ALTERNATIVE COLOURANTS IN SALAMI. EVALUATION OF LIGHT-INDUCED QUALITY CHANGES.

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INTRODUCTION

In Denmark, salami is traditionally produced with synthetic colourants. From the first of July 1989, addition of the synthetic colourant Erythrosine will be forbidden in salami. Instead, the natural colourant Cochineal will be permitted up to a concentration of 100 mg (calculated as carminic acid) per kilogram (The Positive List, 1988).

As an alternative the synthetic colourant, Allura red looks interesting, first of all because of a considerably higher Acceptable Daily Intake (ADI) compared to Erythrosine. The ADI of Allura red and Erythrosine is 0-7 mg/kg (FAO/WHO, 1987) and 0-0.05 mg/kg (FAO/WHO, 1989) respectively. At present, Allura red is not permitted in Denmark (The Positive List, 1988), but Allura red was suggested as an alternative to Erythrosine for use in meat products by the Codex Alimentarius Commission (Codex Alimentarius Commission, 1989) and Allura red has recently been proposed by the EEC as a colourant for foodstuffs (Commission of the European Communities, 1985).

The stability of Allura red has been tested in model experiments (McCormick, 1971) and the pH stability appeared to be good in the range from pH 3.0 to pH 8.0. The model experiments did not include light stability tests.

Model experiments have recently been performed with Cochineal. In the pH range of relevance for meat products results of photochemical experiments have shown that carminic acid, the major colouring component in Cochineal, is very stable towards light (Jørgensen and Skibsted, 1989).

The present study was conducted to compare the initial colour of salami to which were added Cochineal and Allura red with the initial colour of salami with the normal colour mixture (including Erythrosine) added.

In addition, the light stability was determined, and it was examined if the alternative colourants induce other deteriorative processes in the product, e.g. rancidity.

MATERIALS AND METHODS

Salami preparation and packaging

Dry salami chubs with different colourants added (see table 1) were produced at a processing plant. Each salami chub had a diameter of approximately 9 cm and weighed approximately 2.0 kg. After slicing (2 mm) they were randomly vacuum-packed (2 slices per pouch) at Otto Nielsen Emballage A/S in a packaging material with an oxygen transmission rate of 60 cc/m^2/24h/atm. (measured at 25 °C and rh 75%) and at an initial vacuum-level of approximately 99%.

TABLE 1. Colourants used for salami colouring in the salami storage experiment.

Colourant	Quantity added, mg/kg
Normally used colour mixture (Standard)	
Erythrosine	150
Ponceau 4R	40
Sunset yellow	50
Allura red	100
Cochineal C12	
23% carminic acid	100
Cochineal C25	
23% carminic acid	100

Storage

Vacuum-packed salami was stored for 4 weeks in a chill cabinet. Fluorescent tubes (Philips TLD 18 W/92) were used for illumination giving an illuminance of approximately 600 lx on the surface of the packs, where a radiant flux density of UV-light (300-400 nm) of 0.8 $\mu W/cm^2$ was measured.

The product temperature was approximately 7°C. During daily defrosting, the temperature rose to approximately 11°C. Half of the packs for each type of colourant were stored in the dark by means of black plastic. Samples were rotated periodically to assure uniform exposure to the light and to the temperature.

Colour evaluation

The surface colour was measured with a tristimulus colorimeter (Hunterlab D-25 equipped with a D25 M optical sensory head) standardized against a white standard with L = 90.7, a = -0.9 and b = -0.1. In addition, the colour was visually evaluated by a 3-4 member panel using a 0-10 scale (10 = no discoloration, 0 = totally discoloured, 5 = acceptability limit).

The total colour difference (ΔE) were calculated from the initial Hunter values by the following equation as described by Francis and Clydesdale (1975):

$$\Delta E = ((L_x-L_y)^2 + (a_x-a_y)^2 + (b_x-b_y)^2)0.5$$

where L_x, a_x or b_x are coordinates of salami coloured with the normal colour mixture, and L_y, a_y or b_y are coordinates of salami coloured with alternative colourants.

Sensory evaluation

After a display period of 0 and 4 weeks, duplicate samples of salami with each type of colourant were sampled for evaluation of taste by a 4-member trained sensory panel, using a 0-10 scale (10 = no off-flavour, 0 = very strong off-flavour, 5 = acceptability limit). Because of lack of capacity and because Allura red at present is not permitted in Denmark, samples with that colourant were not included in the sensory evaluation.

