CHEMICAL COMPOSITION AND APPLICATION OF SMOKE FLAVOUR

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The toxicological problems attaching to conventional smoking have come more and more into focus, for which reason extensive efforts are being made today to develop toxicologically acceptable smoke flavours. It is wellknown that conventionally generated smoke for smoking foodstuffs comprises i.a. such groups of compounds as fatty acids, carbonyl compounds, polycyclic hydrocarbons and phenols. On the other hand, opinions still differ as to which of these compounds produce the characteristic smoke flavour. Studies of the oil-soluble moiety of smoke condensate have been made by means of gas/liquid chromatography. After being purified by extraction, the smoke flavour proved to contain some 20 different aromatic components, most of which were found to be of phenolic nature. However, the existence of a few aromatic aldehydes was also proved.

Organoleptic studies of the individual components or groups of components showed Cis-iso-eugenal, trans-iso-eugenal, 2, 6-dimethoxy phenol and 2, 6-dimethoxy-4-methyl phenol to be the compounds contributing most markedly to the characteristic smoke flavour.

Optimum flavour characteristics can be achieved only by adding the proper concentration and by application of the proper technology. The concentration necessary to obtain the desired flavour has been found to depend on type of meat, fatty contents and processing method. Hence, examples of concentrations are: Ham, 45 ppm, bacon, 32 ppm, in both cases added to the brine. For minced cooked sausages, cod roe, fish paste and fish sausages the concentrations range from 15 to 45 ppm.

The original object of conventional smoking was to preserve foodstuffs. It is therefore important to ascertain what effect the application of smoke flavour has on the keeping qualities of foodstuffs. Studies have proved some of the components found in smoke flavour to have a marked antioxidative effect together with antibacterial activity. In this case, it is particularly the polycyclic carbonyl compounds such as 2, 6-dimethoxy-4-hydroxy benzaldehyde that are active.

COMPOSITION CHIMIQUE ET UTILISATION DES AROMES DE FUMAISON

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Les problèmes d'ordre toxicologique concernant le processus de fumaison conventionnelle présentent un caractère d'actualité accrue. Voilà pouquoi, on procède actuellement à la mise au point d'arômes de fumage acceptables d'un point de vue toxicologique. C'est un fait connu que la fumée produite en vue du fumage des denrées alimentaires contient, entre autres, des groupes de substances du type acides gras, des composés carboxyliques, des hydrocarbures polycycliques et des phénols. L'unanimité ne s'est, par contre, pas encore faite à propos des composés produisant le goût caractéristique de fumaison. Des recherches portant sur la fraction liposoluble des produits de condensation de la fumée ont été effectuées par chromotographie en phase gazeuse/liquide. Après extraction, l'arôme de fumée révèle environ 20 composés aromatiques divers comportant le plus souvent une fonction phénolique. Quelques aldéhydes de type aromatique ont aussi pu être caractérisés.

Des essais organoleptiques portant sur ces substances prises individuellement ou en groupe ont démontré que le Cis-iso-eugénal, le trans-iso-eugénal, le 2, 6 diméthoxy phénol et le 2, 6 diméthoxy-4 méthylphénol sont les dérivés qui confèrent le plus nettement l'arôme caractéristique de fumaison.

Des caractéristiques gustatives optimales ne peuvent être atteintes que par une addition de ces produits à des concentrations convenables et par l'emploi d'une technologie adaptée. Il s'avère que les concentrations conférant l'effet gustatif optimal recherché dépendent du type de viande, de la teneur en matière grasse et de la méthode de préparation. On utilise les concentrations suivantes: Jambon: 45 ppm, bacon: 32 ppm. Dans les deux cas, les composés aromatiques sont ajoutés à la saumure. Dans le cas des saucisses à chair finement hachée, des oeufs de cabillaud, de pâtés de poisson, les concentrations varient entre 15 et 45 ppm.

A l'origine, la fumaison typique était destinée à la conservation des denrées alimentaires. Voilà pourquoi, il est important de constater l'influence des arômes de fumaison sur la conservation des produits alimentaires. Des essais ont prouvé que certains composés existant dans l'arôme de fumaison ont un effet antioxydant net, de même qu'une action bactéricide. Les composés carboxyliques polycycliques, tel que le 2, 6 diméthoxy-4-hydroxy benzaldéhyde, par exemple, présentent une activité antioxydante.

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RÄUCHERAROMEN, IHRE CHEMISCHE ZUSAMMENSETZUNG UND ANWENDUNG

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Da sich beim konventionellen Räuchern heute die toxikologischen Probleme immer mehr aufdrängen, setzt man sich jetzt sehr dafür ein, toxikologisch akzeptable Räucheraromen zu entwickeln. Bekannt ist, dass auf herkömmliche Weise erzeugter Rauch zum Räuchern von Lebensmitteln u. a. aus Stoffgruppen wie fetten Säuren, Carbonylverbindungen, polycyklischen Hydrocarbonen und Phenolen besteht. Dagegen ist man sich noch nicht darüber einig, welche dieser Verbindungen den typischen Rauchgeschmack bewirken. Man hat mit Hilfe von Gas/Liquid-Chromatographie den öllöslichen Teil von Rauchkondensat untersucht. Nach dem Reinigen durch Extraktion enthielt das Raucharoma rund 20 verschiedene aromatische Bestandteile, die meist den Charakter von Phenol hatten. Einzelne aromatische Aldehyde konnten jedoch auch nachgewiesen werden.

