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PASTEURISED HAM.

THE STABILITY OF COLOUR.

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1. Introduction.

As the researches concerning development of scientific methods able to find out the base of different processes running over in meat are getting on, it has proved to be of absolute necessity to apply objective methods while measuring the colour of meat.

The parameters of colour accepted by C.I.E., the dominant wavelength, the photometrical brightness and saturation have been applied while researches were getting on /1,2,3,4/. In a foregoing paper /5/ it has been proved, that during the exposure of sliced pasteurised ham to light, the changes occuring in its colour are to be observed in the changes of the dominant wavelength and that both these parameters are functionally connected with one another. The slight grow of photometrical brightness during the time of exposure is improportionally small when compared with the observed natural differentiation of brightness of colour of different muscles being parts of the ham.

In the same study while trying to find out a simplified method of measuring the colour of ham, the following dependencies have been discovered.

$$\lambda d = a_1 \cdot S_{640/540} + b_1 \qquad /1/$$

and

$$p = a_2 \cdot S^2_{640/540} + b_2 \cdot S_{640/540} + c \qquad /2/$$

where λd = dominant wavelength

p = saturation

$S_{640/540}$ = relation $\frac{R_{640} - R_{540}}{R_{540}}$

R_{640} = reflectance at 640 mμ

R_{540} = reflectance at 540 mμ

a_1, a_2, b_1, b_2, c = constants

From these equations it follows that $S_{640/540}$ can be used as the measure of the dominant wavelength as well as of saturation.

This report deals with the influence of the exposure conditions upon the changes of colour in pasteurised ham slices. The difference between $S_{640/540}$ in the moment when ham is cut and $S_{640/540}$ after exposure has been taken as the measure of changes of colour / Δ $S_{640/540}$ /.

It has been shown that the changes of Δ S during the time of exposure can be approached by the equation:

$$S_{640/540} = at + b\ /1 - e^{-kt}/ \qquad /3/$$

where t = time of exposure

a, b and k = constants.

Hornsey used a similar formula to show the absorption of oxygen in pork muscle /6/.

2. The influence of climatic conditions during the time of exposure upon the stability of the colour in pasteurised ham.

Experimental.

The experimental material has been prepared by cutting out one of the inner muscles from each of six different hams. Every one of these muscles has been cut into nine samples. They have been subjected to a photometric measurement at the wavelength 540 and 640 mμ and thereafter put into closed Petri plates under the operation of an electric fluorescent lamp of the "white" type with the intensity of 250 lx. Next the closed Petri plates have been placed into several vessels, filled with a hygrostatic solution of sulphuric acid concentrated to a sufficient degree to ensure an average relative humidity of 60%, 80%, 100% respectively. Three plates, each with one of the three a/m relative humidities have been placed in a cooled space with a temperature ranging from 0° to +2°C, another three plates in the temperature of 10° to 12°C, and the last three ones have not been cooled at all. The last three were stored in a room with a normal indoor temperature /about 20°C, oscillation not exceeding ± 2°C/. The samples exposed in the above mentioned way were subjected to a photometric measurement after 1,5; 4; 7; 11 and 23 hours.

Results.

The obtained results are presented in table 1a in the form of the average differences between the initial value of $S_{640/540}$ and its value after exposure. The table 1b shows the results of a threefactorial analysis of variance of the experimental results.

Discussion.

The table 1a has shown, that the changes of the dominant wavelengths during the time of the exposure of samples are dependent on the temperature of the surrounding air. The lower is the temperature the slower are the changes in the dominant wavelength. The influence of the temperature in which the samples of ham are stored is significant, but the changes of temperature do not cause proportionally big deflections in the speed with which the dominant wavelength gets shorter. This is proved by the comparison of the factors Q_{10}. Namely Q_{10} for the range of temperature from 0 to 10°C /after 23 hours of exposure/ which is 1,11 and for the range from 10 to 20°C is only with 1,19 a little bit higher than the first one.

On the other hand no influence of relative humidity upon the speed of changes of the dominant wavelength has been stated /table 1b/.

The above mentioned observations and their analysis have proved, that in average detail trade conditions, where humidity is always rather big, i.e. higher than 60%, the colour of ham does not run risk to be badly influenced by the changes of relative humidity. On the other hand however the temperature in shops seems to be very important in this matter as temperature has a fundamental influence upon the durability of colour of ham.

The figure 1 presents the changes of the dominant wavelength during the exposure of samples of ham under different air conditions. The curves have been traced on the basis of constants calculated from the equation presented in the Introduction. In order to obtain these constants the totality of the experiments has been used, except for the influence of humidity upon the colour of ham, which has proved to be insignificant. The average results of the experiment have been presented by dots. Vertical segments present the average error of this average. The constants of the curves are to be seen on

Table 1a.

