory, in view of the extensive facilities which had been developed there for the analysis of lead-bearing materials in the course of a comprehensive investigation of the occurrence of lead in the human environment. Two other laboratories, one at Massachusetts Institute of Technology, and another in the Department of Biochemistry at Yale University, were supplied with materials for cross-checking in a critical appraisal of analytical methods.

A somewhat less elaborate investigation was made in several far eastern countries from which a number of gums, such as Jelutong and Gutta, are obtained for use in the manufacture of chewing gum.

While these field investigations were underway, chicle from various sources and such other gums as were available in storage in the United States, were being investigated as to their lead content, in the three laboratories. Further, the several analytical methods were being checked through samples prepared to contain equivalent quantities of lead. All of this information was being pooled to gain the maximum amount of knowledge of the facts and the best possible interpretation of their significance. By the time the field survey had been completed, some highly informative results had been obtained pointing clearly to the nature of the contaminant and to its probable source. As we shall see a little later, this information fitted into the observations made in the field in a manner very like that of the odd pieces in a cross-word puzzle, so nicely, in fact as clearly to prescribe the probable remedy, not only for the prevention of the contamination of future supplies of raw material, but for the reclamation of the impounded, contaminated chicle.

But we are ahead of our story, and of the slow laborious steps by which our complete

ignorance was replaced with evidence built up slowly, piece by piece, through the accumulation of data which, when assembled and properly grouped, began to fall into a meaningful relationship leading directly to the solution of the problem. The train of sequential facts comprising the basic shape of the evidence developed in this wise:

1. Commercial chicle, provided in solid blocks approximately 18 inches in length, 14 inches in width and 5 inches in thickness (as I remember their somewhat variable dimensions), yielded samples from various parts of the blocks containing lead in concentrations ranging from 0.15 to 54.0 parts of lead per million parts, by weight, of chicle. Prom information based on our previous analyses of a wide variety of naturally occurring vegetable products, it was clearly apparent that the higher range of the analytical findings excluded the probability that the lead in chicle was natural in origin. Moreover, inside and outside samples from different parts of the same block of chicle varied in their lead content, in some instances, by more than two hundred percent. Thus, it seemed reasonably certain that most of the lead was artificial in origin and particulate in character.

2. By chance, a sample of the chicle latex was available for analysis, it having been kept for some years as an exhibit in the office of one of the large manufacturers of chewing gum. It was found to contain 0.1 part of lead per million parts of the latex. While this sample had not been obtained by means that could be regarded as faultless from the aspect of its chemical purity, its low content of lead tended to strengthen the foregoing conclusion.

3. Analyses for lead made by spectrographic rather than by a chemical method demonstrated the presence of appreciable quantities of tin in samples of chicle of high lead content. By way of explanation to the uninitiated, spectrographic methods of analysis are based on the procedures of burning a small quantity of a substance and of photographing the flame, under

suitable conditions,through which elemental substances yield the "Fraunhofer Lines" which, by their position in the spectrum, serve to identify the elements. Under appropriate conditions, the concentration of the element in the quantity of sample burned can be determined by measuring the density, or the blackness, of one of the spectral lines that characterize the specific element. In addition, every other element that yields lines within the are of the spectrum which is photographed, can be identified and estimated either qualitatively according to the details of the methods. The ultraviolet area of the spectrum, in which the principal lines for lead appear, also has its lines for tin and, in this instance, the principal line for tin was usually relatively dense and clearly evident. The meaning of this seemingly isolated fact was not apparent at once, I regret to report. But we were far from the scene of action, if that circumstance, plus our total unfamiliarity with the industrial technology of the jungle and that of the chewing gum manufacturing plants, can be regarded as extenuating factors. Eventually, however, one or more of us tumbled to the commonplace fact that lead and tin combined may well mean solder, and that a backwoods vessel for evaporating water from maple sap, or for making a variety of stews, broths and brews, may have soldered joints or may require soldered patches. And thus at length, someone suggested X-ray examination of prepared slabs of chicle, and—lo and behold—a photographic collection of bright, opaque spheres varying in size, within the slab and from slab to slab, from those of bird shot to minute specks; but at no point was there a confluent field of slightly increased opacity. These were discrete particles of solder.

The next step in the investigation opened up the promise of a remedy for the impending shortage of raw material for the manufacture of chewing gum, through the reclamation of the impounded chicle. But that step will be recounted later, for the field investigators had returned from their mission and, shortly thereafter, packing cases of specimens of many types, at least a ton of them in the aggregate, arrived at the Kettering Laboratory.