Assessment of lipid oxidation

Lipid oxidation was determined by the 2-thiobarbituric acid (TBA) method of Vyncke (1970) and Vyncke (1975) after a display period of 0 and 4 weeks. The TBA values were expressed as µ-mol of malonaldehyde per kilogram of sample.

Statistical analysis

Statistical analyses were conducted using analysis of variance with the general linear model procedure (SAS, 1979). Separation of means was conducted using Duncan's multiple range test.

RESULTS AND DISCUSSION

Colour evaluation

Initial colour measurements and visual colour evaluations showed that both Allura red and the 2 different types of Cochineal resulted in an acceptable red initial colour compared to salami with the normal colour mixture added (named standard in the following). The colour properties of the different salami types are presented in table 2.

TABLE 2. Colour properties of salami with 4 different colourants added (see table 1). The Hunter L, a and b values are initial tristimulus colour coordinates. All values are means of 5 replicate determinations.

Colourant	L	a	b	ΔE
Normally used colour mixture (Standard)	44.6	33.5	5.9	-
Allura red	45.0	30.3	8.6	4.2
Cochineal C12	43.8	28.2	4.6	5.5
Cochineal C25	44.4	27.1	5.1	6.5

From the ΔE-values it can be derived that Allura red resulted in a colour closest to the standard, but the comments given at the sensory evaluation indicated that the colour of salami containing Cochineal, corresponded more to the standard. It may be explained by the higher Hunter b-value of salami containing Allura red which gave a yellow-red colour instead of the more usual pink colour.

The tristimulus colorimetric parameter Hunter a was found to give the best correlation with the subjective colour score during storage. Figure 1 shows the fading (measured as the change in Hunter a-value, Δa) of each type of salami exposed to light compared to the samples kept in dark.

The Hunter Δ a was calculated by the following equation:

$$\Delta a(t) = a(t) - a(t = 0)$$

The exposure to light clearly affected the surface colour, whereas samples which were un-exposed showed only minor changes. Fig. 1 shows that the standard was very light sensible, while the alternative used were much more light stable. During the 4 weeks of storage the Hunter a-value of the standard decreased by 42% compared to decreases of c. 17%, c. 13% and c. 12% for salami with Allura red, Cochineal C12 and Cochineal C25 respectively. For the samples kept in dark the decreases in Hunter a-values did not exceed 4%.

The visual evaluation of the different salami packs exposed to light are shown in figure 2. It is evident that there is a good correlation between change in Hunter a-value (fig.1) and colour score obtained by the visual evaluations.

