ABSTRACT: A method of providing a low carcinogen content smoke aerosol for use in the smoking of food products. The removal of carcinogens from natural hardwood smoke is affected by cycloning conventionally generated smoke to remove a substantial portion of the particulates thereof and/or by regenerating a condensed natural hardwood smoke in the presence of heat. Products may be smoked in the conventional manner or by application of a condensed liquid smoke to a product by dipping, spraying or mixing the condensed liquid smoke into the product as an ingredient thereof. The process also provides the advantages of increasing the cleanliness of a smoke generating operation, reducing the fire hazard thereof and providing a smoking process that can be closely controlled thereby enhancing reproducibility.
Fig. 1.

10 SMOKE GENERATOR (HEAT, SAWDUST)

12 CYCLONE

PRODUCT SMOKING

14 MULTIPLE STAGE CONDENSOR 15° - 40°F

APPLICATION TO PRODUCT (DIPPING, SPRAYING OR MIXING AS INGREDIENT)

16 SMOKE REGENERATION (DISPERSION WITH OR WITHOUT HEATING)

PRODUCT SMOKING

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Atlas
SMOKING OF FOOD PRODUCTS

BACKGROUND OF THE INVENTION

For centuries, the flavor of various food products has been enhanced by smoking the same. Generally, this involved subjecting the food product, such as cheese, fish, or meat, and products made from the foregoing, to a dense smoke aerosol generally obtained by the oxidation of hardwood.

In those food industries utilizing smoking as a means for flavoring various products, large smoke generating devices are utilized, in the form of a smidgen which is generally formed up of finely divided wood bits from hardwood trees. In such operations, the sawdust will quite often be heated at some point in the smoke generating process to a glow point but normally, open combustion is undesirable.

The resulting smoke is then fed from the generator to a smokehouse in which the product may be placed to be subjected to the smoky atmosphere for a desired period of time. Such smoke may be generally considered to consist of three different types of matter. The first is fly ash which is relatively large in size and approaches the size of the sawdust particles being destructively distilled. The fly ash quite normally is virtually pure carbon along with some residue contained in the wood that will not distill or combust in the smoke generator. Of course, the deposition of fly ash on a product is to be avoided and generally, some steps are taken to remove the fly ash from the smoke conveyed to the smokehouse. Typically, such means includes a trap through which the smoke passes at a relatively low velocity thereby enabling the fly ash to settle out, or a large cyclonic through which the smoke passes at a relatively low velocity which is just sufficient for the fly ash to drop out of its entrained state in the smoke stream.

A second portion of the smoke is the visible, so-called “particulate” phase thereof which consists of relatively small particles of a colloidal size, which particles are generally composed of the higher boiling constituents of the smoke common to this as “tar.”

The third constituent of smoke is the vapor phase thereof. This phase is in a true vapor form as opposed to a colloidal form and it has been found that this phase principally contains the aromatic flavoring constituents which are desirable deposited on the product for the purpose of giving the product a characteristic smoke flavor.

The particulate phase or tar of smoke have been found to be relatively high in carcinogenic content. A typical carcinogenic found primarily in the particulate phase of smoke is 3,4 benzpyrene. As is well known, carcinogenic material, when present at sufficiently high levels, can induce cancer and there is increasing suspicion that even low levels of carcinogenic material can cause cancer after prolonged exposure thereto.

SUMMARY OF THE INVENTION

The invention concerns itself principally with the removal of carcinogenic material from smoke to be applied to food products without diminishing or altering the characteristic “smoked” flavor found in conventionally smoked products.

Furthermore, this invention concerns itself with the elimination of other problems long associated with the smoking of food products such as the maintenance of sanitary conditions and the fire hazards attendant a smoking process.

In a smoke process according to the invention, smoke may be generated by the destructive distillation of hardwood such as sawdust by any suitable means. The smoke thus generated is then run to a cyclone of sufficiently small size so that the smoke velocity therein is sufficiently high to carry out the smoke along with the tar as the plant is hereinafter done. However, concurrently, the smoke is precipitated by a substantial portion of the particulate phase of smoke containing the majority of the carcinogenic found therein.

According to one embodiment of the invention, the smoke material is drawn from the cyclone, which will principally be comprised of the vapor, the smoke of smoke, may then be conveyed to a smokehouse for the smoking of the product in any suitable manner.

