Smoked Cheese

A comprehensive guide for cheesemakers

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Did nomads cooking their curds and whey over an open fire in the desert discover smoked cheese? Or perhaps it was a Viking, thawing out a piece of frozen cheese over a campfire. In any case, smoked cheese has been a prominent and popular flavored cheese product for many years. In fact, smoked cheeses are the second or third most popular flavored cheese category in the U.S. In the past, a natural smoke, generated by burning wood or sawdust, was used to smoke cheeses when they were placed in the vapors of smoke. Over the past 25 to 30 years liquid smoke, or natural smoke flavoring, has been used to smoke cheese. The purpose of this bulletin is to review the proper procedures for smoking cheeses, with both natural vaporous smoke and the use of liquid smoke or natural smoke flavorings.

Chemistry of smoke

Smoke flavor and coloring compounds are generated from wood by thermal decomposition of the wood components. Smoke composition depends on the pyrolysis temperature, amount of air during pyrolysis, type of wood, moisture content of the wood and temperature and humidity of the air. Table 1. lists the smoke components derived from combustion of wood and the functions of those smoke components.

With natural vaporous smoke, the smoke components are generated and reacted through oxidation reactions in the smoke generator. Smoke components coming from the smoke generator will be present in two phases: a particulate phase containing tars, resins, higher boiling phenolic compounds and potential polycyclic aromatic hydrocarbons (PAHs), and a gaseous phase containing the volatile flavor and color forming compounds. In the manufacture of liquid smoke (natural smoke flavoring), the natural vaporous smoke is directed to smoke scrubbers and condensers and smoke components are recovered in an aqueous solution. The tars, resins and PACs are removed with polishing filters and the concentration of smoke components are adjusted to a consistent

Table 1. Smoke components and their function in food products.

Combustion temperature, °C	Wood component	Smoke component	Function of smoke component
200-260	Hemicellulose	Furan, carboxylic acids	Coagulate proteins for skin formation & provides some bacteriostatic properties
260-310	Cellulose	Carbonyls & carboxyl groups	Reacts to provide smoked color and caramelized flavor notes
310-500	Lignins	Phenols & phenolic esters	Smoke flavor and antifungal properties

level. The liquid smoke manufacturing process can level out daily variations in smoke composition due to changes in atmospheric conditions, wood composition, and other variables in the smoke generation process.

Traditional process

The traditional natural vaporous smoke process offers two different options for the smoking process: hot smoking and cold smoking. The hot smoking process, which is used for processed meats, generates the smoke vapors and discharges those vapors into the smokehouse or processing oven at 55-80°C (130-175˚F). The cold smoking process which is used primarily for smoking fish and cheese generates the smoke vapors at a lower combustion temperature and discharges the smoke vapor into the smokehouse at 15-25°C (60-90˚F). The pyrolysis reaction in the hot smoke process proceeds seven times faster than with the cold smoke process and contains a much higher concentration of smoke flavor phenolic compounds than cold smoke. Generally there is no difference in the levels of smoke carbonyls (color forming compounds) between the two processes. Most liquid smoke solutions are produced with the hot smoke procedure since the yield of smoke components is much greater than with the cold smoke procedure and most liquid smoke is produced for use in processed meat products. Raw materials used for smoke production are primarily hard woods, e.g., hickory in southeast U.S., maple in New England and north central U.S., alder on the west coast, and mesquite in southwest U.S. Fruitwoods, nut shells and corn cobs can also be used for specialty smoked products.

Cold smoking cheese

Temperature control is extremely critical for the cold smoking process. The smoke generator should be placed outside the smoking chamber or processing oven to help control the temperature of smoke vapors emitted to the smokehouse. The greater the distance the smoke travels before entering the smokehouse, the cooler it will be. You should use hardwood sawdust or chips with 30% moisture to keep ignition temperatures below 350-375°C. Also, keep the smoke vapor temperature below 29-32°C (85-90°F) to ensure that the cheese does not soften and lose shape or start to oil-off. You can use baffles or filters in the smoke distributor pipe to help reduce the particulate fraction of smoke from depositing on the cheese. The particulate fraction of smoke contains tars ands resins but it also may contain polycyclic aromatic hydrocarbons that are potential human carcinogens, e.g., benzo[a]pyrene.