Wie organoleptische Untersuchungen der einzelnen Bestandteile bzw. Gruppen von Bestandteilen ergeben haben, sind Cisisoeugenal, Transisoeugenal, 2, 6-Dimethoxyphenol und 2, 6-Dimethox-4-Methyphenol diejenigen Verbindungen, die am deutlichsten zu dem typischen Rauchgeschmack beitragen.

Optimale Geschmackscharakteristika lassen sich nur durch Zusatz in genauer Konzentration und durch Anwendung der richtigen Technologie erzielen. Wie es sich gezeigt hat, ist die für die gewünschte Geschmackswirkung erforderliche Konzentration von Art des Fleisches, Fettgehalt und Bearbeitungsmethode abhängig. Genannt seien hier folgende Konzentrationen: Schinken 45 ppm, Bacon 32 ppm, in beiden Fällen der Salzlake zugesetzt. Bei feingehackter Brühwurst, Dorschrogen, Fischpastete und Fischwurst schwanken die Konzentrationen zwischen 15 und 45 ppm.

Ursprünglich wurde mit dem konventionellen Räuchern beabsichtigt, die Lebensmittel zu konservieren. Deshalb ist es wichtig festzustellen, welchen Einfluss die Verwendung von Räucheraromen auf die Haltbarkeit von Lebensmitteln hat. Wie Untersuchungen ergeben haben, haben einige der im Raucharoma enthaltenen Bestandteile ausgesprochen antioxidative Wirkung. Auch eine antibakterielle Wirkung liess sich feststellen. Aktiv sind hier besonders die polycyklischen Carbonylverbindungen wie z. B. 2, 6-Dimethoxy-4-Hydroxybenzaldehyd.

ХИМИЧЕСКИЙ СОСТАВ И ПРИМЕНЕНИЕ ДЫМНО-ВКУСОВЫХ ВЕЩЕСТВ

КАРЛ ЗИР ОЛЬСЕН

Промышленное предприятие П.Бросте, Копенгаген, Дания

Токсикологические проблемы, связанные с традиционным копчением, становятся все более и более актуальными и поэтому, в настоящее время ведутся интенсивные работы над развитием токсикологически приемлимых дымо-вкусовых веществ. Является общеизвестным, что обычным способом генерированный дым для копчения пищевых продуктов состоит между проч. из таких групп веществ как жирные кислоты, карбонильные связи, полициклические гидрокарбонаты и фенолы. Однако отсутствует еще единое мнение относительно того, которые из этих связей создают характерный дымовой вкус. Посредством газово/жидкостной хроматографии были произведены исследования растворимого в масле конденсата дыма. После очистки экстракцией, дымный аромат содержал 20 различных ароматических компонентов, которые в большинстве характеризовались как фенолы. Были установлены также одиночные альдегиды.

Органолептические исследования одиночных компонентов или групп компонентов показали, что цис-изо-эйгенеловые, транс-изо-эйгенеловые, 2-6 диметоксифенол, 2-6 диметокс 4 метифенол, являются связями, которые найболее выраженно способствуют образованию характерного вкуса копчености. Оптимальные вкусовые характеристики достигаются только в случае добавок веществ с правильной концентрацией и при надлежащей технологии. Было установлено, что степень концентрации, необходимая для достижения желаемого вкусового эффекта, зависит от вида мяса, содержания жира и способа переработки. И так, например, можно упомянуть следующие виды концентрации: ветчина 45 частей на тысячу, бекон 32 ч. на тыс. - в обоих случаях добавка производится в рассол. Для мелкорубленной вареной колбасы, икры трески, рыбного паштета и рыбных колбас концентрация вариируется в пределах 15-45 частей на тысячу.

Первоначальной целью традиционного копчения было консервирование пищевых продуктов. Поэтому, является важным установление влияния дымо-вкусовых веществ на сохраняемость пищевых продуктов. Исследования показали, что некоторые компоненты, содержимые в дымо-вкусовых веществах, обладают ярко выраженным антиокислительным эффектом, причем констатировано также их бактерицидное действие. В этом смысле специально действуют полициклические карбонильные связи как, например 2.6 диметокси 4 гидроксибензадегид.

CHEMICAL COMPOSITION AND APPLICATION OF SMOKE FLAVOUR

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INTRODUCTION

Smoking is one of the oldest known methods of preserving food and can be dated back to the nomadic stage of man.

Whether the purpose of smoking at that time chiefly was to preserve the food or impart a characteristic flavour to the food, this tradition has survived and today, where we have many other preserving methods, smoked foods still play a decisive part in our consumption of foodstuffs.

Throughout the years there has been a great deal of research in order to find out what actually happens with the food during the smoking process, but only a few of the processes involved have been examined and explained.

The smoke for the smoking is produced by an incomplete combustion of hardwood. Softwood is not suitable as the smoke gives the products a resinous flavour, which is undesirable. Besides, each kind of wood gives the smoked products a different flavour, because apart from the combustion products there are also different low boiling oils and resins which evaporate before the combustion.

Chemically the smoke consists of a combination between several substances which a large number of scientists have tried to determine with varying success. Without going further into these examinations it can be pointed out that the substances which have been detected up till now can be divided into some characteristic main groups

Tar - creosot - resins	carbonyl compounds	polycyclic hydrocarbons
water	organic acids	heterocyclic amines and
alcohol	phenols	nitrous gasses

This compound of substances is present in the smoke which is a kind of mist where some substances can be found as gasses and others as small drops of 0,1 micron, and in the smoking chamber this mist is condensed on the foodstuffs.