According to a second embodiment of the invention, the on stream smoke from the cyclone may then be fed to a condenser which will condense the smoke to a liquid form. The liquid condensate smoke may then be applied to a product by dipping the product therein, spraying the product therewith or mixing the liquid smoke in the product material makeup as an ingredient.

Alternatively, the liquid smoke may be regenerated by dispersing the same throughout a liquid to be conveyed to a smokehouse for the smoking of a product.

If the dispersion of the smoke regeneration process takes place in a heated state, it has been found that carcinogenic content is further lowered apparently due to a “cracking” effect of the heat on the carcinogenic material than remaining in the smoke.

As an additional alternative, the cycling of the originally generated smoke may be omitted with the smoke being fed directly to the condenser.

Various advantages in addition to carcinogenic removal are present in the foregoing process wherein the originally generated smoke is condensed. For example, the smoke in a liquid form may be easily stored and/or transported to a remote location. As a result, the original smoke generation process may take place in a plant specifically designed for this purpose and wherein no food processing takes place. Thereafter, the smoke may be shipped to the food processing plant for regeneration and application to the product. As a result, unsanitary conditions and/or fire hazards due to the presence of smoke generating equipment in a food processing plant may be eliminated.

Furthermore, when a process according to the invention utilizing regeneration is practiced, significantly more control over the smoking operation than previously possible may be exercised. This is due to the fact that the amount of smoke, and the conditions under which it is regenerated may be more closely controlled than can be standard smoke generating devices. By the same token, the composition of the liquid smoke used in regeneration can be made more uniform.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flow diagram indicating the steps taken in practicing the invention; and

FIG. 2 is a vertical section of a smoke regenerating device which may be used in practicing the method illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Smoke Generation

In the method of generating a smoke aerosol according to the invention, a smoke generator 18 performs the first step in the method. The step of smoke generation can be performed by any suitable means known in the art and generally will consist of the destructive distillation of hardwood normally in the form of sawdust. Of course, wood waste other than hardwood could be used if it produces the desired smoke flavor in the final product.

As an example of suitable means by which the smoke may be generated, so-called “hardwood” sawdust was utilized in a commercially available Karlstoff Puf smoke generator, Model No. 17, which includes three heated plates on which sawdust is progressively heated. In the commercially available Karlstoff Puf generator, the temperature of only the third and final plate is controlled. However, in order to take advantage of reproducibility flowing from other subsequent steps used in this invention, it may be desirable to control each of the three plates to assure that consistent smoke aerosol is generated. Normally, a plate temperature of around 50°F or higher on all three plates will be suitable for purposes of this invention although it will be appreciated that variety of plate temperatures could be used.
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Cycloning The Smoke

The smoke produced by the smoke generator may then be fed through a cyclone 12 to effect removal of flyash entrained in the smoke as well as the carcinogen bearing tar found in the particulate phase of the smoke. The upper limit of the temperature at which the smoke aerosol produced by the smoke generation step is subjected to a cyclone is somewhat critical to the removal of carcinogens but the lower limit need only be sufficiently high to preclude significant condensation in the cyclone. A temperature of at least 180°F is normally sufficient to preclude undesirable condensation.

To effect significant carcinogen removal, the temperature of the smoke when introduced into the cyclone should preferably not be higher than about 350°F. The significance of this figure becomes apparent when it is considered that the cycloning step removes a portion of the particulate phase of the smoke and the percent of the total smoke generated in the particular process at any given time depends upon the smoke temperature. For higher temperatures, many of the undesirable higher boiling tars will be vaporized and then become a portion of the gaseous phase of the smoke. Of course, the cyclone cannot effect a separation of gases and as a result, the higher the temperature of the smoke when subjected to the cyclone, the less of the particulate material will be removed.

In terms of effecting the best temperatures so as to maximize carcinogen removal and yet preclude significant condensation of the smoke within duct work, it has been found that an optimum temperature range for the smoke upon its entry into the cyclone is on the order of 220°-230°F.

Other factors also have an effect on the separation of the particulate phase in the cycloning. For example, the concentration of the smoke will have an effect on the amount of condensates of discrete particles and on collection efficiency. And of course, in a cyclone, the larger the particle size, the greater the separation efficiency.