Cold smoke the cheese for the length of time needed to obtain the desired smoke flavor and color. Remove ashes and add more wood chips or sawdust as needed to maintain a constant supply of smoke vapors. Cold smoking takes a longer time to generate smoke compounds than hot smoking and also depends on the variety of cheese being smoked. You will need a few preliminary trials to determine the smoking time for each variety of cheese. Avoid cold smoking of cheese when air temperatures and humidity are high since the smoked cheese surface color will be a dull, muddy brown under those conditions. Do not over smoke the cheese, excessive smoke flavor phenolic compounds can be very harsh and bitter. Smoke color on natural cheeses is very critical since customers prefer a light golden brown color versus the traditional dark mahogany color of smoked sausage products (Riha & Wendorff, 1993a).

Natural smoke flavorings

Natural smoke flavoring or “liquid smoke” is produced by controlled pyrolysis of hardwood sawdust using traditional smoke generators. The vaporous smoke is then absorbed and condensed in a water scrubbing system. The aqueous smoke solution is aged, filtered to remove the tars, resins, and polycyclic aromatic hydrocarbons and then standardized to provide for a uniform concentration of smoke acids, carbonyls and phenolic compounds.

Natural smoke flavorings have eliminated many of the shortcomings of natural vaporous smoked cheeses. For example, natural smoke flavorings provide greater uniformity of flavor and color without the inconvenience of handling sawdust or cleaning the smokehouse. The emission problems of traditional smoking have also been eliminated since the tars, resins, and benzo[a]pyrene have been removed from liquid smoke by aging and filtration. Natural smoke flavorings are available from a number of wood species. Typical flavor profiles for several wood smoke species are shown in Table 2.

Natural smoke flavorings (or liquid smoke) may be applied to cheese products by various methods:

Table 2. Flavors of Various Wood Smoke Species

Smoke Flavoring*	Smoke species	Flavor description
CharSol AB	Hardwood	Sharp, phenolic note
CharSol H-6	Hickory	Tangy smoke note
CharSol M-10	Mesquite	Musty, peat smoke note
CharsSol 2502	Apple wood	Sweet, fruity smoke note
CharSol 2514	Cherry wood	Sweet smoke note

*Use of trade names of smoke flavorings does not imply endorsement by the University of Wisconsin nor criticism of those not mentioned.

1) direct addition to milk, 2) addition to the brine, 3) surface application to finished cheeses, and 4) direct addition to cheese products.

Direct addition to milk

When adding liquid smoke to milk for making cheese, blend 0.1-0.2 % CharSol H-6 or equivalent in the milk just prior to addition of the coagulant. The pH of the milk after liquid smoke addition should not be lower than 6.2. Preacidification of the milk with liquid smoke acids to a pH below 6.2 may extract excess colloidal calcium from the casein. Losing colloidal calcium influences the rate of coagulation, which may have a negative impact on the body and texture of your finished cheese. The primary advantage of adding liquid smoke to the milk used for cheesemaking is that the smoke flavor is uniformly distributed throughout the natural cheese and smoke carbonyls react with the proteins, both casein and whey proteins, during the make procedure. PLEASE NOTE: Liquid smoke also reacts with whey proteins, so you cannot process whey for food use if you use this application procedure. This application procedure is best suited for colored cheeses since the smoke will color milk proteins light tan.

Since liquid smoke does contain some bacteriostatic compounds, cheeses produced with liquid smoke addition to the milk will have slower body breakdown and flavor development than non-smoked cheeses. You should also keep the bacteriostatic attribute in mind when selecting a starter culture. When liquid smoke is added to the milk for cheesemaking, we recommend either using mixed strain starters or testing all single strain starters for the possibility of inhibition by the liquid smoke. You can use a simple starter activity test for this evaluation.

