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THE PHENOMENA OF QUALITY IN THE SMOKE CURING PROCESS

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Abstract - A better understanding of the high comlexity of the smoke-curing process led us closer to knowing why curing smoke is good or bad. The past 25 years have seen an enormous growth of our knowledge as presented in some 20 published review papers based upon numerous original investigations. Curing smokes present always a dynamic stage. Awareness in particle technology gives a better understanding of condensation and/or polymerisation processes which occur in a short time. Among the fundamental quality criteria wholesomeness is of basic importance and raises problems of zero tolerance. Polynuclear - free smoke has been attained by fundamental smoke research applying a two-stage smoke generation procedure. Revised and programmed smoke production is a good means of controlling the hygienic, sensoric and technological quality of curing smokes and smoked goods. These scientific advances are also reflected in progressive commercial practice although a high variability in the composition of smokes continues to remain a problem. Chemical interactions producing surface colouring and flavour characteristics have been investigated. Wood-smoke flavourings free of unwanted resp. unnecessary compounds possess many potential attributes.

INTRODUCTION

The age-old art of smoking foods was already well established before Homer i.e. more than three thousand years ago. Smoking together with drying and salting belongs to the oldest food preservation methods highly suited to the relatively primitive conditions of the past.

In modern society, however, the status of the smoke-curing process has changed from the former preservative to the flavouring task.

Meat and fish are still smoked directly with the smoke from smouldering hardwood until they have acquired the desired colour and/or flavour. This procedure is often carried out along with heating. It suffices to produce dense, medium or light curing smoke to permit production of smoked products with adequate consumer acceptability. But the highly empirical experience of the smoke curer can never really tell why the product is "well smoked".

In all standard works on food processing and publications on smoking of twenty or more years ago mainly empirical procedures of smoking are cited

(1-7). The complex physico-chemical properties of wood smoke and various interactions with food compounds could hardly be mentioned in those publications, because they were then unknown.

It is of very great significance that research on the smoke curing process turned some thirty years ago from "looking on the outside" of the curing smoke and smoked products to "looking on the inside" for answers to the perplexing questions that have been empirically dealt with by trial and error. Now we are "looking on the inside" of curing smoke with the aid of the physicochemist, organic chemist, food technologist, sensory analyst and bacteriologist. We are becoming acquainted not only with the physical characteristics, not only with the chemistry of the particle and vapor phases but also with the components and fractions of wood smoke and their properties and functions. The understanding of the high complexity leads us closer to knowing why curing smoke is good or bad.

REVIEWS

These past twenty years have seen an enormous growth in knowledge of the smoke-curing process. It is difficult for the ordinary processor or student of food science and technology to catch up with it. Suffice it to say that some 20 reviews report on advances in the smoke curing process since 1958, some of which cited 80 bibliographic references to original research papers (8-28).

Two international symposia devoted to progress in the physicochemistry and technology of the smoking process did much to enlarge our knowledge (10, 11, 15, 20).

But there is only one textbook on the chemistry of curing smoke published in 1969 by Kurko in the Russian language which actualises an earlier edition (1960) on the physicochemistry of smoke curing (29). This latest edition covers in ten main chapters the complexity of the smoking process presenting 71 tables and citing 577 bibliographic sources (30).

There is an acute need for a comprehensive textbook in English to discuss and consolidate this vast field of basic and applied knowledge. The British Ministry of Agriculture, Fisheries and Food plans a wider-ranging review covering traditional smoking methods, the foods which are subjected to smoking, the purpose for which smoking is used, the chemical composition of the smoke fractions deposited in the food being smoked, and evidence of its safety in use (31). This review to be published will be the result of the Food Additives and Contaminants Committee Report on the Review of Preservatives in Food Regulations, published in 1972 which touched on the question of food smoking in the context of the definition of "preservative". The FACC's review set out in paragraph 30 of that report that the whole question of smoking of food and the composition of smoke and smoke solutions and smoke flavours should be carefully considered separately. Hence this report may become the first monographic elaboration in English.

Awareness in particle technology

Curing smoke is a classic aerosol consisting of a suspension of minute particles in a vapor phase. All curing smokes present always a dynamic stage.

