Sterilization of Dishes and Utensils in Eating Establishments*

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INTRODUCTION

For several years it has been generally accepted that disease producing agents may be transmitted through improperly sanitized dishes and food utensils. A human "carrier" with no disease symptoms may be equally as effective as a "case" infection in the contamination of dishes. Reports have been made of instances in which a healthy family became infected with colds after the visit of a dinner guest. Presumably the guest was a "carrier" and the dish sanitizing was inadequate. Transmission could have been by direct contact, handshaking, droplets, etc., as well as through inadequate dish sanitizing.

The term "sterilization" implies the complete killing or removing of all forms of microorganisms, including the more resistant spores as well as the ultramicroscopic viruses. Actually, under practical dishwashing conditions we frequently do not use bactericidal agents sufficiently strong to kill spores in the exposure period and under the conditions prevailing. For complete sterility, temperatures higher than boiling (under pressure) would be required, e.g. with the use of a pressure cooker or autoclave. However, spores generally are of relatively little sanitary significance on dishes since comparatively few of the common diseases are caused by organisms capable of spore formation. On the other hand, spores may be of considerable significance largely from the standpoint of food spoilage in utensils used for dairy and food industries, including bakeries. Rope formation in bread or high thermophilic count in milk may be a result of poor food utensil sanitation, resulting in survival of resistant spores. It would not seem likely that such pathogenic spore-forming bacteria as the anthrax or the botulism bacillus would generally need be considered in utensil sanitation of eating establishments. However, many of the filterable viruses are responsible for infection. Likewise the cysts of certain pathogenic protozoa may at times become a problem in food sanitation and possibly under unusual conditions in dish sanitation.

We are primarily concerned with making dishes safe for use and in this connection the word "sanitize" has been used. This does not imply the killing of all microorganisms but only those types which are likely to cause infection.

After food utensils have been properly cleaned in warm water employing a satisfactory detergent, and have been rinsed, we have at our disposal two commonly-used types of germicidal agents for sanitizing: (1) heat, and (2) chemicals. It is generally agreed that hot water is as satisfactory and as safe as any agent, however, the temperature must be high and the exposure period adequate. Hot water in sufficient supply is not always available or practical, hence we do have need for the chemical agents.

* Presented at the Sixth Annual Meeting of the Kansas Public Health Association, Topeka, Kansas, April 15-17, 1948.
STERILIZATION OF DISHES AND UTENSILS

A contaminated water may ordinarily be made safe but not necessarily sterile by simply bringing it to a boil and allowing it to cool. Slightly longer periods of high-temperature exposure might conceivably be necessary at high altitudes where boiling temperature is lower, especially if contamination is high. The U.S. Public Health Service Ordinance and Code Regulating Eating and Drinking Establishments (1943) (1) stipulates that utensils and equipment be immersed "for at least 2 minutes in clean, hot water at a temperature of at least 170° F., or for one-half minute in boiling water. Unless actual boiling water is used, an approved thermometer shall be available convenient to the vat. The pouring of scalding water over washed utensils shall not be accepted as satisfactory compliance." The U.S. Army Regulations (2) require a final dish rinse by immersion "in hot water for 30 seconds at 180° F., if the heat is controlled by an adequate thermostat or thermometer. If not, they will be immersed in boiling water for at least one minute and then removed and allowed to air-dry." Mallmann (3) et al. (1947), stated that for machine dishwashing "a 10-second rinse at 170° F. would appear to give us a practical standard with a good safety margin."

The use of hot water or heat for sanitizing dishes has many advantages. If the water is sufficiently hot for sanitizing purposes, the dishes and utensils air-dry quickly, requiring no toweling. The U.S. Public Health Service Code (1943) permits the use of drying cloths but recommends that wherever possible, utensils be allowed to drain dry without the use of drying cloths. The Army Regulations specifically state that fishes will be air-dried. The danger of towels becoming contaminated by hands and thus contaminating dishes is evident.