Addition to brine

You can flavor your brine-salted cheese by adding liquid smoke directly to the salt solution during brining. Liquid smoke concentrations in the brine ranging from 0.25-1.0% CharSol H-6 or equivalent should produce the desired smoke flavor and color characteristics to the cheese. Filter the brine after liquid smoke addition to remove any potential insoluble smoke polymers that may have formed on dilution with the brine. Also, cheese fines may have reacted with smoke carbonyls to form brown colored protein particles that may be deposited on the surface of the cheese and appear as dark specks of material if they are not removed. When smoke flavoring in the brine, we recommend the following:

- Make sure the cheese remains totally submerged in the liquid smoke-brine solution to ensure a uniform flavor and color development on the cheese surface. Brine temperature should not exceed 55°F.
- Keep the cheeses from touching one another while in the smoke flavored brine solution to eliminate any streaking or marking effect.
- When using liquid smoke in the brine (instead of natural vaporous smoking), the surface of the cheese is wetter so a longer, or warmer, drying schedule is needed to get the desired surface condition before waxing or packaging.

Since brine solutions tend to grow in volume with syneresis of whey from the cheese, the concentration of smoke flavoring is gradually depleted. Unless the brine is replenished with added smoke flavoring, your cheese will not develop the desired smoke flavor and color that it would with fresh smoke flavored brine solutions.
PLEASE NOTE: Do not use brine-soluble smoke flavorings, containing Polysorbate 80, since Polysorbate 80 is not soluble in saturated salt brines used for brining cheeses.

Surface application of liquid smoke

Natural smoke flavoring (liquid smoke) may be used in place of the traditional smoking process. Apply liquid smoke to the surface of the aged cheese and then heat to enhance the reaction of smoke components with the milk proteins, producing reactions similar to the traditional smoking process. The temperature of the cheese and smoke solution during surface application should be in the range of 40-60°F. In small operations, small blocks of cheese may be dipped in a diluted liquid smoke solution as shown in Figure 1. In larger operations, diluted liquid smoke may be sprayed on to the surface of the cheese in a continuous spray or drench system as shown in Figure 2. Liquid smoke solutions should be continuously filtered to remove cheese fines and free fat that might otherwise be deposited on the cheese surface producing a dark speck when dried. The intensity of smoke flavor is regulated by the concentration of smoke solution and the length of contact time in that smoke solution. For more surface color, use higher concentrations of liquid smoke and shorter contact times. On the other hand, for greater penetration of smoke flavor, use lower concentrations of liquid smoke with longer contact times. A good recommended starting concentration of liquid smoke would be a smoke solution with 3-4 mg of smoke flavor phenols/ml of solution (e.g., 50% CharSol H-6 or equivalent). A recommended contact time for surface application of liquid smoke would be 15-60 seconds. In previous research, we found that smoke concentration was optimum after about 30 seconds of contact time as shown in Table 3.

Figure 1. Surface application of liquid smoke by dipping cheese in smoke solution.

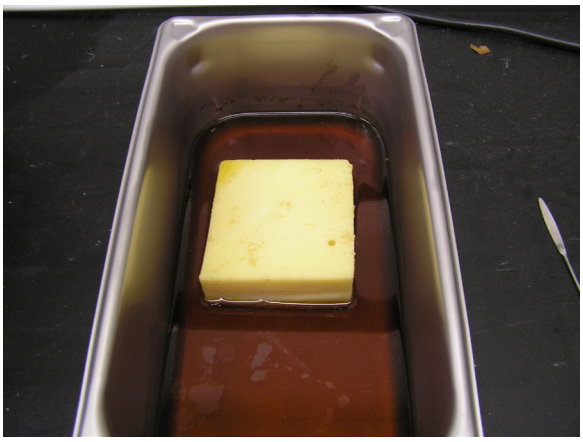
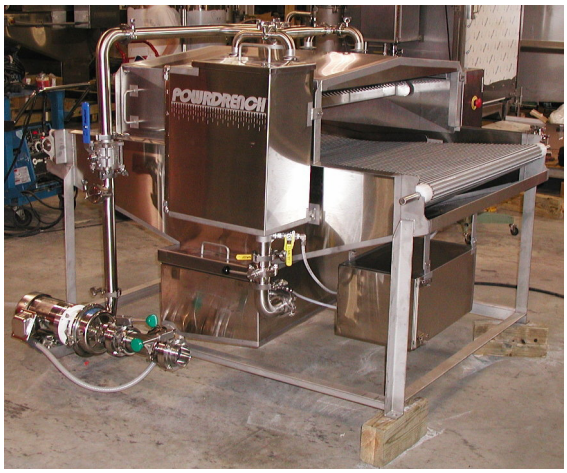


Figure 2. Surface application of liquid smoke by use of spray or drench system.