The technological development of these smoking chambers which has taken place in order to obtain a better control of the process, will not be treated in this paper, but only the smoke itself, where it can be established that in this compound there are some substances with the wanted effect, some substances which are only fill, and some substances which are direct harmful.

Looking at the different substances in a smoke there is among scientists some disagreement as to which substances are responsible for the good taste.

The tarry phase contains cresol guajacol, eugenol methylguajacol and pyrogollol to mention a few of them. Often these substances are credited with the antibacterial and antioxidative effect which smoking is supposed to have.

The water phase contains low boiling fat acids, carbonyl compounds and alcohols, where among others pyroligneous acid, formalin and furfurol can be mentioned, and especially formalin is responsible for the immediate sterilisation of the meat surface while the meat is in the smoking chamber, and the carbonyls are claimed to be responsible for the formation of the colour.

The taste of both phases is rather different and scientists all over the world disagree on which should be preferred.

Among the smoke flavour products which can be found on the world market today, some chiefly consist of acids, others of acids, esters and carbonyl compounds, and finally some which chiefly consist of phenols.

A comparison of these commercial products has been made by V. M. Gabatov and is shown in table 1.

COMPOSITION OF SIX LIQUID SMOKES

COMPOUNDS mmol/100 ml	JAPAN	FRANCE	HUNGARY	SCANSMOKE	CHARSOL	USSR
Phenols	2.4	1.5	3.4	30.0	2.1	2.2
Carbonyl Compounds	18.1	1.4	11.4	7.3	16.8	10.5
Including:						
Unsaturated	17.4	1.1	4.7	7.8	11.2	6.0
Saturated	0.7	0.3	6.7	0	5.6	4.5
Furfural	2.3	0.6	1.1	0.6	0.5	0.5
Acids	45.0	4.8	53.7	1.6	100.0	45.0
Esters	17.2	4.6	59.5	1.5	8.1	44.6
Methanol	15.3	2.1	2.0	3.2	4.9	1.6
Non-volatiles %	2.3	0.47	0.16	13.6	3.5	1.4

Source: V. M. Gabatov, Food Technol., 25, 71-77 (1971)

