The practice of smoke preservation of foods extends far back into prehistoric times and probably stemmed from the custom of hanging such items as meat, fish, cheese, fowl, etc., near the smoke vent of the dwelling or the cave roof so as to be out of reach. The keeping qualities of the foodstuffs so exposed were noted to be greatly improved. The ancient Egyptians developed the preservation of biologic materials through smoking preservation to a high state of art and science in their mummification process.

Historically, and until relatively recent years, the smoking with its attendant curing process was carried out to preserve the meat or other food over prolonged periods. The current apparent consumer demand, however, is for mildly cured, lightly smoke-flavored meat products which have only slightly less perishability than fresh meat. There is a minor exception to this in the very limited demand for products of the Smithfield or Country Cure type, and certain highly-seasoned, highly-smoked dry or semi-dry sausages such as Thuringer, Smoked Salamis and Lebanon bologna.

Smoking as practiced today is almost always combined with heat, and the following effects among others may be listed as resulting from the deposition of smoke constituents and the effects of temperature:

1. Drying
2. Development and fixing of color of lean portions.
3. A tendering action from increased activity of autolytic enzymes of meat due to elevated temperature.
4. The imparting of a desirable finish or gloss on the skin and/or flesh sides of the meat pieces.
5. The imparting of desirable flavor and odor properties.
6. The imparting of antioxidants to the fat.
7. The impregnating of the outer portions of the meat with constituents of smoke which can exert a preservative action.
8. A reduction of the micro-organism level present in the meat.

Studies in our Research Laboratories in connection with the development of the so called "cured" flavor and the control of micro-organisms...
in the finished product, such as bacon or ham, have caused us to revise some of our prior concepts. It was previously felt that "adequate" time in cure was an absolute requisite for the development of cured flavor and the loss of the fresh pork taste. Definition of the term "adequate" varied with the individual. Our work has conclusively shown that cured flavor is a function of the type and load of bacterial flora present in the bacon or ham at the time of hanging in the smoke house. Further, that the flavor is the result of metabolic end products of the proper types of organisms which reach logarithmic growth rates while being carried through their incubation zone during the heating phase of the smoking operation. These proper types of organisms have been shown to be part of the natural flora of the packing-house. Since they tend to the psychrophilic types, the only thing that time in cure did was to assure their presence in adequate load at the time of hanging the meats in the smoke house. There would appear to be a fertile field of research in the use of controlled inoculation for the development of cured flavor in primal cuts such as bacon and ham. Success in the area of controlled inoculation in the development of typical flavor has already been demonstrated in the field of certain dry or semi-dry sausages by the work of the American Meat Institute Foundation, Merck & Company, and others using Pediococcus cerevisiae in Thuringer, Lebanon Bologna, Pork Roll, etc. Also the known, unpublished work of others in the United States using different organisms, and the published work of Niinivaara of the Research Institute of Meat Technology in Hameenlinna, Finland.

As an alternate area of research to the use of controlled bacterial inocula, it would seem that the use of bacterial metabolites produced from the proper strains of organisms grown on suitable substrate under the proper conditions could be used directly as the cured flavor agent.

There are two primary types of smoke houses in general use today -

(Lights Off)

(Slide 1) 1. The multifloored as is shown in this slide.

(Slide 2) 2. The cabinet (or kiln as it is referred to in England and on the Continent) as is shown in this slide.

The multifloored smoke houses served their purpose admirably when they were initially designed and installed. The smoking practiced then was for preservation which required prolonged smoking of harshly cured product with heavy smoke at relatively low temperature to dry the product out and make it keep, rather than to produce the lightly smoked, mildly cured, succulent product of today. The rigid control of temperature, humidity, air velocity and smoke volume so necessary in the modern operation was practically impossible to attain in the multifloored houses, and hence the development of the cabinet house where these important factors can be quite critically controlled.

Some attempts have been made in the use of continuous smoking operations and should be mentioned here. Our experiences in this area have been that products can be successfully smoked in a continuous operation using electrostatic smoke precipitating procedures as is demonstrated in these two slides.
This one, showing the electrostatic precipitation chamber, and this one, showing the smoked finished product. Where heating of the product to uniform desirable temperatures is also required there is much research left to be done. It is our understanding that continuous operations are extensively used in the smoking of fish.

