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FORMATION OF SURFACE COLOUR OF SAUSAGES IN THE PROCESS OF HIGH - TEMPERATURE SMOKING

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Material and methods

- The bars of mortadella type sausages were prepared in artificial protein casings of diameter of 75mm. The sausage emulsion was made of cured or uncured meat. Sausages were thermally treated in an experimental smoking house equipped with temperature, humidity and smoke density regulators. Smoke generator was installed inside the hermetic smoking house where the standardized portions of wooden chips were burned. It made possible to differentiate the smoke density. Succesive portions of wooden chips were introduced into generator in 10 min. intervals. That time interval was sufficient for complete burning the largest portion of wooden chips used /3g/. Then the smoked sausages were cooked until the internal temperature of 68°C was reached.

The surface colour of sausage bars was measured using the spectrophotometer Unicam SP1700 equipped with reflectance attachement. Two 4mm thick slices were cut off from the surface of each sausage. The reflectance spectra of the slices were measured in the range of 380 to 700 nm in 10 nm intervals. The colour parameters: dominant wavelength λd, nm; brightness, %, colour saturation, were calculated according to CIE /light source C/.

Using some standard samples as references, the differential spectra were graphically prepared. All spectrophotometrically tested samples had been previously sensorically evaluated by 4 members panel, using 10 points graphical scale.

Two mechanisms of the formation of surface colour of sausage. Analysis of differential reflectance spectra.

The differential reflectance spectrum of a sample was obtained by using as a reference other sausage sample instead of whiteness standard. Mostly, as a reference sample the sample of the same sausage but untreated with smoke or curing salts, was used. It made possible to separate the effect of this treatment on the colour of experimental sample. The examples of such spectra are shown on fig. 1 and 2. Fig. 1 presents the spectrum of cooked unsmoked cured sausage with cooked unsmoked uncured sample as a reference /50/54/ demonstrating the colouring effect of nitric-oxide--myoglobin; the spectrum of cooked cured smoked sausage with cooked cured unsmoked sample as a reference /34/50/ demonstrating the colouring effect due to chromatic smoke constituents sedimentation; the spectrum of cooked uncured smoked sausage with cooked uncured unsmoked sample as a reference /38/54/ demonstrating associated colouring effects of chromatic smoke constituents sedimentation and meat pigments with smoke constituents reaction.

It can be seen, that curve 50/54 is relatively flat with some number of more or less characteristic peaks. The more characteristic ones are at 440, 450, 460, 485, 520 and 650 nm. Curve 34/50 is a typical one band spectrum. Curve 38/54 demonstrates peaks characteristic for both curves disscused above, suggesting close relation among the three spectra.

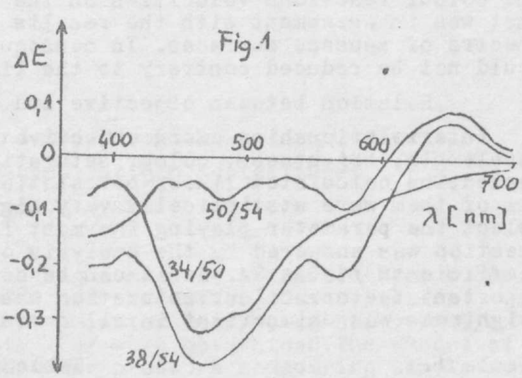


Fig.1

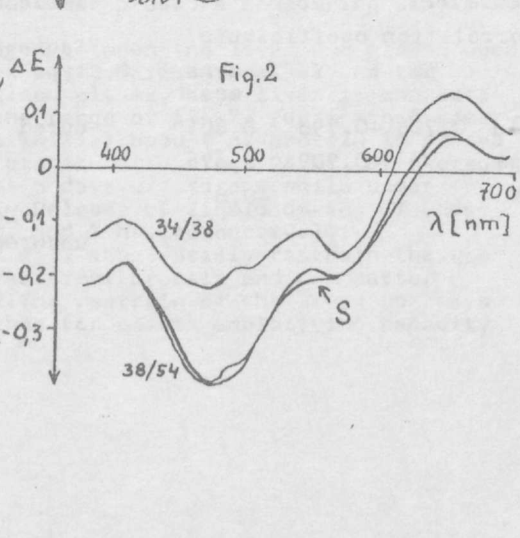
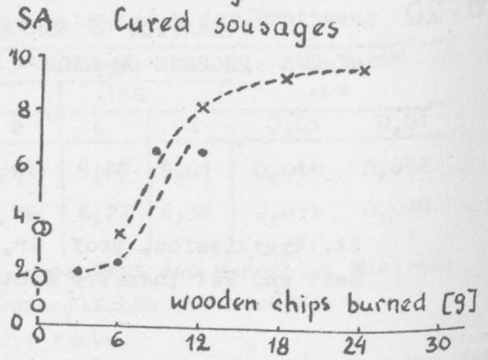


Fig.2

Fig.2 presents the spectrum of cured smoked sausage with uncured smoked sample as a reference /38/54/ demonstrating the colouring effect of meat pigments reduction and of meat pigments - smoke constituents interaction; the curve S as a sum of two spectra 50/54 and 34/50 demonstrating the same shape as the spectrum 38/54 and the spectrum 34/58 of the shape in close relation to 38/54. All these observations confirmed the hypothetical mechanism of the formation of surface colour of sausage.