Table 1

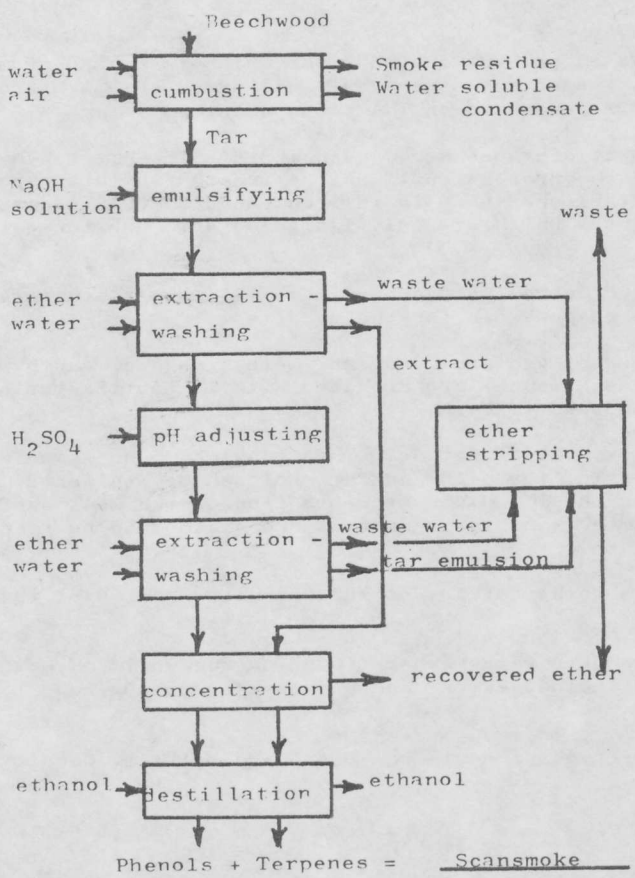


Fig. 1

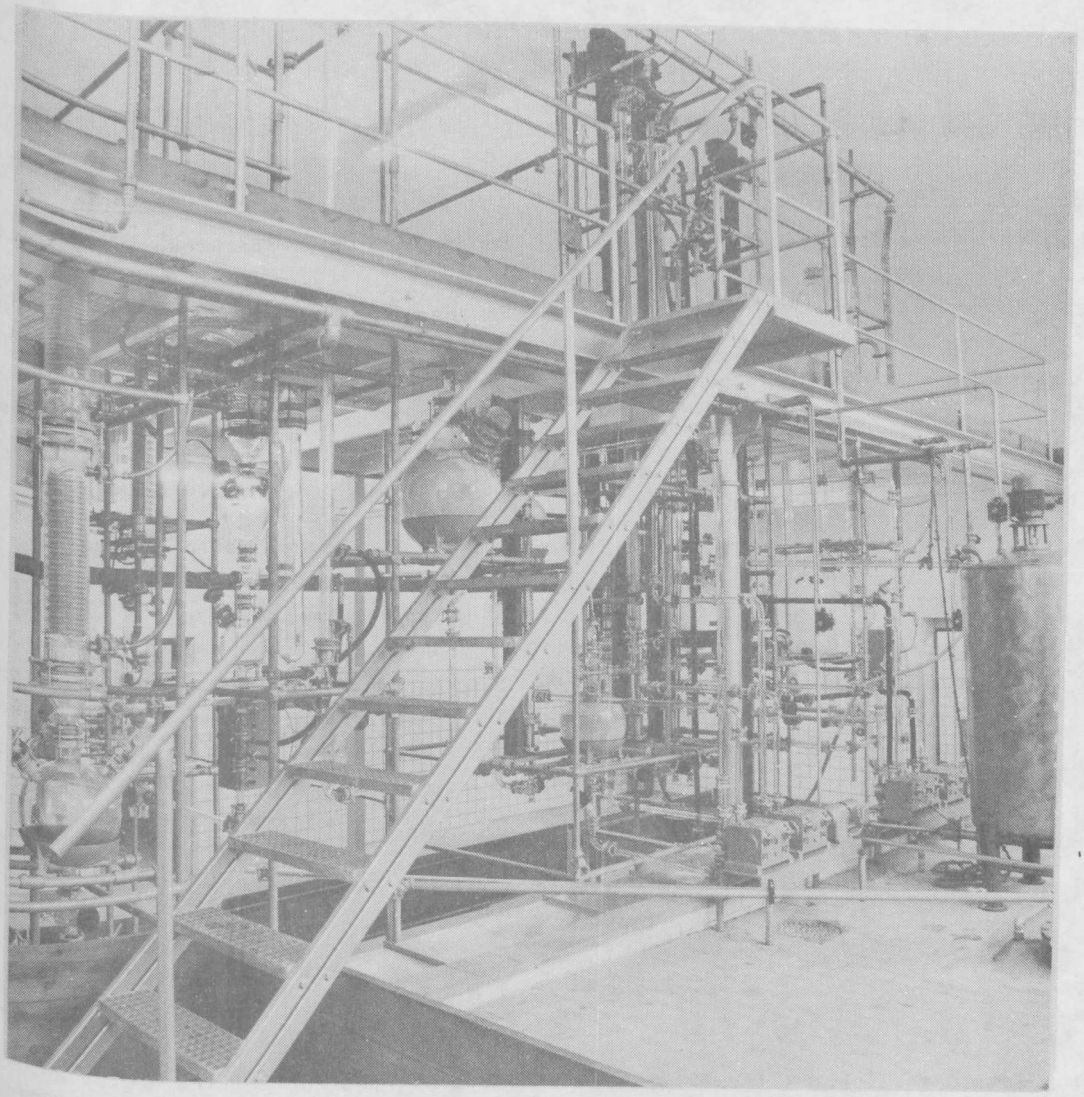


Fig. 2.

PRODUCTION

The following experience has been based upon a smoke flavour, mainly containing phenols, because through a large series of organoleptical tests dr. K. Miler from the Polish Meat Research Institute has found that a fraction of phenols with a dissociation constant between 11,0 and 13,5 contains a mixture of substances, producing a good and round taste which is very close to smoke flavour.

Briefly described the product is produced by incomplete combustion of beech (see figure 1), then the smoke is condensed in an electrostatic field, after which the water phase is removed, whereas the tarry phase is emulsified in alkaline liquid with pH approx. 13.5.

An extraction with ether is then made so that all undissociated compounds, including the carcinogenic polycyclic hydrocarbons are removed. The pH is adjusted to pH 11.0 by addition of acid and another extraction with ether is made.

Compounds with a dissociation constant between 11 and 13.5 can now be isolated from the extract and mixed with carriers approved for food. There are different kinds of carriers dependent on the fact to what kind of food the finished smoke flavour shall be used.

A pilot plant for production of a smoke flavour according to the above directions is shown on figure 2.

TOXICOLOGY

Before such a product can be sold it must be approved by the health authorities and therefore a series of toxicological and chemical tests has been made in order to prove that the substances with unhealthy qualities, existing in the original smoke, have been removed through the extraction process.

Animal tests on mice, rats and pigs have all been made in Poland at the School of Medicine in Wroclaw. At these tests different dosage levels have been used (table 2) which have been based upon the found LD_{50}-values.

Lethal dose of Scansmoke

MICE:	LD_{50}	=	4.125 mg/kg
RATS:	LD_{50}	=	5.625 mg/kg
PIGS:	LD_{50}	=	7.500 mg/kg

mg Scansmoke/kg body weight per day

Animal	Control	I	II	III
Rats/90 days	0	280	560	840
Pigs/90 days	0	45	450	+
Mice/2 years	0	42	+	+
Rats/2 years	0	28	+	+

Tentative ADI-value: 0,3 mg/kg/day
i.e. 18 mg/person/day.

Table 2

Dosage level of Scansmoke

Food products	Scansmoke SV - as conc.	
Sausages, fine	2,0 g/kg	30 ppm
Sausages, course	2,0 g/kg	30 ppm
Luncheon meat	1,0 g/kg	15 ppm
Ham	3,0 g/kg	45 ppm
Bacon	3,5 g/kg	52,5 ppm
Canned fish	7,0 g/kg	105 ppm

Example of daily intake

50 g luncheon meat:	15 ppm	0,7 mg
15 g ham:	45 ppm	0,7 mg
38 g sausages:	30 ppm	1,1 mg
100 g canned fish:	105 ppm	10,5 mg
		13,0 mg

Table 3

Without going into details about these tests it can be mentioned that at the 2-year animal tests a no-effect level and an effect level have been proved, meaning that out from these examinations an ADI-value of ca. 0,3 mg/kg/day of the product could be established.