Time of exposure /hours/		Temperature								
		0 - 2°C			10 - 12°C			18 - 22°C		
		Relative humidity /%/			Relative humidity /%/			Relative humidity /%/		
		60	80	100	60	80	100	60	80	100
1,5	$\bar{x}$ σ	0,902 ±0,092	0,135 ±0,038	0,148 ±0,060	0,128 ±0,064	0,133 ±0,073	0,122 ±0,044	0,173 ±0,047	0,223 ±0,074	0,182 ±0,074
4	$\bar{x}$ σ	0,227 ±0,152	0,233 ±0,079	0,242 ±0,093	0,273 ±0,064	0,272 ±0,143	0,275 ±0,034	0,338 ±0,115	0,385 ±0,116	0,373 ±0,172
7	$\bar{x}$ σ	0,257 ± 0,129	0,327 ±0,110	0,287 ±0,038	0,373 ±0,091	0,365 ±0,094	0,363 ±0,038	0,442 ±0,108	0,482 ±0,146	0,457 ±0,182
11	$\bar{x}$ σ	0,317 ± 0,161	0,395 ±0,158	0,370 ±0,064	0,410 ±0,092	0,423 ±0,099	0,413 ±0,049	0,502 ±0,140	0,543 ±0,156	0,517 ±0,178
23	$\bar{x}$ σ	0,467 ± 0,173	0,517 ± 0,155	0,473 ±0,116	0,517 ±0,104	0,553 ±0,134	0,550 ±0,079	0,615 ±0,190	0,653 ±0,190	0,670 ±0,197

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Table 1b.

Source of variance	Degrees of freedom	Sum of squares	Mean squares
A. Time of exposure	4	5,0646	1,2662xx
B. Temperature	2	0,8954	0,4477xx
C. Relative humidity	2	0,0532	0,0266
Interaction AxB	11	0,0625	0,0057
Interaction AxC	11	0,0061	0,0006
Interaction BxC	13	0,0105	0,0008
Interaction AxBxC	1	0,0265	0,0265
Error	224	3,1282	0,0140

xx = significant P = 0,99

table 2.

Table 2.

Temperature °C	Constants a	b	k
0 to +2	0,01014	0,253	0,3470
10 to 12	0,01096	0,288	0,3908
18 to 22	0,01042	0,406	0,4029

Because of a restrained quantity of measurements it is difficult to prove statistically that the influence of temperature is essential only to the alinear part of the equation 3 of the dominant wavelength. Yet this seems to be obvious.

3. The influence of the intensity and quality of light upon the stability of the colour of pasteurised ham.

Experimental.

The experiment has been carried out in two parts. The first one deals with the changes of colour /the dominant wavelength/ of cut ham, which has been exposed to different light sources or not exposed at all. The experiment ran in the following way: five hams have been cut in a dark space. There have been taken two cork-like pieces out of the middle part of each of them. These were sliced into five discs each. One of these slices has been left in the dark space. The other four discs were photometrically measured, and three of them were exposed to light with the intensity of 250 lx from following sources: a fluorescent lamp of the "white" type, another one of the "day light" type and a normal tungsten lamp 100 W. The fourth after having been left for 15 minutes under day light with the intensity of not more than 200 lx, was put back in the dark room. After 23 hours the above mentioned 4 discs and the fifth one stored in the dark room, were subjected to a photometrical measurement. Owing to this kind of operation the initial values of $S_{640/540}$ were known also for the samples left in the dark room and the new photometrical measurement, which is also an exposure to light, was not necessary. The experiment prepared in the above mentioned way had to answer the following questions:

1. Are there any changes possible in the dominant wavelength, when cut ham is stored in a dark room ?

2. Is a short, single exposure able to cause the start of decoloration which continues to run however the exposure has been stoped ?

3. Has the quality of light any influence upon the process of decoloration of ham?

The second part of the experiment whose chief aim was the examination of the influence of light upon the durability of the colour of ham, has been carried out in the following way: there have been taken out of six hams six muscles out of the middle slice of each of them. These muscles have been cut into six small patches. These muscles have been put on Petri plates and exposed to the light of two fluorescent lights, one of the "white" type, the other one of the "day light" type. The patches have been placed in a distance from the lamps able to ensure the following differences of intensity of light: 100 ± 16 lx, 250 ± 15 lx, 400 ± 15 lx. Next the patches have been photometrically measured in the same spaces of time as it was the rule in the experiments described in chapter 2.

As well in the first as in the second part of the experiment the temperature was maintaind in the range 18 to 20°C /normal indoor temperature/, and relative humidity was settled at 80 %.

Results.