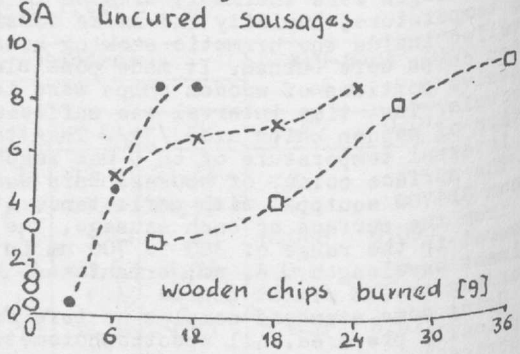
Fig.3



The influence of curing process and smoke density on the effect of sausage smoking.

The results of experiments are shown on fig. 3 and 4. Cured and uncured sausages were experimentally smoked using smoke of different densities The effectiveness of smoking was then sensorically assessed /SA/. In first experiment no smoke was used -○-, in second one - smoke generated from 1g of wooden chips/10 min. -●- and in third one - smoke generated from 2g of wooden chips/10 min. -×- were applied. For uncured sausages the additional experiment with smoke generated from 3g of wooden chips/10 min. -□- was performed. The smokin process was finished after 30, 60, 90 and 120 min. As it can be seen, using no smoke it was impossible to obtain a characteristic surface colour of sausages. Using smoke of moderate density and sufficient time /2 hours/ a proper colour of high intensity was observed. The increase of smoke density in smoking cured sausages demonstrated a positive effect on colour at the same portion of wooden chips burned. The increase of smoke density had no effect on the surface colour of uncured sausages. It was due to the limiting effect of the colour reactions velocities on the formation of surface colour of sausages. That was in agreement with the results of analysis of differential reflectance spectra of sausage surfaces. In consequence, the time of uncured sausages smoking could not be reduced contrary to the time of cured sausages smoking.

Fig.4



Relation between objective and sensoric assessement of colour.

Interrelationships among objective colour parameters, namely dominant wavelength, brightness, colour saturation, and sensoric assessement of colour were tested. The calculated linear correlation coefficients are presented in table 1. All of them were statistically very significant, therefore it was difficult to select the parameter playing the most important role in sensoric sensation. That question was answered by the analysis of the 2nd and 3rd order partial correlation coefficients /table 2/. As it can be seen, the dominant wavelength was the most important factor. Colour saturation was important in cured sausage only, and brightness was unimportant in all cases.

Table 1.
Correlation coefficients

	pe	Y	sens. ass.
λ_d	0,726	-0,798	0,801
pe		-0,709	0,676
Y			-0,816

Table 2. Partial correlation coefficients

Sausage type	correlated variables	constant variables λ_d	pe	Y	other two variables
cured	λ_d		0,581	0,330	0,466
	pe	0,578		0,317	0,541
	Y	0,404	0,400		-0,086
uncured	λ_d		0,752	0,499	0,493
	pe	0,754		0,088	-0,015
	Y	0,404	0,685		0,272

The simplified objective method of the determination of surface colour of smoked sausages.

Colour parameters calculation according to CIE is based on full reflectance spectra data of the samples. It was found, that two monochromatic reflection coefficients: at the wavelengths of 540 nm /R540/ and 640 nm /R640/ could be used for colour determination. The value of R540 was used as a measure of colour brightness:

$$Y = 1{,}151 \cdot R540 + 2{,}495 \quad /\%/$$

with the correlation coefficient r = 0,979.
The ratio R640:R540 was used as a measure of dominant wavelength:

$$\lambda_d = 576{,}2 \cdot /R640:R540/^{0{,}021} \quad /nm/$$

with the correlation coefficient r = 0,960.
Both factors, R540 and R640:R540 were applicable for cured as well as for uncured sausages. In the case of cured sausages the high significant correlation between colour saturation and the ratio R640:R540 was also observed. The regression equation was:

$$pe = 0{,}055 \cdot R640:R540 + 0{,}431$$

with correlation coefficient r = 0,901.
The paper presents a part of results of a complex study of the physical aspects of smoking process.