Just like the traditional smoking process, temperatures of the cheese surface during heating for smoke reaction should not exceed 32˚C (90˚F) to avoid melting and oiling off of milkfat. The surface color of the smoked cheese should be develop sufficiently within 1-2 hr of heating. This natural browning reaction between the smoke carbonyl compounds and the amino groups on the milk proteins may continue to intensify slightly during storage. Accordingly, on smoked white cheeses such as provolone, mozzarella, swiss and string cheese, it is advantageous to keep the smoked cheese properly cooled at all times and be sure to rotate stock properly. This intensification of smoke color is not as evident on colored cheeses such as cheddar and colby.

Table 3. Effect of smoke concentration and contact time on surface color (ΔE).*

Contact time (sec.)	50% Zesti Smoke Code 6	100% Zesti Smoke Code 6
Unsmoked control	3.2	3.2
15 sec.	5.2	8.0
30 sec.	5.8	8.6
60 sec.	5.9	8.8

*Treated cheeses were heat processed at 32˚C (90˚F) for 1 hr to react smoke carbonyls with cheese. ΔE = total color difference calculated from Hunter L, a, and b color dimensions.

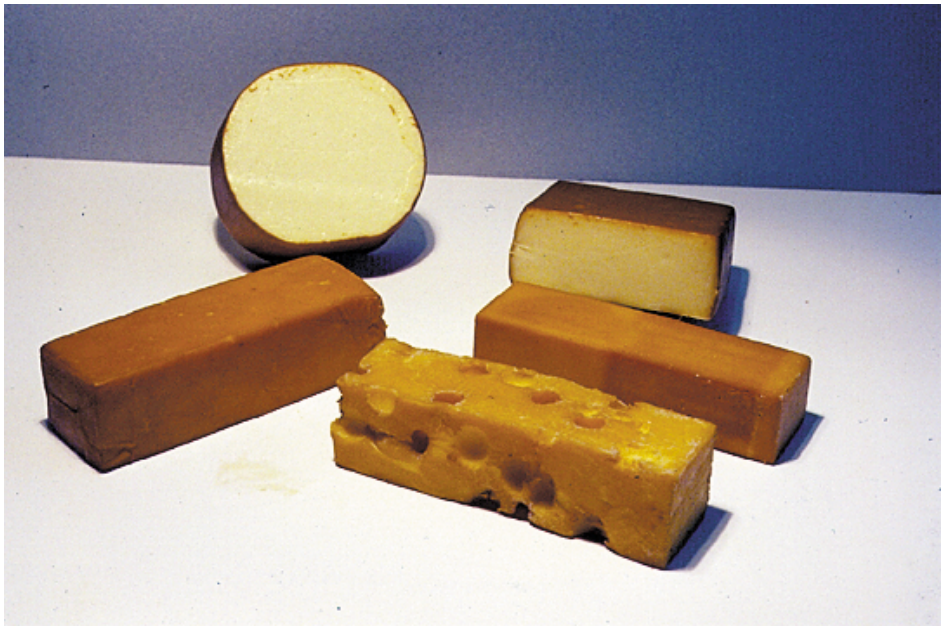
(Source: Riha & Wendorff, 1993b)

Earlier research (Riha & Wendorff, 1993a) indicated that, although smoked cheese colors range widely, consumers find some colors more acceptable than others. Consumer panelists rated the lighter colored smoked cheeses with higher hue angle and chroma values as more acceptable. Overall preferences indicated that panelists preferred a light golden brown surface on smoked cheese to darker mahogany or walnut brown as shown in Figure 3.