Table 3a shows the results of the first part of the experiment in the form of the differences between initial and the final values of $S_{640/540}$ as well as the average values of the variants. Table 3b is a table of onefactorial analysis of variance. Table 4a and 4b shows the results and their statistical analysis of the second part of the experiment.

Discussion.

The first part of the experiment has shown that cut ham stored in a dark space does not change its colour. This leads to the conclusion that light is the dominant factor able to cause changes in the colour of ham. Ham exposed for a short space of time and next stored in a dark room does not show big changes in its colour however these changes are certainly to be seen. This proves that the process of decoloration of ham depends on a somewhat longer exposure /it means more than 15 minutes/. If this exposure is interrupted after a short time the process of decoloration does not continue by itself.

On the other hand it has been shown, that the type of lamp does not influence the dominant wavelength if the intensity of light has been the same. This conclusion has been proved by the statistic analysis of the second part of the experiment.

As well in this part as in the first one there has been found no influence of the type of lamp upon the dominant

Table 3a.

No	A	B	C	D	E
1	0,03	0,12	0,57	0,66	0,74
2	0,10	0,12	0,82	0,89	0,87
3	-0,03	0,28	0,84	0,94	0,92
4	-0,20	0,10	0,73	0,42	0,62
5	-0,14	0,16	0,62	0,56	0,60
6	-0,06	0,19	0,49	0,55	0,46
7	0,12	0,22	0,84	0,88	0,77
8	0,13	0,18	1,01	1,10	1,06
9	-0,03	0,06	0,60	0,69	0,58
10	0,07	0,04	0,74	0,73	0,72
$\bar{x}$	-0,001	0,147	0,731	0,742	0,734

A = samples not exposed
B = samples exposed 15 minutes
C = samples exposed 23 h /fluorescent lamp "day light"/
D = samples exposed 23 h /fluorescent lamp "white"/
E = samples exposed 23 h /tungsten lamp/.

Table 3b.

Source of variance	Degrees of freedom	Sum of squares	Mean squares
Type of exposure	4	5,3539	1,3385^{xx}
Error	45	1,0660	0,0237

^{xx} = significant P = 0,99

Table 4a.

Time of exposure /hours/	Type of lamp											
	"day light"						"white"					
	Light intensity /lx/						Light intensity /lx/					
	100		250		400		100		250		400	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
1,5	0,165	±0,091	0,297	±0,080	0,302	±0,082	0,190	±0,104	0,220	±0,050	0,288	±0,109
4	0,290	±0,121	0,430	±0,127	0,460	±0,090	0,293	±0,131	0,397	±0,103	0,482	±0,109
7	0,358	±0,126	0,538	±0,144	0,552	±0,123	0,333	±0,131	0,525	±0,122	0,572	±0,124
11	0,410	±0,140	0,592	±0,170	0,610	±0,157	0,427	±0,136	0,585	±0,150	0,632	±0,150
23	0,485	±0,190	0,670	±0,205	0,645	±0,145	0,483	±0,178	0,702	±0,175	0,713	±0,160

Table 4b.

Source of variance	Degrees of freedom	Sum of squares	Mean squares
A. Time of exposure	4	2,9876	0,74690xx
B. Type of lamp	1	0,0003	0,00030
C. Light intensity	2	1,1403	0,57015xx
Interaction AxB	4	0,0151	0,00377
Interaction AxC	9	0,0715	0,00794
Interaction BxC	2	0,0241	0,01205
Interaction AxBxC	7	0,0087	0,00124
Error	150	2,7847	0,01856

xx = significant P = 0,99

Wavelength. The intensity of light however seems to have a grat influence upon the changes of colour especially when it overruns 100 lx. Figure 2 shows the diagram of the changes of dominant wavelength in their relation to the intensity of light. The constants for the equation 3 have been calculated here without having taken into account the influence of the type of lamp. On the diagram except the curves realizing the equation, dots have been put which represent the average values used for the calculation of constants, as well as segments which represent the average error of the average. The constants of the curves are to be seen in table 5.

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Table 5.

Light intensity /lx/	Constants		
	a	b	k
100 ± 15	0,00482	0,373	0,3473
250 ± 15	0,00810	0,500	0,4208
400 ± 15	0,00504	0,562	0,4139

The above mentioned experiments have shown, that the intensity of light influences in a high degree the changes of colour in ham. It is clear that in normal light conditions this influence cannot be quite eliminated but limited if possible. As decoloration does not occur during the first 23 hours of storing it is adviseable not to cut ham before it is really necessary and keep the ham slices in dark spaces. Taking into account the total of experiments it may also be suggested to choose such kind of lamps which reproduce exactly the colour of ham, no matter what kind of lamp it is. This conclusions may be asserted by the study /7/, which suggests that the elimination of short waves of fluorescent lamp does not influence the process of decoloration of different meat products, ham among others.