There has been quite an evolution in the field of smoke generation. And again, this has taken place in relatively recent years. When I first started in the meat packing industry, we were still generating smoke by smoldering hardwood logs in the pit of the old multitiered houses. The practice of sprinkling hardwood sawdust on the smoldering logs gradually completely replaced the logs. The next step was to remove the smoke generation to an external sawdust burning pit constructed adjacent to the smokehouse as is seen in this slide. This materially reduced smokehouse fires which had been rather commonplace when the generation had been done in the pit of the house itself. An improvement over this procedure was the development of mechanical sawdust burners which produced a much more uniform flow and volume of smoke with practically no operator attention time which is shown here.

Among the most recent developments is that of friction generation - in this country using hardwood logs pressed onto a rotating disc, and in Europe by pressing the logs onto a rotating cylinder, the U. S. type being shown in these next two slides. The first showing an overall view of the generator and the second a view of the weighting system on the hardwood log. The smoke produced by this type generator is not entirely comparable to that produced by the more conventional method of smoldering hardwood sawdust as is shown by the chemical analysis of the two types of smoke in this slide.

### TABLE I

<table>
<thead>
<tr>
<th></th>
<th>Friction</th>
<th>Non-Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sawdust</td>
<td>Sawdust</td>
</tr>
<tr>
<td></td>
<td>Steam</td>
<td>Non-steam</td>
</tr>
<tr>
<td></td>
<td>Volatile</td>
<td>Volatile</td>
</tr>
<tr>
<td>pH</td>
<td>4.00</td>
<td>4.20</td>
</tr>
<tr>
<td>Total Acids</td>
<td>1.28</td>
<td>0.18</td>
</tr>
<tr>
<td>(as acetic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Aldehydes</td>
<td>0.63</td>
<td>0.16</td>
</tr>
<tr>
<td>(as acetaldehydes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Phenolic</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>(as phenol)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>86.7</td>
<td>70.6</td>
</tr>
</tbody>
</table>
There is still research to be done in the area of "cleaning up" the friction produced smoke to make it more comparable to that which has had such wide spread acceptance.

Another recent development is that of the use of "cold" smoke on which a U.S. patent has just been issued. In this procedure, hardwood sawdust is combusted in much the same manner as coke is made from coal. In other words, the wood is heated in a closed container, except for a smoke outlet, in the absence or nearly so, of oxygen, over any suitable heating device. The smoke so produced is then "piped" to a very closely confined smoking chamber. This procedure has been researched as demonstrated in (Slide 10)this slide. Our experiments with this process have shown that even such items as frozen steaks may be smoked since there is no, or relatively little, heat involved. Also, since the concentration of the smoke flavor is so great, only a matter of minutes is all that is necessary to obtain the desired flavor. Further, because of these time and temperature factors, it is not essential to have the meats cured to prevent bacteriological spoilage as is (Slide 11)necessary with conventionally smoked product. Pictured here are (Lights On) two fresh spare ribs - one cold smoked, the other untreated.

There would appear to be an area for the development of a whole host of new products in which a smoked flavor is desired without the attendant curing process or cured flavor and color requirements.

With respect to smoke deposition, we might say that there are four:

1. Regular.
2. Electrostatic.
3. Cold.
4. Dip

In the smoking of meats in the conventional process, we have previously mentioned the necessity for critical control of temperature, humidity, air velocity and, to some extent, smoke density. Regularly smoked meats generally have the smoke applied during their early hours in the smoke house - that is, while the meats to be smoke processed are still moist on the surface and cool. Most generally the smoke application is stopped long before the heat processing is completed. For example, in the case of regular smoked hams - those which are taken to an internal temperature of 137°F, the usual processing time is from 18 to 24 hours depending on weight - but, the smoke is applied only during the first 8 to 12 hours on the average. Sectional likes and dislikes throughout the country enter the picture here with regard to degree of smoke flavor desired.