Before turning to them, let us go to the jungle and follow the entire process of the production of chicle from the tree to the market, through the mediumof the efforts and observations recorded by the investigators.

The tree known as the Acras Sapote is found in sufficient quantities for exploitation in the collection of chicle in the northern half of the Territory of Peten in Guatemala, the northern half of British Honduras, and in the Mexican States of Campeche and Yucatan, and in the Mexican Territory of Vera Cruz. This tree is found extensively in this entire area but always in the forest among other trees, rather than in solid clumps or in cultivated forests of the one species. The terrain of this area is substantially limestone with some clay, over which is a heavy layer of humus formed by the decay of the forest through many centuries. There is a rainy season in the area for six to seven months, beginning in early July and extending into January or at times as late as March. The remainder of the year is dry.

The latex of this tree, which is the source of chicle, is collected as a milky, sticky liquid during the rainy season only, and it varies in its volume of flow and its viscosity with the relative wetness of the rainy season. This latex oozes out of the young bark outside the cambium layer, from disconnected channel-reservoirs which empty themselves and then cease to flow. Because of their shortness, the bark must be severed by cuts spaced at short intervals. Consequently, the cuts made in the bark may be in the form of a spiral extending from the ground to the first branches, forty feet more or less above the ground, or in zig zag cuts which slope downward into a channel that is central to them. The latex flows for a time from the top to the bottom of the tree, where it is led off into a canvas bag through a spout made of a palm leaf.

The men who gather the chicle, known as chicleros, are of several native breeds. They spend ten or eleven months in the jungle, housed in open-sided thatched roof shelters with their

children and womenfolk, some of whom may be wives, so to speak, for one or more seasons. The men are very agile, in climbing up a tree barefoot with the sole help of a rope against which they lean while wielding their machetes with great accuracy in cutting the bark, often within an inch or less from the rope which supports them. The tree continues to bleed for but five or six hours. The chiclero cuts four to six trees in the forenoon and then waits until all of the latex has flowed and been collected, amounting to one to three quarts from each tree, and then combines all of that obtained from the several trees into a larger canvas bag and returns it to the camp. There the latex is kept in these bags for several days until enough has been obtained to fill a large metallic kettle. The latter is placed in an open space and a wood fire is built under it to evaporate off water. The end-point of the "cooking" is determined by an elder chiclero through his experience in wielding a wooden stick as a stirring rod. The stirring is continued throughout the cooking process to hasten the latter and to prevent local burning. The kettle is then removed from the fire and its contents poured into wooden molds which have been coated on the inside with some type of grease or oil which will prevent sticking. (These lubricants range all the way from several varieties of soap to kerosene). Letters or numbers, usually of wood, are inserted at the bottom of the mold, for purposes of identification, and are removed from the solid block of chicle after it has hardened. The blocks are put into henequen bags and transported to the nearest warehouse of the purchaser and shipper, where each block is cut with a steel machete for inspection and then stored until it can be shipped to a designated port in the United States. This entire series of operations is financed from the United States, f r the most part (some ninety percent, as has been said) by a major manufacturer of chewing gum and by a New York company, the supplier of several other manufacturers.

As may readily be understood from this recital, numerous opportunities occur for contamination of the commercial chicle with chips of

bark, soil and other dirt from the collection bags, lubricants from the molds, and other materials in transit or storage. None of these sources, however, would be expected often to yield other than small amounts of heavy metals. But the reports made by the field investigators told the story of the grosser contamination with lead in no uncertain terms, and the expectations, as well as these reports, were confirmed by the examination and analysis, when necessary, of the exhibits and samples returned from each of the jungle camps and warehouses involved. The facts were verified further by experimental trials made by cooking fresh latex in representative kettles. Kettles from the camps that were the sources of highly contaminated chicle yielded correspondingly contaminated chicle under experimental conditions, while kettles from the unconvicted sources were of different material or of different construction and yielded a product which was satisfactory from the aspect of contamination with lead in more than traces.

The history of the most serious type of contamination would be incomplete, and much less intriguing, if one were to ignore a certain aspect of its origin which illustrates the manner in which a well-laid technical program can be defeated by a human foible, in this instance the primitive appeal of the decorative art. A Mexican entrepreneur, learning of the existence of numerous blackened, beaten-up kettles in a large area of the jungle, sought and obtained a contract to replace each of these with a new kettle. His kettles were made bright and attractive by a complete and fairly heavy coating of solder on the inner surface. The latter feature was not made known to the contracting officers, but the attractive product was exhibited to the chicleros, who were delighted by the exchange of the old for the new. By such means the entire output of chicle from the Merida district was made unusable.