Acknowledgement.

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Résumé.

On étudient an spectrophotométre de reflexion les changement de couleur de tranches du jambon pasterisé exposé a la lumiere. En faisai varie divers parametres: la temperature et l'humidite du milieu, l'intencité et le gênre de la lumiere. Les résultates de cette étude mentrent que la temperature du milieu et l'intensité de la lumiere influ la rapidité des changement de la couleur.

Резюме.

Целью настоящей исследовательской работы является изучение влияния некоторых параметров на скорость перемен окраски облучённой ветчины. Принято во внимание: температуру, относительную влажность, источник освещения и его интенсивность. Определение окраски проводится при помощи рефлекторного спектрофотометра. Установлено что температура и интенсивность освещения оказывают влияние на скорость обесцвечивания ветчины.

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Figure 1

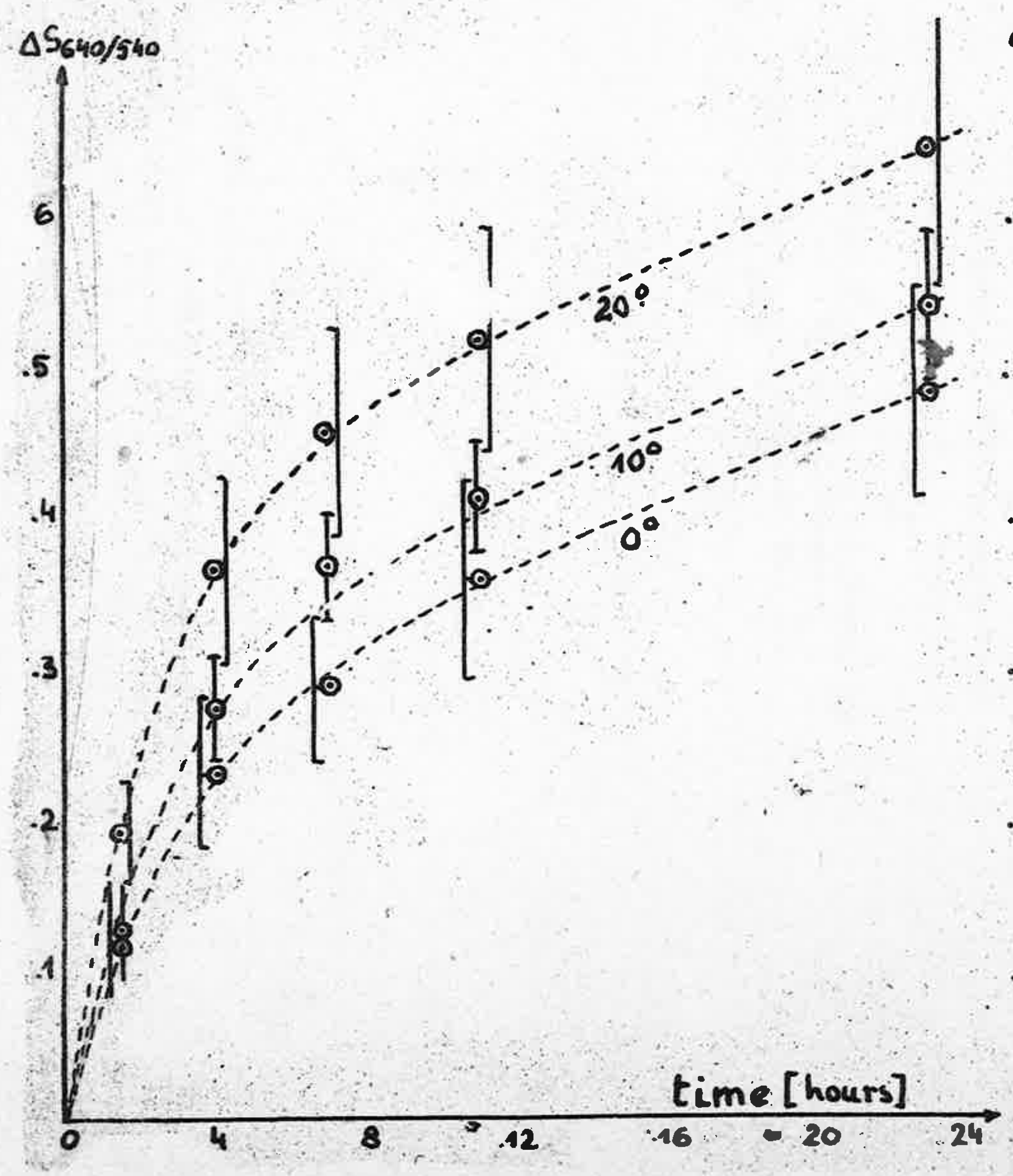

Figure 2