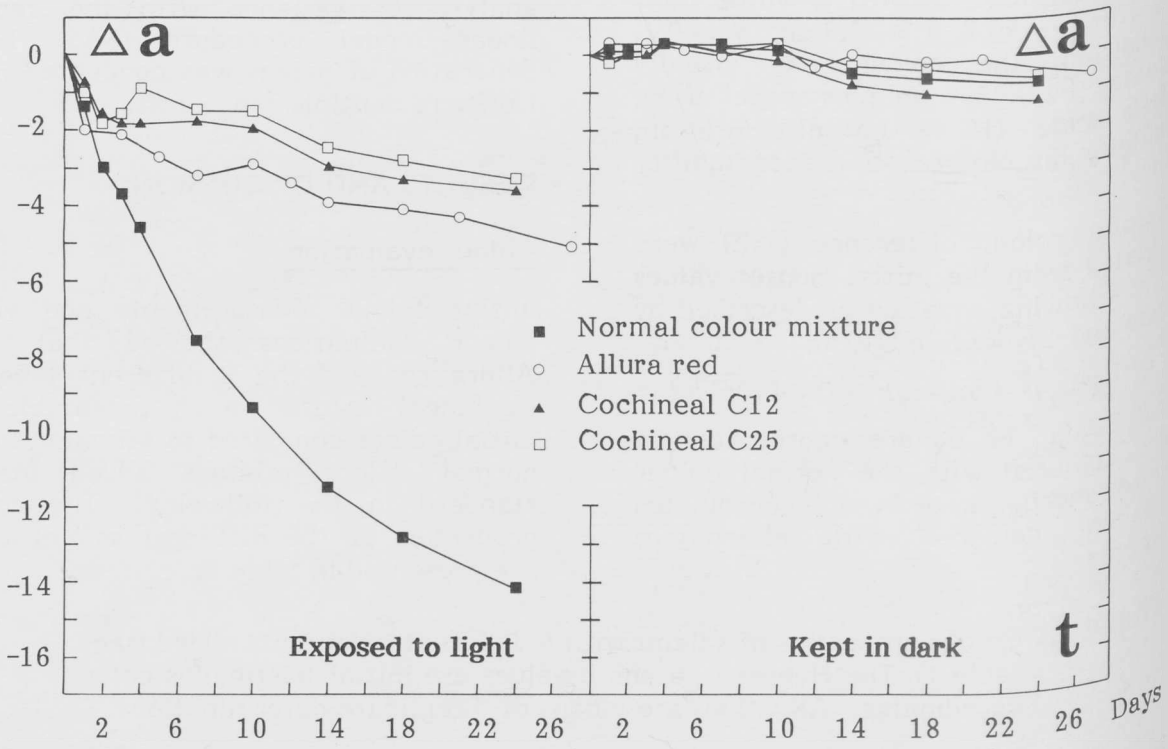

Fig. 1. Fading of red colour of sliced, vacuum-packed salami with 4 different colourants added (see table 1) during storage in a chill cabinet. The colour was measured regularly during storage by tristimulus colorimetry and fading was measured as change in Hunter a-value (Δa). All values are means of 5 replicate determinations.

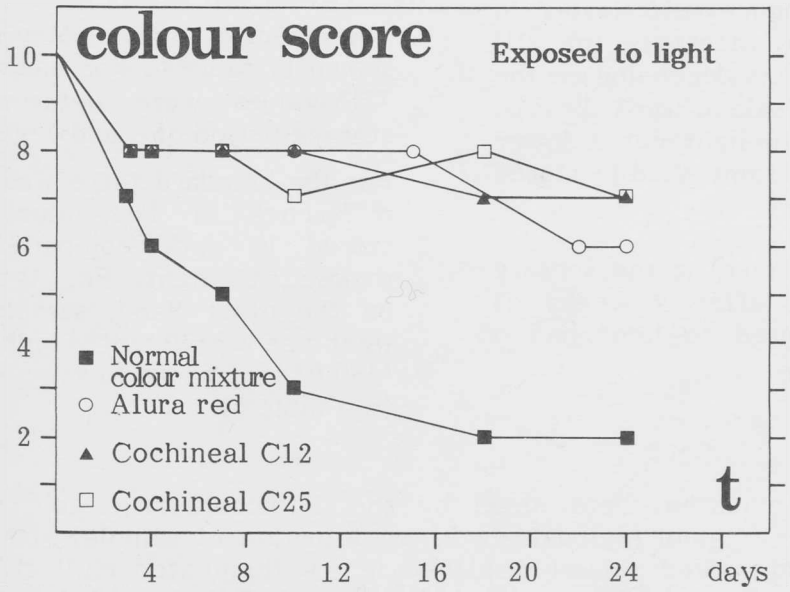

Fig. 2. Colour evaluation, for sliced, vacuum-packed salami with 4 different colourants added (see table 1), displayed in an illuminated chill cabinet for app. 4 weeks. Evaluation scale: 0-10 (10 = no discoloration, 0 = totally discoloured, 5 = acceptability limit).

Sensory evaluation

Table 3 shows the results of the sensory evaluation. For each salami, there is an initial taste score together with a taste score after 4 weeks of light exposure and of 4 weeks of dark storage (except for salami with Allura red added).

TABLE 3. Sensory evaluation of sliced, vacuum-packed salami displayed in an illuminated chill cabinet for app. 4 weeks: Effect of light exposure and dark storage. Evaluation scale: 0-10 (10 = no off-flavour, 0 = very strong off-flavour, 5 = acceptability limit). - See also a) below table.