This figure must be related to the dosage which is necessary for the right flavour, and table 3 shows a number of foodstuffs together with the necessary dosages. Here we can see that if a person only eats smoked food, this person will never reach the quantity of smoke flavour, corresponding to the ADI-value.

ANALYTICAL CONTROL

When the health authorities give an approval, based upon animal tests, it is of course on condition that the product can be produced consistently in the way that the composition always is equal to the batch which was used at the animal tests. Therefore a running control of our production is made. This control can be divided into 2 phases.

1. phase consists of an examination of the content of polycyclic hydrocarbons, especially with a view to determination of the content of 3,4 benzopyrene. The determination is made according to the analytical method developed by dr. Howard and approved by IUPAC (Technical Report, no. 4, February 1972). After this method the sample is cleansed by extraction and by column- and thin layer chromatography and then it is determined quantitatively by spectrophotometri.

2. phase of our control is a GL chromatographic analysis (figure 3). On this gaschromatogramme we first control if the individual peaks have the right size compared to the chromatogramme of the batch used at the animal tests, and secondly we follow the size of peak no. 10 to 13 carefully, because through organoleptical examinations we have found that the compounds which are represented by these peaks are decisive for the flavour of the product.

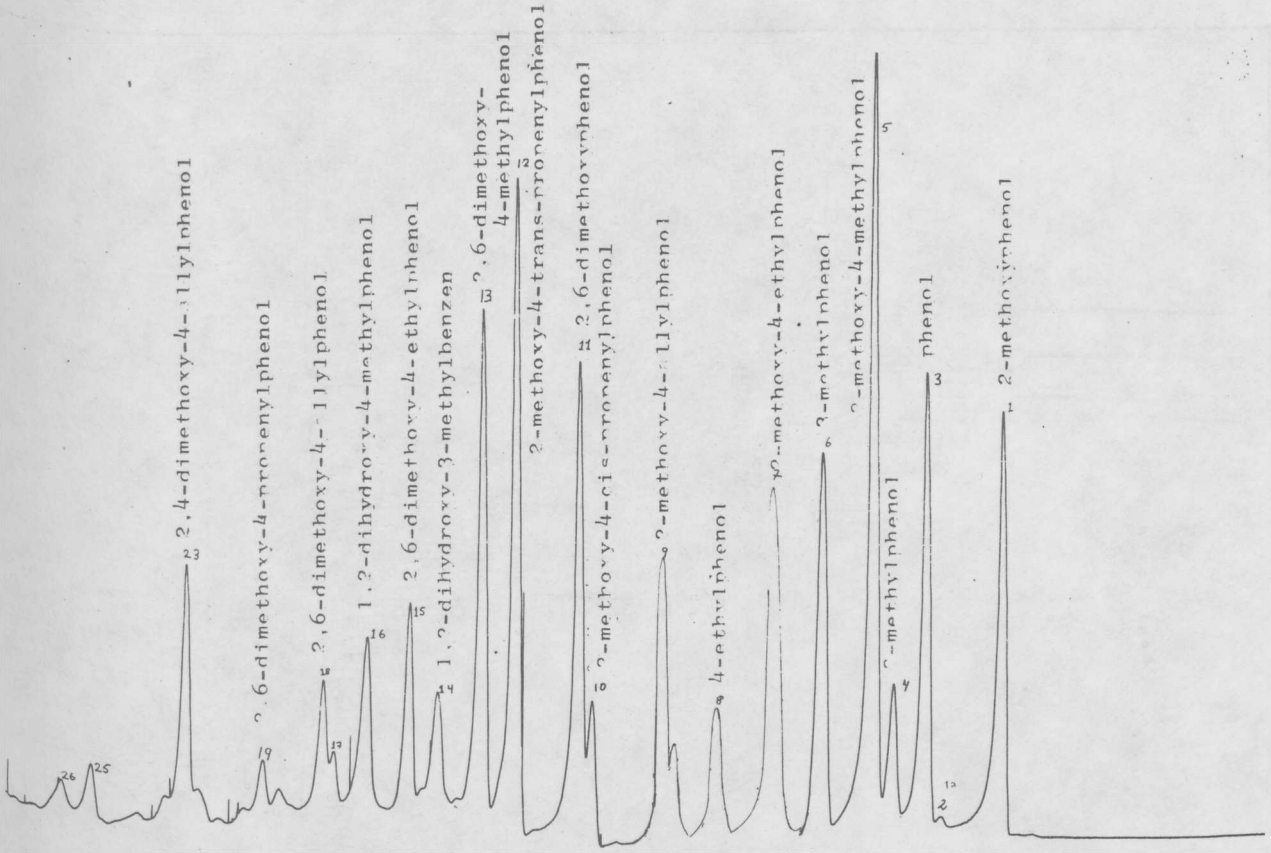


Fig. 3.