Similarly, the flow rate of the smoke will have an effect on the separation. The flow rate must be sufficiently high with respect to the geometry of the cyclone in order that the velocity of the smoke stream introduced into the cyclone is sufficient to cause the colloidial size particles in the particulate phase to be separated out. This is in contrast to heretofore known systems wherein cyclones have been used for the purpose of separating out flyash without separating out the particulate phase of the smoke.

Of course, cyclones have effects on separation. For relatively large cyclones such as those heretofore used in the separation of flyash, the velocities obtained within a cyclone are insufficient to cause the separation of the particulate phase of the smoke from the gaseous phase to an appreciable degree notwithstanding any of the foregoing factors. Thus, the cyclone should be extremely small so that high velocities may be obtained therein. As an example of a suitable cyclone which may be used in the method, it has been found that a so-called "4-inch cyclone" may be used with success without particular regard to the factors of concentration and flow rate which are extremely difficult to determine.

The operation of the cycloning step will become apparent from the following example.

EXAMPLE I

Smoke was generated in a standard Kartridge Pak Model 17 generator operated at 2.75 r.p.m. and which included at its output, a tar trap or pot having a standard draft opening so that the smoke generated was admitted with air. The smoke and air mixture was then conveyed through a 2 and 1/4 inch duct work to a 4 inch cyclone located approximately 10 feet away and the pressure drop across the cyclone was in the range 1.0 to 1.25 inches of water. The smoke temperature at the cyclone was in the range of 180°-200°F. The emerging gaseous phase of the smoke together with that portion of the particulate phase which was not separated out was then condensed and analyzed for carcinogens and the resulting figures, when compared with smoke generated under similar conditions but not passed through the cyclone indicated that 70 percent of the carcinogenic material, measured in terms of the presence of 3.6 benzyrene, was removed.

EXAMPLE II

Smoke was generated using three modified Kartridge Pak Model 17 generators wherein all three plates were controlled at a temperature of 750° F. All three generators were operated at 2.5 r.p.m. and the resulting three streams were combined and fed directly to a 4 inch cyclone located twenty feet away through 2 1/4-inch duct work without the admission of air. The temperature of the smoke at a trap located next to the generators was in the range of 350°-500° F. and the pressure drop across the smoke was 0.3-0.75 inches of water with the smoke emerging at a temperature in the range from 180°-230° F. Again, 70 percent of the carcinogens measured on the same basis were removed.

Comparing the Smoke

The smoke material emerging from the cyclone 12 and comprised primarily of the gaseous phase of the smoke with or without entrained air may then be fed to a multiple stage condenser 14. According to one embodiment of the invention, three stages of condensers are used with each stage being water-cooled at about 40°F, the second being ammonia-cooled at a lower temperature and the third being ammonia-cooled at a temperature of about 15°-20° F. Of course, a single condenser could be used and there is no restriction on the type of cooling, or the number of stages involved in the condenser. However, it is generally desirable to use a multiple stage system since as the constituents of the smoke flowing into the condensing system have different condensing temperatures and the possibility that those constituents condensing at a relatively higher temperature might not only proceed to the liquid phase but to the solid phase and thereby clogging of the condensing system avoided. Specifically, through the use of multiple stages, liquified smoke fractions may be taken from each stage at a temperature above that at which they would cause the flow to proceed to subsequent stages.

It is also desirable that the temperature of the final stage of the condenser be on the order of 15°-20° F. as mentioned previously for the reason that such a temperature will effect condensation of 90-95 percent of the smoke aerosol.

Where multiple stages are used, the outlet streams may then be recombined to provide a liquid smoke composition virtually identical to the original smoke except, of course, for the lower content of carcinogenic material. However, depending upon the flavor desired to be imparted to a product, the various fractions need not be recombined but may be used separately. For example, in a comminuted meat product, use of the fraction obtained from a high temperature stage results in what may best be characterized as a "sweet" taste and at the temperature of the stage decreases to the lowest temperature, the taste of the comminuted meat product treated with the same will gradually go from the "sweet" taste to so-called "phenolic" taste.

The smoke fractions emerging from the condenser may be separately or in recombined form used as an input material for the step of smoke regeneration as will hereinafter appear. Alternatively, the streams are used separately as to be entirely used for product flavoring by application as a liquid to the product. For example, the product may be dipped in the liquid smoke, sprayed with the liquid smoke, or the liquid smoke
may be mixed in the makeup of the product as an ingredient. In the case of dipping and spraying, it may be desirable to dilute the liquid smoke as necessary to obtain desired flavor.