In the electrostatic deposition of smoke we have found that "every thing" is deposited. In some instances the flavor of the resultant product from the "smoke" standpoint left something to be desired. Various means have been attempted to "clean up"
the smoke - that is, filtering through different media, water washing, preliminary electrostatic precipitation, etc., with mixed results. It would appear that additional research is needed in this area to provide either selective precipitation or a suitable precipitant. When depositing smoke by this means, it has been determined that, in general it may be done at any stage of the process except the final. It is necessary to give the product a final heat treatment (thinking now in terms of smoked primal cuts or sausage products) in order to "set" the smoke so that it cannot be wiped or washed off. This method of smoking currently is confined primarily to the fish industry, but it is also used in the smoking of hams, picnics, etc., for canning.

Insufficient work has been done to know about the merits of the "cold" smoking method. Smoke composition, proper conditions with respect to time, temperature, humidity and smoke density are some of the areas which need resolution. The mere fact that desirable smoked flavors can be achieved on frozen, fresh, uncured meat products should be stimulus enough for rather extensive research in this area.

There has been a rather large "hue" and "cry" in recent months for the use of "dip" smoking. This encompasses the use of condensates from wood combustion which have been redistilled. It has been reported that the pyrolyeitous liquor, free of tar and heavy undesirable constituents, is distilled to yield pure smoke oil (fumeol). This may be made into a 2-3% solution for soaking the food or it may be sprayed on the food or added with salt. Supposedly this treatment retards oxidation and bacterial spoilage. Of course, the artificial application of smoke flavor to meats is currently disfavored by the Meat Inspection Division of the U. S. Department of Agriculture. If it could be shown, however, that this was a more desirable way to impart such flavor, I am sure that there would be no hesitancy on the part of M.I.D. to approve such procedure.

We have previously presented a table showing the chemical composition of smoke produced both by the conventional smoldering of hardwood sawdust, and by the more revolutionary method of friction generation from hardwood logs. Naturally, there is a variation in the composition of smoke produced from various woods as seen in this slide.
TABLE II

APPROXIMATE COMPOSITION OF SMOKE FROM VARIOUS WOODS

<table>
<thead>
<tr>
<th></th>
<th>ACIDS</th>
<th>ALDEHYDES</th>
<th>BASIS</th>
<th>PHENOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEECH</td>
<td>4.0</td>
<td>2.7</td>
<td>4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>OAK</td>
<td>5.2</td>
<td>1.8</td>
<td>1.6</td>
<td>2.7</td>
</tr>
<tr>
<td>PECAN TREE</td>
<td>5.1</td>
<td>5.2</td>
<td>1.8</td>
<td>4.0</td>
</tr>
<tr>
<td>BIRCH</td>
<td>4.0</td>
<td>2.3</td>
<td>3.9</td>
<td>3.4</td>
</tr>
<tr>
<td>PINE</td>
<td>12.3</td>
<td>0.1</td>
<td>4.1</td>
<td>3.3</td>
</tr>
<tr>
<td>ALDER</td>
<td>4.3</td>
<td>3.4</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>LIME</td>
<td>6.0</td>
<td>4.8</td>
<td>3.1</td>
<td>3.8</td>
</tr>
<tr>
<td>ASPEN</td>
<td>9.1</td>
<td>5.2</td>
<td>4.1</td>
<td>5.2</td>
</tr>
<tr>
<td>FIR</td>
<td>6.8</td>
<td>0.2</td>
<td>3.8</td>
<td>4.6</td>
</tr>
</tbody>
</table>

There is still some controversy extant as to whether high resin containing woods such as balsam, fir, pine, etc., as opposed to hickory, oak, apple, cherry, etc., are suitable meat smoking woods. Let us say that "it all depends on what is desired." It has even been proposed that 20% mesquite roots be mixed with hickory as an ideal wood combination for the smoking of meats. Many of the high resin containing woods are regularly used to smoke fish.

Of rather exceptional interest, however, is the recent work of several European, Russian and Japanese investigators into the carcinogenic properties of wood smoke. The presence of 3,4 benzpyrene and 1,2,5,6 dibenzanthracene have been shown in smoked meats - particularly fish. The amounts are shown in the analysis (Slide 13) in this chart of a liquid dip condensate.