THE IMPORTANCE OF THE COMPOSITION REGARDING THE FLAVOUR PROFILE

Through a fractionated distillation we have for tests produced five fractions. An organoleptical test of these fractions with trained arbiters of taste resulted in the fact (table 4) that most of the volatiles which mainly consist of phenol, cresol, methyl- and ethylguajacol, have a very sharp and bitter taste, which feels a bit "cold".

The second fraction, consisting of peak no. 10 to 13 contains isomers of isoeugenol and 2,6 dimethoxy-4-methylphenol and gives a very pure and soft smoke flavour, which must be described as the best, but, however, it has turned out that it does not have the necessary intensity to be compared with conventional smoke flavour.

The last column in table 4 states the judgment of the Scansmoke-taste. This smoke flavour, which contains all the other fractions, has been given the highest marks in spite of the low marks given to the individual fractions. This is perhaps surprising, but on the other hand it illustrates the many aspects in a flavour which apparently cannot be explained nor synthesized. In figure 4 an analysis of the three distillates states that the same compounds, which are in Scansmoke, can be found in these.

These model tests have been made in lukewarm milk, because every nuance in the taste can be found in this neutral substrate. The concentration of smoke flavour was 3 g flavour per 1 milk.

PRACTICAL FIELDS OF APPLICATION

So far it has mostly been about the production of smoke flavour. It is all very well that we can produce a good and clean smoke flavour, but we must also be able to utilize the smoke flavour in a practical way. Therefore a brief description of the possibilities of application is mentioned below, not only within the meat industries, but also within other food-producing industries.

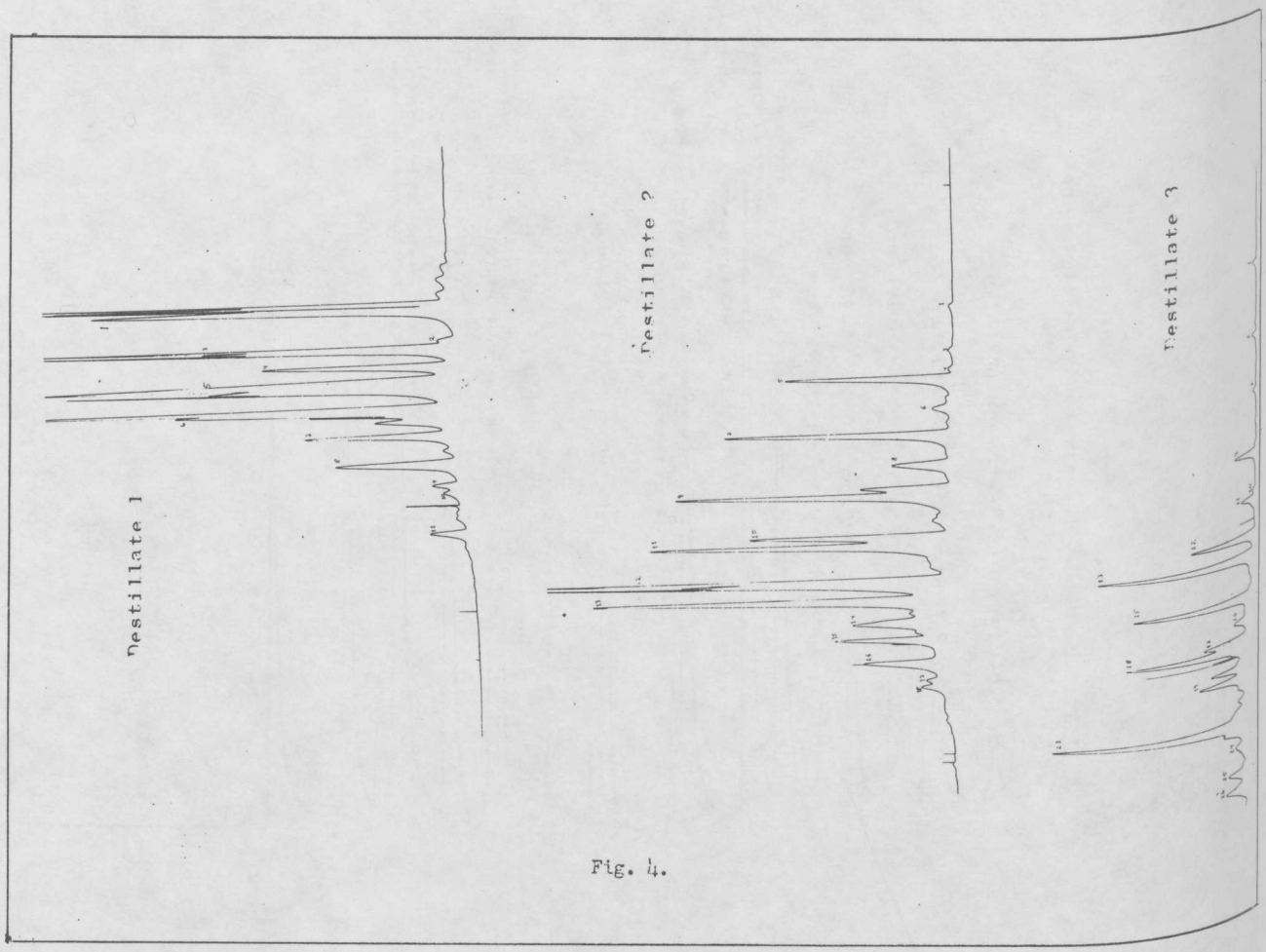


Fig. 4.