Foster's early research concentrated on the physical state of the smoke aerosol and was an important step forward in describing particle dispersions and gas suspension of smoke (32-34). Our current awareness in particle technology is concerned with the study of the physico-chemical production of particles during the thermal degradation of woody material and characteristics and properties of particles and their gas dispersion. The application of this may lead to optimization of the smoke process operation.* The field of particle technology is thus very wide-ranging, from physico-chemical generation of smoke particle to gaseous effluent control (35).

Condensation and/or polymerization processes occur in a short time and may be easily detected visually. It is known that ether solutions of smoke after a few days show dark tarry coagulants at the bottom and side of the receptacle. The amount of phenols in ether solutions may decrease twofold within two weeks. To indicate the general composition of smoke is a very difficult task since there are many factors affecting the composition of wood smoke.

Fundamental quality criteria

The function of smoke components is primarily to provide the desirable colour, aroma and flavour of smoked products and to contribute to preservation by acting as an effective bactericidal and antioxidant agent. But the preservative properties have lost greatly their former primary importance due to the massive development of strict hygienic requirements, modern packaging and a continuous refrigeration chain.

Growing dietetic awareness of the consumer places purity, wholesomeness and safety on top of modern food quality requirements. Unfortunately biased or ill-informed consumerist advocates feed the public with inaccurate, unsubstantiated specious information.

Wholesomeness and problems of zero-tolerance

Wholesomeness is the first quality requirement. Food must not be harmful to health either directly or through repeated consumption. There is therefore full justification for the demand of total absence of polycyclic aromatic hydrocarbons in curing smoke, smoke flavourings and smoked foods. Any contamination, unintentional as it may be, should be challenged and eradicated since restoring the wholesomeness of our food is of major concern to all.

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* There is a newly organised Particle Science and Technology Information Service at the Univ. of Technology in Loughborough, Great Britain, publishing monthly particulate information and scanning over 250 journals averaging 600 bibliographic references per month, ensuring the best possible coverage of the world wide literature in the field.

There are however methodological problems since the analysis of benzo(a)pyrene as an arbitrary indicator does not give a full picture of the content of the carcinogenic polynuclear compounds in curing smoke (36). The separation into fractions and indication of the trace amounts of over 25 individual polynuclear compounds identified in curing smoke is still rather cumbersome especially in the case of fatty smoked food products.

It is rather unwise to pick any single source as a particular hazard of carcinogenesis and to ignore others which act f.ex. as pollutants of the environment or through thermal decomposition of organic substances with access to air and higher temperatures as during grilling, roasting or toasting. Carcinogens in curing smoke and smoked foods are only one possible source. Nevertheless investigations dealing with the presence of benzo(a)pyrene in smoked foods continue to receive much attention as can be observed from eight contributions to this Symposium.

Polynuclear - free smoke

New ideas of the smoke generation procedure were presented by Miler (37, 38) by introducing the two-step hypothesis. In the first step, thermal decomposition in each wooden macroparticle takes place in the form of an "internal mantle" without oxygen contact. In the second step the oxidation of the volatile decomposition products occurs in the diffusion zone, i.e. in the external part of the "mantle". The velocity of oxidation is determined by oxygen diffusion and the smoke quality by a sufficient surplus of oxygen. Miler's real break-through in basic smoke research was fundamental in constructing a two-stage smoke generator which has all attributes for a programmed and controlled smoke generation (39). This is certainly the first principal quality phenomenon in curing smoke technology.

It has been firmly established that curing smoke is free of benzo(a)pyrene when the thermal decomposition of the wood does not exceed 425°C and the oxidation temperature 375°C. The measurement of the exact combustion temperature requires special precautions in order to avoid wishful interpretations. Heating to higher temperatures leads to polynuclears (40, 41).

Unfortunately, in all traditional smouldering-type smoke generation procedures much higher temperatures than generally assumed are encountered, reaching up to 966°C (38) and causing a concurrent generation of polynuclears. The proportion of individual substances of this chemical group seems to be specific for every temperature level, and the amounts vary in a wide range (41).