(Lights On)

TABLE III

APPROXIMATE CHEMICAL COMPOSITION OF SMOKE

<table>
<thead>
<tr>
<th>Specific Weight</th>
<th>Total Acids</th>
<th>Lactic Acid</th>
<th>Formic Acid</th>
<th>Esters</th>
<th>Alcohol</th>
<th>Aldehydes &amp; Ketones</th>
<th>Furfurals</th>
<th>Phenols</th>
<th>Insoluble Tars+</th>
<th>Reducing Substances</th>
<th>3,4 Benzpyrene (g./l.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.318</td>
<td>-9.92</td>
<td>-3.45</td>
<td>-0.96</td>
<td>-0.43</td>
<td>-0.05</td>
<td>-0.27</td>
<td>-0.05</td>
<td>-5.67</td>
<td>-7.65</td>
<td>-21.00</td>
<td>-150-200</td>
</tr>
</tbody>
</table>
This is of particular importance in European countries where a great deal of the meat and fish are smoked - up to 40% of the meat and more than 10% of the disembarked fish. For example, in four countries in 1957, 1,650,000 tons of meat products were smoked (USSR 760,000 tons, Federal Republic of Germany 580,000 tons, Poland and Czechoslovakia 150,000 tons each). As regards fish, for USSR - 150,000 tons, Poland 10,000 tons, and the United Kingdom 75,000 tons. It has been demonstrated that the majority of the so-called carcinogenic compounds are deposited on the surface of the smoked material.

There is an indication that these undesirable compounds are produced only in the high temperature pyrolysis of smoke generation - temperatures in excess of 300°C (572°F.). Also, that these tar-containing substances are produced to 3 times the extent from the lignine materials than from the cellulose materials of wood. It is therefore recommended that the combustion temperature be kept at that not greatly exceeding the burning point of cellulose - 180°C - 280°C (356°F. to 536°F.). It would seem that this is another area which definitely bears investigation.

Smoked meats in this country today are used by-and-large for their character and flavor. This is in direct opposition to the fact that a large part of the world's production of smoked meats, including fish, is used for the purpose of preservation. Between these two, then, we must distinguish first, flavor, or second, preservation.

The finest recent compilation of factual information on the smoking of meats of all types is that prepared and presented by Dr. D. J. Tilgner of the Animal Products Technological Institute of Poland in "Die Fleischwirtschaft" for October and November, 1958.

I leave you now with these unresolved areas in which I firmly believe additional research is necessary:

1. The use of controlled bacterial inoculum or bacterial metabolites for the production of cured flavor.
2. The uniformity of heating during continuous smoke processing.
3. The "cleaning up" of smoke from any source.
4. The making of electrostatic smoking acceptable from the standpoint of flavor and appearance.
5. The use of the so-called "cold" smoke procedure.
6. The use of applied "smoke" or the so-called "dips".
7. A study of the burning point of wood or suitability of wood combustion products for human ingestion.
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MR. SULZBACHER: Thank you, George. To handle the discussion for this very fine paper from George Brissey, we have the Freshman member of our Committee, Roman Kulwich, Quality Evaluation Section, Biological Sciences Branch of the United States Marking System.

MR. ROMAN KULWICH: Thank you. Ladies, Gentlemen, and Guests: I think we all profited by his excellent paper, and appreciate his visit to our conference. The smoking of meats has been going on many, many centuries. We still don't know all about it, and since time is short, I think we will open the floor to questions and comments at this time.

MR. WELLINGTON: I was interested in the table you showed, the friction generated smoke and normal smoke that you might get with hotplate system. Would you care to elaborate any further on this as to how much this affects the flavor? My real question, maybe you won't want to answer it, is the friction generated smoke flavor acceptable in the industry?

MR. BRISSEY: We don't think so in our place. Some people do. Some of you are aware, we have installed two continuous frankfurter manufacturing units, one in our South St. Joseph plant, and one in South San Francisco plant, and we had the plant in South St. Joe going while we were installing the South San Francisco unit, we had a special generator, we had a friction generator on the machine at St. Joe, and