PANEL TEST RESULTS

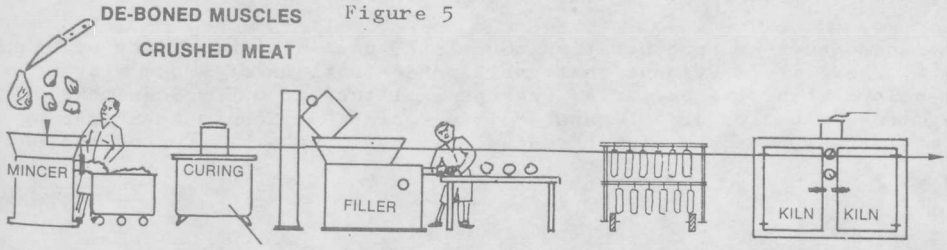
	Distillate 1	Distillate 2	Distillate 3	Phenols	Terpenes	Scansmoke
Distillate range (°C)	67-90	91-132	133-200			
Yield	16%	23%	17%			
Intensity of smoke taste	6	7	3	11	4	10
Intensity of tarry taste	3	1	2	0	6	1
Intensity of chemical taste	1	1	3	0	1	0
Intensity of acidulous taste	1	2	3	0	0	0

Scale of intensity: 0 = below threshold value. 11 = highest value

Table 4.

In the meat industries it is mainly emulsified (i.e. Scansmoke SV) or saltbased smoke flavour (i.e. Scansmoke SALT) which is the most interesting. The emulsified smoke flavour can be admixed into the brine, and injected direct into the meat and absorbed during conventional curing processes. The smoke flavour can also be absorbed during processing in curing and massaging machines and tumblers, such as ham sausages for slicing and vacuum packing.

Figure 5



This product is usually made from crushed pork legs, e.g. pork leg muscles which have been passed through the meat mincer in which only the precutting disk has been fitted. The resulting pieces of meat are of a size which will allow passage through a continuous sausage stuffer. The meat pieces in question can be tumbled or massaged in such way that the brine, in which Scansmoke SV is admixed, is fully absorbed into the meat. After tumbling/massaging the meat is stuffed in fibrous casings and cooked.

The advantages of this process are that the technology in meat processing is simplified, thus improving both control and hygiene. The ultimate sliced product has an even distribution of smoke flavour, owing to the method of application of Scansmoke SV.

The waterbased as well as the saltbased smoke flavour can be used in production of, sausages and other comminuted meat products. Practical experience has shown that smoke flavour is ideal for Pork, Beef, Horsemeat, Reindeermeat etc. Paneltest has shown that there is practically no difference in the taste of traditionally smoked meat and meat to which smoke flavour has been added.

As far as the dosage is concerned, the paneltests have shown that both overdosage as well as underdosage can give a tarry taste, which only can be explained by different afinity between the different fractions, as mentioned above, in the smoke flavour and the meat substrate. It is furthermore evident that excessive oxidation of the smoke flavour during the comminuting process can cause a tarry taste, and for this reason it is necessary to add the smoke flavour as late as possible during the process or to utilize vacuum cutters or mixers.

Typical dosage levels for comminuted products are from 1,5 to 2,5 g Scansmoke SV per kg product, or from 0,7 to 1,2 g Scansmoke SALT per kg product. It should be emphasized that the dosage level should always be adjusted according to the meat quality used, and to taste-preferences of the consumers.

A marked advantage of using smoke flavour is that the meat product tastes of smoke right through to the very centre of the product, whereas the taste of smoke in a conventionally smoked product is limited to the outer zone of the product. The use of smoke flavour has now made it possible to add smoke taste to products, packed in impermeable casings or bags. The advantage of this is not only the possibilities of creating new products, but also the advantage of a marked increase in the shelf life of the product.

Within the fishing industries smoke flavour has long been used for fish pastes, fish sausages, caviar, roe, sprats etc. It is mostly the oil based smoke flavour (i.e. Scansmoke SO) which is interesting for the fishing industries. It can be mentioned that in the case of caviar, the dosage level will be 2% of Scansmoke SO, calculated on the oil/fat phase, which beside an improved smoke taste also extends the shelf life of caviar in tubes extensively.

For canning it is possible to mix the smoke flavour direct with the oil, thus having the effect that the canned product is receiving its smoke taste during the heat processing of the already closed and seamed can. Paneltest has shown that there is no significant difference between traditionally smoked and canned fish, and fish on which only smoke flavour has been used. Long time storage of experimental batches has shown no change to the stability of the smoke flavour. The application of smoke flavour is especially interesting in connection with the increasing use of minced fish meat where smoke flavour can be added to the crust used for fish sticks, fish burgers. In this case Scansmoke SALT is mixed with the bread crust, the spices and the colouring agents. The increasing utilization of minced fish meat makes this particular field of application most interesting.

It should also be mentioned that development within the dairy industries has called for the use of smoke flavour in processed cheese as well as in cheese with ham. New development is also taking place within the salad industries and the snack food industries.

In order to round off the discussion of the characteristic qualities, which should be found in a smoke flavour, a brief mention of some examinations, illustrating Scansmoke's bactericide and antioxidative effect, is necessary.

It is a well-known fact that consumers traditionally expect that smoked food beside the characteristic taste also has a longer shelf life than fresh food.

The bacteriological tests have partly been made as model tests with staphylococcus aureus 758/III in a substrate of nutrient broth (Difco) and partly with native staphylococcus on pork loin.