Many data have been collected by a number of authors about polynuclears absorbed during the smoking process by the smoked product together with other smoke constituents. The amounts are affected by many factors of smoke generation such as temperature of combustion and oxidation and air supply, density, length and temperature of the smoke cure, characteristics of the product surface and composition, kind of casing either natural, cellulose or synthetic, etc.

Controlled smoke generation procedure

It is now firmly established that the control and regulation of the exact temperature of the smoke generation process and the amount of air introduced are a good means of controlling the hygienic, sensoric and technological quality of smoke and smoked products. Extensive studies have been made of the effect of smoke generation parameters on smoke composition using different methods of smoke generation, investigating the effect of various kinds of wood etc. By correlating smoke composition and flavouring quality of each smoke a deeper insight of smoke quality could be obtained (42, 43).

It must be emphasized over and over again that even very small changes in smoke generation parameters cause differences in smoke quality and smoked products. This is our second basic quality phenomenon in smoke-curing technology. Significant odour differences exist between smokes of the smouldering, friction and the two-stage smoke generation type (43). The oral flavour profiles differ, of course, also from each other distinctly, having 6-8 oral flavour notes of which the typical smoke-cured flavour is generally the strongest since it is detectable at a very low dilution level. These odour and flavour notes penetrate and are passed on to the smoke cured product.

There is still another inherent drawback in all these investigations, namely the very high sensitivity of the complex reactions occuring during smoke generation and smoke deposition and high variability of the curing smoke. In spite of strict adherence to all technical details during the generation of curing smokes, replicas show a considerable range with regard to their chemical composition, i.e. the dry substance, phenolic and acid content etc. (43). These peculiarities confirmed in repeated experiments, in spite of our increasing efforts to attain chemically uniform duplicates, require further investigations since the range among replicas is often greater than among different smoke groups. Thus the obtained results lead to a discussion of case histories.

As can be seen from the above there are some physico-chemical obstacles which form a scientific challenge for qualified and devoted research teams in order to grasp the continuously changing behavior of curing smoke.

Surface colouring

Many smoked goods are expected to possess an attractive surface colouring ranging from light yellowish golden to dark brown shades. It has been established that this surface colouring involves complicated carbonyl-amino reactions and is directly connected with the loss of the carbonyl groups of smoke. The more carbonyls- the higher the intensity of the colour. The free amino group of the proteins is essential 44 . The role of phenols is insignificant but at pH 7.25 phenols with ortho- and para OH groups intensity colour of proteins. Different factors such as interaction of some specific smoke components with some proteins or amino acids, exposure to light, heat, oxygen, rh changes etc. influence the shade and intensity of colour formation (45-49). This knowledge is our third quality phenomenon.

Flavour components

Intensive studies of the flavour components of wood smoke and smoke products have so far given only approximate hints about sensorically detected "smokiness" or smoke-cured aroma and flavour (50, 51). It is certain that the desired target aroma and flavour is a blend of smoke components (52, 53, 54). This is our fourth quality phenomenon. Thoughts about quality interactions and requirements of wood smoke flavourings are dealt with in a separate contribution (55). It is also most valuable that more details about odour intensity, hedonic characteristics of smoke flavour and their wholesomeness are presented. However much research is still needed until all flavour characteristics and compensation and interaction phenomena are known. It is reasonable to expect further development of wood-smoke flavourings since they possess significant advantages.

Good wood-smoke flavourings are free from unwanted components, and should show uniformity since they should not be subjected to variations due to changes in environmental and smoke generation conditions. Their adaptability to processing and storage conditions is high. By creative blending of permitted ingredients contained in natural wood smoke these natural flavourings should have an equal status to stimulate more effective research in the development of ever-improving smoky flavours.

This symposium is held at a time when many of those engaged in smoke flavourings production and regulatory activities are especially interested in aspects of standardisation evaluation and safety of these products. Poland faces a great challenge and opportunity as a country in the forefront of applications and advances in smoke flavourings.