In other areas, iron kettles with both riveted and soldered seams had been fabricated and, in the course of the years, had gradually replaced

many worn out kettles. These had yielded moderate and variable degrees of contamination which had gone unnoticed. The solder, in all instances, but in large quantities in the case of the fully lined kettles, had melted off into the cooking chicle, most of it in the first season of usage. Just how it had come about that an inspector in the Food and Drug service of the United States had come to pick up a sample of the heavily contaminated chicle at an American port in this specific year has not been established, but one may suspect that the rapid development of precise methods for the analysis of lead in biological materials had contributed an element of probability into this otherwise fortuitous occurrence.

The wealth of carefully collected samples of soil from the vicinity of tapped trees, of the bowl, bark, leaves and sap of the trees, of wood ashes from the surface of the areas in which the kettles and their contents were handled, of twenty-eight varieties of lubricants for the molds, of jute mats and henequen bags, of floor sweepings from the warehouses, of plaster and painted objects from their surfaces—most of these served useful purposes in tracing the opportunities for some contamination of chicle (and other raw materials harvested similarly in the wild and handled in commerce), and also in providing additional information on the distribution of lead in the natural and artificial environment of mankind. Soil and water from the Mexican and far eastern jungles, as well as animal life, vegetation, and such vegetable products as the latex of trees that provide the natural gums of commerce, were found to yield minute to moderate traces of lead. Thus, it can be said on the basis of the probabilities established by numerous positive results and none negative, that lead is and has always been a constituent of living things including man, and that here, as in the great preponderance of instances, toxicity is not an intrinsic property of a substance, but is a function of its quantity in a specific animal tissue or in a species of living organism. This principle has come to have highly meaningful and practicle significance in our defense against the

hazards visited upon modern society by the technological developments of our time and those of the future. But for a comparable development of the technology of the control of hazards and the prevention of illness and disease based on this principle, modern man would be destroyed by his own acts of scientific adventure and commercial exploitation. People are only beginning to appreciate this possibility. They must be reminded again and again that should general scientific research and practical commercial and military applications continue, as in the past, to outrun research and practice in preventive medicine and hygiene, we shall have little ultimate reason to be concerned about racial strife, the revolution of youth, and the proliferation of crime and political chicanery, for we shall have been emasculated and destroyed by forces less subtle and more powerfully destructive than any of these. This fact has been demonstrated for all who can see, by one dramatic scientific development and its exploitation for the purposes of warfare. Unfortunately, whereas the disastrous effects of sufficient human exposure to atomic energy have so shocked mankind as to deter the most reckless from loosing it freely upon the earth, the more likely threat, in the form of the collective, insidious effects of incompletely explored, man-made alterations of the human environment, inspire little real concern in the minds of men generally and in high places—certainly not enough concern to bring about the changes in thought and action that are urgently required to prtect our society. It is political expediency, in the main, that dictates current moves in this direction, rather than responsible statesmanship.

But we stray from our story. The analytical data obtained from the finished chicle, from the numerous materials involved in its preparation, and from samples of latex, demonstrated clearly that the only source of gross contamination was that of the soldered kettles. It is of interest to recognize that only minute traces of lead were found in twenty-eight samples of the latex, while forty other samples contained considerably greater concentrations. Many of the

latter had been collected in containers that were clean by ordinary, but not chemical, standards, while others had been "stabilized" by boiling or by the addition of a preservative. No sample could be regarded as uncontaminated if it contained more than minute traces of lead. Minor variations in the analytical findings might well be due to the combined effects of analytical deviation and variable moisture content of latex, from tree to tree. Likewise, the determination of the lead content of three samples of freshly collected (in our containers) latex of jeletong from the far east was of the same order of magnitude as that of the chicle latex collected with similar precautions. Other samples of this latex, from various sources, which had been coagulated by kerosene, acetic acid, gypsum or other minerals, contained much higher concentrations of lead. The fact that twenty-seven samples of this wax collected from various locations or at various stages in its production, following the evaporation of moisture from the latex, or in the finished blocks of commerce, varied ten-fold in their lead content , is suggestive evidence of varying minor degrees of contamination. Other waxes from other sources fielded somewhat similar results, but none of these materials contained lead in excess of tolerance set by the Federal Food and Drug Administration.