The model tests showed a clear concentration correlated bactericidal effect of Scansmoke, shown in figure 6, where it is evident that small concentrations of smoke flavour have no effect on the development of the bacteria, whereas admixture of 6,5 g Scansmoke SV per kg prolongs the lag time by 4 days at 30°C and admixture of 9,8 g Scansmoke SV per kg gives a prolongation of 14 days, whereas higher concentrations cause a killing of the bacteria culture.

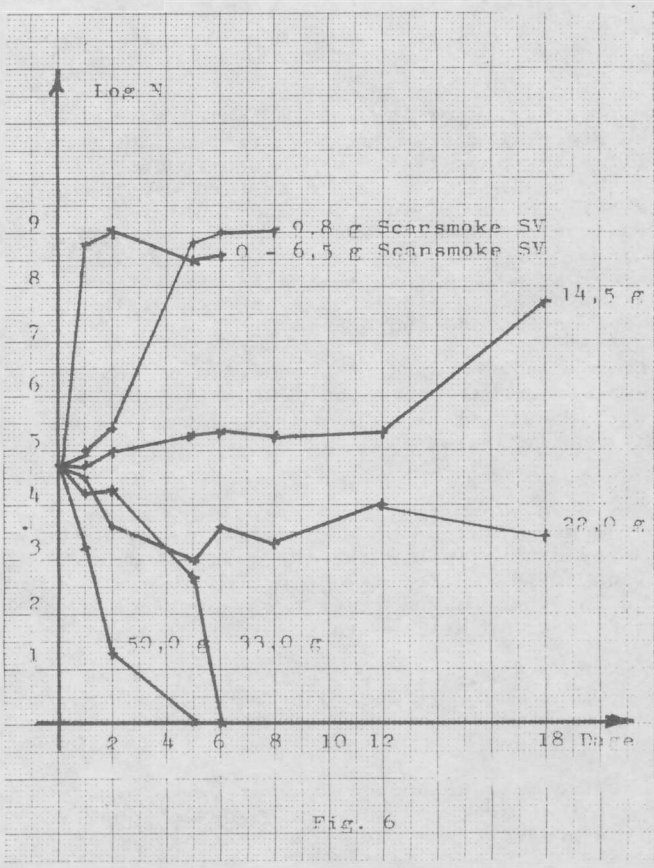


Fig. 6

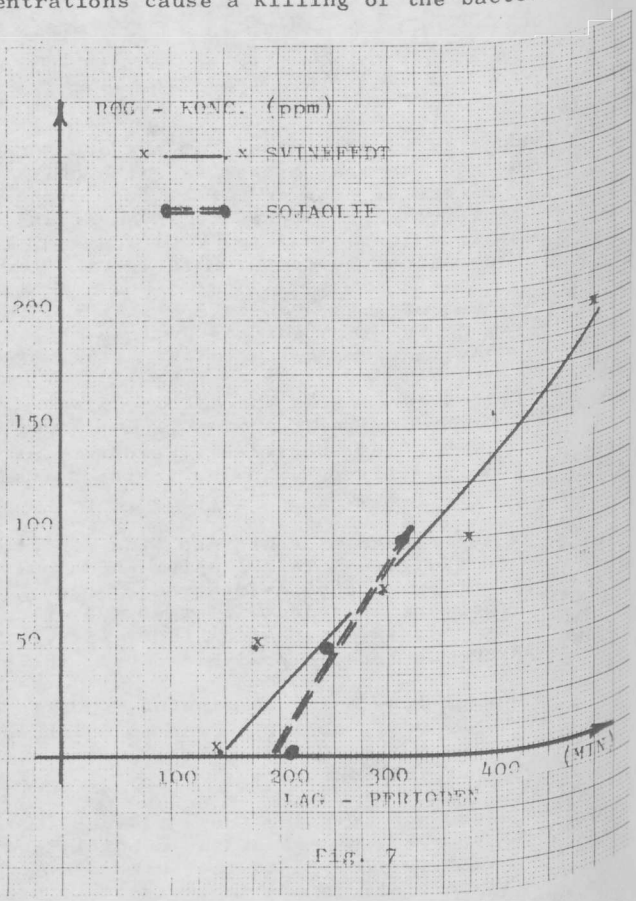


Fig. 7

It must be noted that the basic concentration of bacteria is very high (10^5 per ml), and the effect of Scansmoke will be better under better hygienic conditions.

In a similar way you can practically expect an effect at admixture of considerably smaller quantities of smoke flavour, because here it will act together with other preserving methods such as vacuum packing, cooling etc.

In tests where Scansmoke SV has been added to pork loin together with the brine, attempts have been made to verify the results of the model tests. However, we have reduced the used concentrations of Scansmoke SV to 3 g, 3,5 g, 5 g and 13 g per kg.

The bacteria-countings showed a clear relation between the time of the lag and the concentration of smoke flavour, which we for practical reasons consider to be extremely important. A prolongation could already be established at a concentration of 3,5 g Scansmoke SV per kg pork loin.

Finally the antioxidative effect of smoke flavour was examined by a swift test of both lard and soya oil.

As it appears in figure 7 there is a clear effect at higher concentrations, and in our opinion this can be extremely important for instance at addition of soya oil, because smoke flavour and oil can be mixed at an early stage of the production and thus ensure the longest possible shelf-life of the raw materials.

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