There are some limitations in the use of hot water. Some waters, when heated, do precipitate substances responsible for temporary hardness which may leave mineral deposits on dishes. Then too, many small eating establishments unfortunately are not equipped with satisfactory equipment for maintaining an adequate supply for hot water rinsing. Temporary eating establishments at fairs, carnivals, etc., also face this problem.

Where dishwashing machines are employed and an adequate supply of sufficiently hot water is available, it is essential that the holding period be sufficiently long in order to insure adequate heating of the utensil's surface. In hand dishwashing the final rinse should be made by complete immersion of all utensils by means of a dipping basket (e.g. metal) for the stipulated time. Wood linings in the metal baskets help prevent streaking of dishes. Care must be exercised to prevent the trapping of air under utensils, thus preventing contact of the hot water with the surface of the utensils. All too frequently the rinse water is allowed to become cool and the hands, instead of the metal dipping basket, are used for immersion of utensils. A rinse water cool enough to permit hands to be immersed will not kill bacteria. The use of testing thermometers by both the dishwasher and the sanitary inspector is essential.

It was pointed out previously that different times and temperatures of utensil exposure have been recommended. Generally with a given contamination of utensils and other conditions constant, the higher the temperature of exposure, the shorter the time required. If the bacterial load of contamination is increased at a given temperature, the holding period will need be extended or, if the holding period cannot be extended, then the temperature of the immersion bath must be increased in order to result in the same sanitizing effect.

As newer research is completed we will undoubtedly gain more information relative to limits of safety in exposure periods at high temperatures. With heavily contaminated utensils, al-
most the full 2-minute exposure may be required at 170° F., whereas with lighter loads a shorter period of exposure will undoubtedly be feasible. Nevertheless, until we learn the limits, it would appear wise to maintain a good margin of safety, both by maintaining the temperature and by not reducing the exposure time. In this connection, the need for an adequate hot water supply or the use of booster sink heaters is evident.

Generally then, it is essential that utensils always be properly cleaned before sanitizing. Hot water (not less than 170° F.) for a period of two minutes is considered an excellent sanitizing agent for clean food utensils. Shorter periods of exposure at this temperature should be considered only after we have had the opportunity of testing under varied conditions, and data are available indicating these limits.

**Chemicals as Sanitizing Agents**

Where hot water is not available, generally we have two possibilities of cold germicides in the chemical agents: (1) chlorine, and (2) quaternary ammonium compounds. A few other types of compounds have been proposed. Chemical agents as germicides function more rapidly as the temperature is increased, and the speed of reaction is augmented by increasing the germicide concentration.

**Chlorine**

Chlorine compounds vary considerably in their speed of reaction and germicidal efficiency. Hypochlorites are ordinarily faster in their action than chloramines (including chloramine T) (4, 5), however the latter are generally considered more stable in the presence of organic matter. pH influences the germicidal efficiency of hypochlorites tremendously (6), the hypochlorites becoming increasingly slower in their action as the alkalinity increases. The germicidal action of chlorine is apparently due to the hypochlorous acid formed and the quantity formed is a function of the pH. Alkaline hypochlorites would appear to require higher concentrations of available chlorine than neutral or acid hypochlorites, other things being equal.

The U. S. Public Health Service Ordinance and Code Regulating Eating and Drinking Establishments (1943) (1) stipulates that when hypochlorites are used, utensils should be immersed for at least 2 minutes in a lukewarm chlorine bath containing at least 50 p.p.m. available chlorine. The solution should be made up at a strength of 100 p.p.m. If chloramines are used, a concentration of equal bactericidal strength should be prepared. The relationship between hypochlorite and chloramine (or chloramine T) concentrations required for equal bactericidal strength is not well defined. Generally, however, since in the absence of organic matter, chloramines are slower in germicidal action than hypochlorites, higher concentrations would appear to be required for equal effect. Chloramines (7) generally are slower in their germicidal action than are the slower alkaline hypochlorites (6) but some exceptions have been noted and further study for clarification on this point is needed (8).