Direct addition to cheese

Natural smoke flavorings can be added directly to cheese products as a flavoring ingredient. Liquid smoke may be added to curds just prior to hooping and pressing; however, the smoke flavor components do have a background color that will stain the surface of curds and yield a seamy appearance to the final cheese. In most cases, the direct addition of natural smoke flavorings to cheeses is limited to processed cheeses, namely cold pack and pasteurized process cheese foods and spreads. The smoke flavorings may be added to the cheese mass at the end of the melting or blending process, prior to filling. The recommended level of usage for aqueous smoke flavoring, e.g., CharSol H-6 or equivalent, in cheese foods and spreads is 0.3-0.5% based on the weight of the cheese.

Figure 3. Consumer preference for smoked cheese color.



(Preferred color is shown on Swiss cheese)

Oil-based natural smoke flavorings may also be used in pasteurized process cheeses products. Recommended level of usage is 0.3% based on the weight of the cheese. The smoke-flavored oil should be blended into the melted cheese mixture after the addition of emulsifying salts. Oil-based smoke flavorings contain only the mellow oil-soluble smoke phenolic flavor compounds and will not react to form a smoke color. Oil-based smoke flavorings may be limiting if added to curds since the vegetable oil carrier may interfere with the binding of curds in the final cheese.

Dry smoke flavorings are also available for addition to process cheese products. These flavorings should be added to the cheese mixture along with the salt and other dry ingredients.

Approvals and Labeling

The provisions for use of natural vaporous smoke and natural smoke flavorings in cheese and cheese products are covered in Part 133 of Chapter I of Title 21 of the Code of Federal Regulations (Food and Drugs). The specific standards of identity that allow for the use of natural smoke flavorings are: cold pack cheeses, 21 CFR 133.123-124; process cheese, 21 CFR 133.169, 173, and 179; and spiced, flavored standardized cheeses, 21 CFR 133.193.
USDA Policy Memo 058A is the guideline you should follow when labeling products prepared with natural vaporous smoke and liquid smoke (natural smoke flavoring).

1. Products that have been exposed to smoke generated from burning of hardwoods, sawdust, corn cobs, mesquite, etc., may be labeled as "Smoked cheese" or with terms such as "Natural Smoked cheese" to indicate the traditional smoking process were used. In this case, smoke incorporation is part of the smoking process and does not have to be labeled as an ingredient.

2. Products may be labeled "Smoked cheese" if natural liquid smoke flavor is applied by spraying, dipping, liquid flooding or similar processes prior to or during heat processing. In such cases, the natural liquid smoke flavoring is reacted with milk proteins with the heat of processing. (With natural cheese products, we recommend heating to a temperature no higher than 95˚F for 1 hour to retard surface drying and potential oiling off) With this application, it is assumed that the smoke flavoring is transformed to the reactive state similar to natural vaporous smoke and does not have to be labeled as an ingredient.

3. Products to which natural smoke flavor has been added directly by marination, brining, injection, addition to curds or cheese emulsion must be labeled to identify the smoke flavor as part of the product in the ingredient statement. Carriers for dry or oil-based smoke flavorings used in cold pack or process cheese would also be required in the ingredient statement. Both traditional vaporous smoked and liquid smoke treated product processed according to (2) can be labeled as "smoked". Both smoked products can also label the species of smoke used e.g., "hickory-smoked cheese" or "applewood-smoked cheese". However, only traditionally smoked product can be labeled as "natural hickory-smoked cheese". On the other hand, natural smoke flavorings (liquid smoke) can be identified as "natural smoke flavor" or "natural hickory smoke flavor" in the ingredient listing of products produced under (3). FDA has generally accepted the USDA labeling policy as the guideline for smoked food products such as cheese.

References

Riha, W.E., and W.L. Wendorff. 1993a. Evaluation of color in smoked cheese by sensory and objective methods. J. Dairy Sci. 76: 1491-1497.

Riha, W.E., and W.L. Wendorff. 1993b. Influence of processing conditions on surface color of liquid smoke-treated cheeses. Cultured Dairy Prod. J. 28(4): 4-9.

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