It is important to recognize the fact that even modest degrees of contamination of these gums with lead would elevate measureably the concentration of lead in chewing gum and would increase thereby the total daily intake of lead by the regular users of chewing gum. Considering the multitude of ways by which individual items of food and beverages can be so contaminated, and so contribute to the total intake of lead in our food and drink, it is not surprising that this total averages up to about one-third milligram of lead per day per average male adult (the values for the distaff side of the house differ little from this, in all likelihood, but have not been investigated broadly). It appears from a considerable weight of indirect evidence that about half of this is of natural origin, while the

remainder is contributed by a large number of minute contacts of our food and beverages with lead-containing materials which are used for many purposes. In view of the fact that twice this quantity of lead taken into the digestive apparatus daily for years—that is, regularly throughout life—approaches the threshold of potentially dangerous accumulation of lead in the human body, this is not a matter of mere academic or literary interest. Thus, it is reassuring to know that the persistent efforts of governmental agencies and food processors and distributors in the United States are serving gradually to reduce the average intake of lead in our generally available foods and beverages.

The final chapter of this story may be told briefly, in recounting the efforts made to eliminate future contamination with lead, in more than traces, from the raw materials of which chewing gum is made, and in removing the excessive quantities of lead from the impounded and otherwise stored, contaminated chicle. Both of these problems were attacked at once. Certain exchanges of information between the field investigators and their home offices, augmented by the analytical findings, had made it possible for the responsible managers in the United States to localize the sources of the trouble. Chicle imported from Tuxpena, from the Cozumel Bank Lands, from the Carmen District of the State of Campeche, and from Belize were free of serious contamination, so that this chicle could be used in the production of chewing gum currently. Moreover, there was no need for the introduction of corrective measures into the operations in these areas. The chief source of the contaminated chicle was in the Merida district of Mexico. The supply from this fairly large and productive area would remain impounded for the present, while efforts were being made, as promptly as possible, to obtain new solder-free kettles and to introduce them into use. Modifications in the design of kettles, such as the provision of a double bottom for the protection of the chicle against burning, were considered, as were also matters of size and the choice of materials for their fabrication. But this was no

time for elaborate tests, and therefore, a first batch of kettles of somewhat variable size and shape was made in the United States, of stainless steel, of black iron and cast iron, and shipped to the field investigators with instructions to replace all of the soldered vessels that could be found, with the new ones, free of charge. The soldered kettles were to be taken up, removed entirely from the area, including even those in the hands of individuals and small groups of chicleros who were operating independently. A little later, additional black iron kettles were fabricated by a Mexican contractor under the eyes of an inspector representing the purchasers in the United States. Little or no resistance was offered to the exchange of kettles, and inspectors were provided in the field to cover all of the camps and to complete the replacement of any that may have been missed in the first round. The new kettles were stamped for identification and furnished with distinctive handles to facilitate their recognition at a glance. Before the end of the season, some eighteen-hundred-fifty (1,850) kettles had been distributed at a total cost of nearly fifty thousand dollars ($50,000) to the industry in the United States. All other importers of chicle in the United States, not included in the original group mentioned above, were fully informed of the facts and urged to take similar action with the people from whom they had purchased chicle. Further, in order to insure themselves against future local innovations that might result in a repetition of this or a similar episode, eight inspectors were selected from men trained in the business, familiar with the country, and accustomed to the life of the chicle camps, whose sole duties were to travel from camp to camp, at intervals of thirty to sixty days during the season, throughout the entire area of production, to examine all of the kettles and all of the operations, so as to maintain satisfactory conditions throughout the field.

Meanwhile, methods for cleaning up contaminated chicle , both that stored in the hands of the major importers of chicle and the manufacturers of chewing gum, and that impounded by the federal

authorities, were developed and applied, first experimentally, and then routinely under the supervision and cooperation of the authorities, until virtually the entire supply of contaminated chicle could be reconditioned for commercial use. Methods of filtration had been found to be useful in removing the lighter types of such contaminants as finely divided bark and other foreign substances, while the droplets and particles of solder could be removed in a steam jacketed centrifuge. All of the lots so treated were subjected to analysis and were found consistently to have been freed of all but traces, presumably, for the most part, that which occurred naturally in the chicle, well below the prescribed tolerance. Further, as a matter of future precaution, analytical facilities were provided in the plants of the principal manufacturers of chewing gum, so as to add this means to those previously employed to insure adequate control of the quality of chewing gum.

So ends this account of an episode which has been repeated, in varying ways and degrees, by industries engaged in the processing of raw and finished foods, under the impetus of the laws relating to pure food in these United States.

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