Chlorine compounds have been used as germicides for many years and a wealth of information is available regarding their germicidal efficiency. Some investigators (8) feel that hypochlorites should never be selected when the tuberculosis organism is to be killed, since this organism is known to be relatively resistant to chlorine. Certain viruses have been rather readily inactivated by chlorine, however only meager data are available on this subject. Also, limited data are available regarding the efficiency of chlorine against protozoan cysts. Generally these cysts resist chlorine concentrations many times as great as could be tolerated in drinking water. However, it would appear that by increasing the
chlorine concentration to that used in food utensil sanitation, more favorable results should be obtained, especially if the exposure period is prolonged.

While chlorine compounds, when properly used, do have good germicidal action, they also have some limitations. They exhibit the property of combining with organic matter, forming products of lower germicidal efficiency than hypochlorite, or of no germicidal value at all. The need for complete removal of all organic matter by thorough rinsing, e.g. in the use of 3-compartment sinks, is evident. Chlorine solutions are often irritating to the skin of the hands of dishwashers, and it is frequently difficult to get dishwashers to use chlorine. Silver and silver-plated tableware may be darkened when treated with chlorine compounds. With utensil sanitizing there is gradual loss of chlorine by escaping as a gas, by being converted to chloride, or by combining with organic matter, in all cases resulting in reduction of the germicidal agent. The available chlorine residual should be checked periodically in order to ascertain the "life" of the germicide in terms of the number of utensils which may be sanitized before the solution needs to be renewed.

A reasonably accurate measure of the effective germicidal residual (hypochlorous acid) of chlorine solutions under field conditions may be made by use of testing procedures such as the ortho-tolidine-arsenite method (9).

**Quaternary Ammonium Compounds**

Within the last few years quaternary ammonium compounds have been introduced as germicides. These compounds have been known for years by the chemist and have found use in the textile field. As early as 1890 they were reported to have germicidal properties, but the first record of their practical use as germicides appears to be about 1935 when Domagk (10), a German scientist, called attention to their high anti-bacterial activity. During the recent war and up to the present time the production of these compounds has increased greatly.

Quaternary ammonium compounds appear to have many desirable qualities when considered in terms of food-utensil sanitation. Among their desirable properties frequently publicized are: surface activity, relative freedom from toxicity, and freedom from skin irritation in concentrations used for hand dishwashing.

It is well established that certain substances do interfere with the germicidal action of quaternary ammonium compounds. These quaternary salts are cationic, and are capable of being inactivated by anionic agents in proper proportion. Among these interfering substances are: soaps, anionic wetting agents, some detergents, certain types of organic matter, and substances in some types of waters. It is known that hardness (calcium, magnesium, etc.) is one factor in water but may well not be the only one which causes a reduction in germicidal efficiency of at least some quatarnaries.

Quaternaries have been combined with detergents to attempt to produce combinations which will cleanse and sanitize in a single operation. The detergent added must be compatible with the quaternary. Non-ionic detergents have received considerable attention in this connection. The efficiency of a combined quaternary detergent in a single one-step operation remains to be proved. The germicidal efficiency of quaternaries generally is improved as the alkalinity is increased; however there is some evidence to indicate that with alkaline compounds, soaps will be formed in the presence of fat, resulting in at least partial inactivation of the quaternary (11). Until it has been proved that these combinations can cleanse and sanitize in a single operation in the presence of organic matter (food, milk, etc.), it would seem wise to first wash utensils, then rinse, and then immerse in the quaternary (e.g. as in a 3-compartment sink).
A number of detergents are incompatible with quaternary ammonium compounds (12). Hucker (13) has recently proposed a modified non-ionic detergent for combination with quaternaries which may prove to be of added value in cleaning and sanitizing in a single operation.

The use of brushes in connection with detergents and quaternaries has been reported to aid in the efficiency of these substances. Quaternaries have been used in connection with machine dishwashing (14) to substitute for the germicidal action of the hot water in case the water temperature drops, a condition which prevails more generally than is commonly believed.