Smoke Regeneration

The liquid smoke had from the condenser system may be regenerated by dispersing the same by a smoke regeneration 16. The dispersion may be affected by any of a variety of mechanical means and once dispersed, a smoke aerosol suitable for smoking of a product is provided.

A further reduction in carcinogen content measured in terms of the presence of 3:4 benzpyrene may be effected during the smoke regeneration step if the dispersion takes place in a heated zone. The following examples illustrate the reduction.

EXAMPLE III

A condensed liquid smoke had sufficient 3:4 benzpyrene added thereto to have a concentration of about 1.05 p.p.m. to facilitate analysis. The same was mechanically vaporized in a zone at a temperature of about 400°F and the resulting smoke aerosol was then condensed and again analyzed for 3:4 benzpyrene which was found to be present at a level of 0.08 p.p.m.

EXAMPLE IV

Procedures of the foregoing example were repeated except that the zone temperature at which the dispersion took place was 800°F. The resulting smoke aerosol had a concentration of 3:4 benzpyrene of 0.06 p.p.m.

EXAMPLE V

The procedure of Example III was again repeated except that a zone having a temperature of 700°F was utilized. The resulting smoke aerosol had a 3:4 benzpyrene concentration of less than 0.01 p.p.m.

EXAMPLE VI

The procedure of Example III was again repeated except using a zone with a temperature of 800°F. The resulting smoke aerosol had a 3:4 benzpyrene concentration of about 0.01 p.p.m.

EXAMPLE VII

The procedure of Example III was again repeated utilizing a zone at a temperature of 825°F. The resulting smoke aerosol had a 3:4 benzpyrene concentration of about 0.02 p.p.m.

EXAMPLE VII

A liquid smoke condensate having sufficient 3:4 benzpyrene added thereto to provide a level of 0.54 p.p.m. was regenerated in a zone heated to a temperature of 225°F. The resulting smoke aerosol was condensed and analyzed for 3:4 benzpyrene. The analysis indicated that the regeneration process destroyed 56 percent of the 3:4 benzpyrene.

EXAMPLE IX

A condensed, cycloned liquid smoke containing 33.0 parts per billion (p.p.b.) was regenerated by spraying the same at a plate heated to a temperature of 750°F to regenerate the same. After regeneration, the smoke aerosol was condensed and when analyzed was found to contain 1.67 p.p.b. of 3:4 benzpyrene.

EXAMPLE X

Condensed, cycloned smoke containing 33.5 p.p.b. of 3:4 benzpyrene was regenerated by spraying the same at a plate heated to 750°F to regenerate the same. Upon condensation, the regenerated smoke as found to contain 0.74 p.p.b. of 3:4 benzpyrene.

When the regenerating procedure was attempted utilizing zone temperatures of 850°F and more, the liquid smoke burned with fire and flashing, and at a temperature on the order of 900°F, the dispersion was accomplished by an explosion.

The mechanism by which 3:4 benzpyrene concentration is reduced by dispersing in a heated zone is not fully understood but it is believed that a certain amount of thermal cracking takes place. That is, carcinogens such as 3:4 benzpyrene one broken down into compounds of lesser molecular weight which are not classified as carcinogenic.

Furthermore, while it is not totally clear due to the inability of generating the smoke aerosol at temperatures of 850°F or more, the fact that such regeneration attempts resulted in combustion and the fact that a slight upward was noticed in the 3:4 benzpyrene concentration at zone temperatures of about 700°F, it is also considered that at temperatures higher than 850°F, formation of 3:4 benzpyrene may actually be encouraged due to combustion of the liquid smoke.

Smoking of the Product

The regenerated smoke having a low carcinogen content may then be directed to a smokehouse 18 for smoking products in any suitable manner.

EXAMPLE XI

Various cycloned, condensed liquid smoke compositions having an average 3:4 benzpyrene level of 32.9 p.p.b. were regenerated in the manner generally described in Examples IX and X above and were applied to all beef franka in a conventional smoke house in conventional manner. The resulting smoked franka were then analyzed to determine the extent deem of 3:4 benzpyrene using analysis techniques having a detection limit of 0.37 p.p.b. of 3:4 benzpyrene. No 3:4 benzpyrene was detectable on the franka thereby indicating that the level of the same on the smoked franka was less than 0.37 p.p.b.