Colourant	Taste score		
	Storage time (weeks)		
	0	4	
		Light display	Dark storage
Normally used colour mixture (Standard)	9.7	1.8^{A}	8.0^{C}
Allura red		-	-
Cochineal C12		4.8^{B}	7.6^{C}
Cochineal C25		3.6^{B}	7.0^{C}

a) All values are means of 2 replicate determinations. Values in the same line and column bearing the same superscript letter do not differ significantly ($p>0.01$) from each other.

Results of the sensory evaluation (table 3) indicate that light induces off-flavour in salami. A significant difference ($p>0.01$) in taste score was found depending on the storage conditions, a salami (regardless of colourants) exposed to light got a lower taste score than the same sample stored in dark.

The main comment given at the sensory evaluation was that after 4 weeks of storage, salami exposed to light had a rancid taste.

Assessment of lipid oxidation

The effect of light display on rancidity is shown in table 4. For each colourant the TBA-values were determined after a storage period of 0 and 4 weeks.

For the standard there was no significant difference in TBA-values for samples stored in dark compared to samples exposed to light. For the alternatives, on the other hand, samples exposed to light had significantly higher TBA-values ($p>0.05$) compared to samples kept in dark (see table 4).

TABLE 4. Lipid oxidation determined by the 2-thiobarbituric acid (TBA) method (µ-mol malonaldehyde per kilogram of sample) of sliced, vacuum-packed salami displayed in an illuminated chill cabinet: Effect of light exposure and dark storage. - See also a) below table.

Colourant	TBA		
	Storage time (weeks)		
	0	4	
		Light display	Dark storage
Normally used colour mixture (Standard)	3.6^{A}	5.3^{B}	4.9^{B}
Allura red	3.1^{A}	7.0^{B}	3.6^{C}
Cochineal C12	4.1^{A}	7.1^{B}	3.2^{A}
Cochineal C25	3.4^{A}	7.6^{B}	3.8^{A}

a) All values are means of 2 replicate determinations. Values in the same line bearing the same letter do not differ significantly ($p>0.05$) from each other.

CONCLUSION

Cochineal C12 and C25 looked very promising as alternative colourants to the normally used colour mixture in salami, as both resulted in an initial colour very close to the standard and besides they were much more light stable, when exposed to light in a chill cabinet for approximately 4 weeks. Regarding the colour of salami with Allura red added, the light stability was very good, but the initial colour was a little more yellow-red than the initial colour of the standard.

The TBA-test indicated that light exposure during 4 weeks of storage resulted in a rancid taste for salami with Cochineal and Allura red added. Accordingly, the sensory evaluation of Cochineal resulted in a low taste score for samples exposed to light.

For no obvious reason light exposure of the standard did not result in significantly higher TBA-values, even though the sensory evaluation indicated higher rancidity during 4 weeks of light exposure.

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REFERENCES

Codex Alimentarius Commission (1989):
ALINORM 89/16.

Commission of the European Communities (1985):
KOM (85) 474, Final, 19. September.

FAO/WHO (1987):
FAO/WHO food additives data system. Evaluations by the joint FAO/WHO Expert Committee on Food Additives, 1956-1984. FAO Food and Nutrition Paper 30, Rev. 1, Add. 2.

FAO/WHO (1989):
Evaluation of certain food additives and contaminants. Thirty-third Report of the joint FAO/WHO Expert Committee on Food Additives. Technical Report Series 776.

Francis, F.J. and Clydesdale, F.M. (1975):
Food Colorimetry: Theory and Applications. AVI Publishing Co., Westport, CT.

Jørgensen, K. and Skibsted, L.H. (1989):
Chemistry Department, Royal Veterinary and Agricultural University. Personal communication.

McCormick, R.D. (1971):
Allura red - new food colour offers greater brillance and stability. Food Product Development, vol. 5, No. 1, 26.

SAS (1979):
SAS User's Guide, Statistical Analysis System. SAS Institute Inc., Cary, NC.

The Positive List (1988):
List of approved food additives (in Danish). The National Food Agency of Denmark, Publ. no. 171.

Vyncke, W. (1970):
Determination of the thiobarbituric acid value in trichloracetic acid extracts of fish as measure of oxiditative rancidity. WEFTA meeting, September.

Vyncke, W. (1975):
Evaluation of the direct thiobarbituric acid extraction method of determining oxidative rancidity in macherel (Scomber Scombrus L). Fette, Seifen, Anstrichmittel, 77, 239.