Numerous chemical testing procedures have been developed for measuring the residual effective quaternary in the germicide rinse used in dish sanitizing. While a number of test kits have been developed for field inspection use, these generally measure the quaternary added, and it appears that as yet none is available for actually measuring the effective germicidal residual (15). Until such a testing procedure is perfected for field inspection use and we can determine the effective residual, we will be handicapped in our use of quaternary ammonium compounds.

**Selection of a Satisfactory Germicide**

There are numerous conflicting reports in the literature regarding the germicidal efficiency of quaternary ammonium compounds, and it becomes extremely difficult for those charged with sanitation control to select satisfactory germicides. In addition to this, our knowledge of these compounds is limited and we are still in the process of developing the most efficient methods for practical application of quaternaries in sanitation control.

The phenol coefficient (16) has been employed rather generally in estimating germicidal efficiencies of quaternaries, probably because this procedure has been used for years for regulatory purposes and to prevent gross fraud in the field of germicides. However, no direct method appears available for interpreting phenol coefficients in terms of practical application in food utensil sanitizing. A factor of 20 has been proposed for estimating effective concentrations (17) of phenolic-type compounds. Testing methods based on "use" concentrations, and "use" exposure periods under as nearly practical conditions as feasible are desirable, since the factors concerned are not necessarily "straight-line" functions and results with different concentrations, times, etc. cannot always be accurately predicted by extrapolation.

Quantitative methods (18) involving the enumeration of bacteria surviving after definite exposure periods are more applicable.

The type of test organism makes a tremendous difference in the results of certain types of germicide tests using these compounds. Gram-positive bacteria such as *Staphylococcus aureus* are generally more susceptible to quaternaries than are Gram-negative types (e.g. coliform), yet many of the tests carried out have made use of rather susceptible organisms. In addition, the greater the number of test organisms added per milliliter of test solution, the longer will be the killing time. Yet many tests have been made using rather low numbers of bacteria. Some of the reported testing experiments have been carried out without the use of adequate inhibitors or neutralizers for the germicidal action of the quaternary, hence a new light may be thrown upon their efficiency when tests are repeated employing adequate inhibitors.

Generally all germicides become more efficient as the temperature is increased. An average value which one might expect to find for the temperature quotient (Q10) would be about 2. This means that by decreasing the temperature 10 degrees Centigrade (18°F.), one might expect to
double the killing time. The temperature at which a germicide is tested is of considerable significance.

In selecting a germicide for sanitizing food utensils, because of the wide variety in these compounds one should have available information as to how the germicide functions under conditions approaching practical application as nearly as possible. In order to insure an adequate margin of safety, all proposed germicides should be tested with a high number of test organisms comparable to the most highly contaminated utensils one might find under practical conditions, and at a temperature no higher than room temperature since under practical conditions the temperature is often this low. In addition, the water (15) used in the test should correspond to that to be employed under practical conditions. Other substances employed (detergents, etc.) and conditions should likewise approach practical application as nearly as possible. In this connection we have recently developed a laboratory procedure (18) for evaluating practical performance of quaternary ammonium compounds and other germicides proposed for sanitizing food utensils. Indications are that the killing time determined by this procedure will serve as an index to the exposure period necessary for sanitizing food utensils with a given germicide.

**DISCUSSION**

To check the efficiency of a germicide only by determining the bacterial count on sanitized utensils is not adequate. First of all, the bacterial "load" of contamination may be light and the proposed germicide may be doing little other than diluting or clumping bacteria so that the colony count is reduced (19). Secondly, the types of bacteria present may not be as resistant as others which may be encountered elsewhere under practical conditions. A germicide proposed for use should first have a good laboratory performance test (18) and then be given practical tests under actual "use" conditions by swabbing utensils (20). However, in the interpretation of results from practical tests, a germicide cannot be said to be satisfactory simply because it reduces the count to below the generally-used standard of 100 per utensil. The limit of "100 per utensil" should apply only to utensils which have been held for some time after sanitizing and have been exposed to air-borne contaminants, and should not apply to utensils as they are lifted from the germicide bath. Utensils coming from a germicide bath should be sterile, except for possibly an occasional resistant spore-forming organism which would probably be of no sanitary significance. This interpretation in connection with the evaluation of germicides in no way invalidates the use of the limit of "100 per utensil" for routine enforcement procedures.