Smoke Generator Structure

One form of a smoke generating device which may be used in practicing the method of smoking air according to the invention is illustrated in FIG. 3 and is generally designated 30. The smoke generator 30 includes a base plate 32 which is centrally spattered at 34 to provide an air or insert gas inlet 36.

The base 32 mounts rectangular housing section 38 which has its upper end terminating in a truncated pyramidal section 40. The truncated pyramid section 40 is, in turn, terminated in a square to round transition section 42, the upper end of which is connected to a tee 44 having one end blocked by a plate 6 so that the tee 44 serves as an elbow.

The plate 46 includes an aperture 48 through which an elongated pipe 50 extends. A collar 52 is welded to the outer surface of the plate 46 and includes a central aperture 54 which is aligned with the aperture 48 to receive the pipe 50. A setscrew 56 is associated with the collar 52 and the aperture 54 so that the vertical position of the pipe 50 may be set as desired.

At approximately the junction of the truncated pyramid section 40 and the square to round transition section 42 there is provided sleeve 58 which surrounds the pipe 50. Spacing means 68 connected to the inner wall of the square to round transition section 42 centrally locate the sleeve 58.

At the lower end of the pipe 50 there is located a conventional spray head 62 which is adapted to have a spray pattern as indicated by the dotted lines 64. The spray pattern 64 is within a heated zone defined by a metal box, generally designated 66. The metal box 66 is comprised of four side plates 68 (only three of which are shown) and a bottom plate 70. Electrical strip heaters 72 are in-
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generation operation can be removed from the food processing plants. Accordingly, the attendant fire hazards and sanitation problems in a food processing plant can be avoided.

Regeneration of liquid smoke according to the invention by

dispersing the same in a heated zone provides for further carci-
genosis removal if desired. Of course, if additional carcinogen
removal is not required, dispersion need not take place in a
heated zone and in either case the advantages of eliminating
the fire hazards and unsanitary conditions are still present.

As another alternative, the cycloning step may be omitted
and if smoke is then condensed, the advantages of elimin-
ation of the fire hazard and the unsanitary condition may still
be present and, if desired carcinogen removal can be effected
solely by regeneration by dispersion in a heated zone.

Finally, the liquid smoke obtained from the condensation
process need not be regenerated if desired but may be added
directly with or without dilution to the food product to be
processed in a variety of known ways to arrive at a product
having the characteristic smoked taste.

We claim:

1. A method of making a reduced carcinogen content
smoke aerosol for use in the smoking of food products compris-
ing the steps of:

a. generating smoke by subjecting a desired wood to heat;

b. removing a substantial portion of the particulate phase
of the smoke containing the majority of the carcinogens
found therein;

c. condensing the remaining smoke to a liquid by subjecting
said remaining smoke to a temperature in the range of
15°-40° F.; and

d. vaporizing the liquid smoke at an elevated temperature in
the range of 220°-850° F.

2. The method of claim wherein step (b) is accomplished by
feeding the smoke from step (a) through a cyclone of a suffi-
ciently small size to separate out colloidal size particles at
a temperature in the range of about 180°-300° F.

3. A method of making a reduced carcinogen content
smoke aerosol for use in the smoking of foods comprising the
step of vaporizing a liquid smoke composition at an elevated
temperature in the range of about 220° to 850° F. to generate
smoke aerosol having a carcinogen content reduced from that
of the liquid smoke composition prior to its vaporization.

4. A method of preparing a reduced carcinogen content
smoked foodstuff utilizing the method of claim 3 to generate a
smoke aerosol, and thereafter subjecting a foodstuf/ to the
smoke aerosol to smoke the same.

5. A method of making reduced carcinogen content smoked
foodstuff comprising the steps of:

a. subjecting a desired wood to heat to generate smoke;

b. passing the smoke through a cyclone of sufficiently small
size at a temperature in the range of about 180°-300° F.
to remove substantial portion of the particulate phase
of the smoke containing the majority of the carcinogens
found therein; and

c. thereafter subjecting a foodstuff to the remaining smoke.

6. The method of claim 5 wherein the step of subjecting a
foodstuff to the smoke is preceded by the steps of condens-
ing the reduced carcinogen content smoke to a liquid, and
dispersing the liquid smoke; and the foodstuff is subjected to
the smoke by contact with the dispersed liquid smoke.

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