The clear conclusion of this symposium will probably be that good curing smoke flavourings are as safe and dependable as the best traditional direct smoke curing procedure provided that they are monitored continuously for flavouring quality and safety using acceptable international standards. Once criteria and methods have been chosen, optimal levels specifications can be determined for all pertinent smoke flavourings. These levels should be derived from surveys of good curing smokes and similar commercially available flavourings of good manufacturing practice. Reliable methods of quality examination of these flavourings must be available and agreed upon in international trade. The choice of methods of examination can be influenced by practical considerations such as simplicity of operation of methods and the cost of carrying them out. Precision, accuracy and sensitivity are prerequisites.

In this connection one can make the statement that there is the growing possibility of bypassing in practice the traditional direct smoking process by using coloured casings or wrappings of the required shade and by flavouring the product with proper wood smoke flavouring of the desired profile, intensity and high dispersibility.

Commercial practice

Although empirical methods still prevail a notable trend in commercial practice can be observed away from the obsolete smouldering wood smokehouses or smoking towers (56, 57). Lately new and original smoke generation methods and different technological applications have been proposed or introduced In hot smoking prevailing on the European continent a higher temperature, usually around 60-80°C is applied as against 15-20°C in cold smoking. The relative humidity of the smoke aerosol is usually strictly adjusted according to the requirements of the specific product. Heating elements inside the processing unit and the ventilation ducts permit an adequate heat supply. Stainless steel jets for air, moisture and smoke are standard equipment for modern smoking units.

The whole processing cycle is programmed and controlled by way of a cam assembly contoured for the specific product according to optimal quality conditions. Examples of these parameters established in detail in pilot experiments and used in commercial practice will be presented at this symposium and are the result of Dr. Pietrzyk's persevering investigations (58). In modern commercial practice a central steering and control panel observes preselected optimal heating and smoking conditions. This is our fifth quality phenomenon in the smoke curing process.

Smoke is not any longer generated at the bottom of the smoking kiln but in a separate unit under more or less monitored up-to-date conditions. There are interesting new developments in smoke generation methods with the aim of obtaining curing smoke at comparatively low temperature levels and thus eliminating undesirable smoke components. Generally the fresh smoke is freed from most or all dusty particles before being introduced into the smoke ducts or smoking chamber. The velocity of the smoke-air mixture is supposed to be even on all levels of the smoking cabinet to ensure uniform processing conditions and uniform quality in each batch or production period. In this respect the Torry Research Station controlled smoking kiln possesses superb aerodynamically adjustable diffuser walls to produce an even velocity over the whole cross-section of the smoking chamber (57). Electrostatic deposition of smoke particles has been introduced and considerably improved by investigating all the critical factors responsible for a high-quality smoked product. A continuous electrostatic smoking unit coupled with infrared heating has been devised and all optimal processing parameters have been described in detail and published pro publico bono (59). This may be considered as our sixth quality phenomenon.

To satisfy environmental pollution fighters and be a good neighbour the ensuing volatile products from the heat processing of fish or meat mixed with smoke components must be controlled. The obnoxious gaseous effluent from a smoking unit cannot be neglected; avoidance of pollution should be obligatory.

CONCLUDING REMARKS

The aim of opening lecture is to sketch the status and some advances in the last few decades of the smoking process without going into details discussed in original and review reports. Six distinct quality phenomena can be specified.

The symposium attempts to address both the mechanism of curing smoke and the consequences of good or bad smoke as they affect the needs and wants of both producer and consumer. The call for volunteered papers received over 28 answers from 11 countries as we can see from the titles of contributions specified in our program. These contributions together with seven plenary lectures create the real content of the symposium. They encourage confidence that new achievements in curing smoke science and technology will have increasing impact on traditional smoking procedures.

The arrangements of the Organising Committee provide a suitable framework to promote a lively exchange of scientific observations and experiences and establish contacts between scientists from different countries. Combining equal parts of scholarly devotion to our subject and skill in presenting and discussing the complicated problems this Symposium should achieve its aim. There remains however one of the greatest challenges facing us today, namely the transfer of scientific knowledge and expertise into actual practice, and to the younger generations. I trust that this challenge will be met in due time and be rewarding to all.

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