A good germicide properly used will result in sanitized utensils which are practically sterile, while a poor germicide leaves utensils with either low (below 100), medium, or high bacterial counts, depending upon the initial contamination and other factors previously discussed. The importance of holding the bacterial count low in the wash water and thus decreasing the load of contamination is evident. The dishwasher may easily recontaminate adequately sanitized dishes simply by improper handling. Dishes properly sanitized may be held indefinitely if properly protected in storage, and would not necessarily need be resanitized immediately before use. However, long storage periods for food and dairy utensils would be unsatisfactory where large numbers of air-borne bacteria would increase the rate of spoilage or conceivably contribute toward food poisoning.

The use of the swab-rinse bacterial count technique (20) is extremely valuable for enforcing satisfactory dish sanitizing procedures. Care must be taken to employ adequate amounts of inhibitors either for chlorine or for
quaternaries for protection of the surviving bacteria in transit to the laboratory. The chilling of swab vials is also essential to help prevent changes in bacterial population previous to plating.

**Conclusions**

In the sanitizing of food utensils the utensils should be first thoroughly cleaned with a good detergent (compatible with the germicide to be used), and then rinsed. Sanitizing may be accomplished with hot water (170°F for 2 minutes in the case of manual methods) or with chemicals (chlorine or quaternary ammonium compounds).

Chemicals proposed for use as germicides should be thoroughly tested in the laboratory and then tested under practical “use” conditions in order to ascertain concentrations and time of exposure required. There is no satisfactory method available for interpreting phenol coefficients in terms of dishwashing efficiency; practical tests are of more value. A chemical germicide should not be considered satisfactory for use, however, simply because the bacterial count after sanitizing is below the limit of 100 per utensil. Some chlorine compounds are generally slow in their action (e.g. chloramines), hence higher concentrations must be employed for adequate sanitizing. Chlorine compounds have been used for many years and we have considerable factual information regarding their advantages and their limitations.

Quaternary ammonium compounds are relatively new. While they have many advantages they also have definite limitations, and undoubtedly we have not yet learned either all of the advantages or all of the limitations. Since these compounds are new in the field of germicides, they should be thoroughly tested before being put into practical use. The method of testing, including the type of test organism used, number of test organisms employed, type of water used, etc., is very important.

**Summary**

Advantages and limitations of food utensil sanitizing (sterilizing) agents were discussed. Hot water, chlorine germicides, and quaternary ammonium compounds have been considered. It was pointed out that a new chemical germicide should be thoroughly and adequately tested before being employed under practical conditions. The type of test procedure (including the type of test organism, number of test organisms, type of water, etc.) is extremely important. Phenol coefficients do not give us information applicable to "use" conditions; a practical test approaching "use" conditions is more valuable, yet the swab-rinse bacterial count in itself does not give us adequate information. Reference was made to a recently-developed laboratory procedure (18) for evaluating practical performance of quaternary ammonium compounds and other germicides proposed for sanitizing food utensils.

**References**


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both syrups; while as much as 6.25 percent added lactic acid was required to arrive at the same result, and citric acid in the highest concentration used, 7.25 percent, failed to inhibit mold growth.

As a practical check to the above results, raspberry syrup with 0.33 percent acetic acid added was exposed to room temperature in an open container under conditions which would be conducive to spoilage. Frequent periodic inspections were made and evaporated water was replaced. No spoilage was observed after three months exposure.

Carbonated beverages were prepared from raspberry and strawberry syrups acidified with 0.33 percent acetic acid, by adding three parts of carbonated water to one part syrup. A tasting panel was unable to detect any difference between these drinks and similar drinks prepared with unacidified syrups.

REFERENCES


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