Influence of storage time of raw material on color and lipid oxidation of cooked sausage

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Early discoloration of vacuum-packed sliced cooked sausages is a quality defect often seen at retailers. Since, in industrial processes, raw material is usually freeze-stored before processing, the influence of extended storage time on the level of discoloration and oxidation in final products was investigated. Therefore, four batches of meat and lard were freeze-stored for nine months. Every three months, cooked sausages were produced, exposed to light, and analyzed for color and oxidation state (peroxide value, TBARS, and hexanal value).

The results showed no influence of raw material storage time on the level of discoloration. However, oxidation state of the cooked sausage increased markedly for raw material stored for nine months, although raw lard did not have elevated peroxide, TBARS, and hexanal values. These results confirm industrial practices to store meat and lard no longer than six months.

Key Words – lipid oxidation, freeze-storage, cooked sausage, discoloration, light exposure

I. INTRODUCTION

Cooked sausages are mainly presented in transparent packaging. Light exposure at retailers leads to visible color changes and lipid oxidation [1, 2, 3], and early discoloration has a negative influence on the buying decisions of consumers [4]. The present work aims to investigate the extent to which the common freeze storage of raw material in the industry at -18 °C up to six months influences color stability and lipid oxidation in displayed cooked sausages.

II. MATERIALS AND METHODS

Lard and meat were blended separately, and both ingredients were divided into four equal batches (15 kg total weight per batch). One batch was processed directly into cooked sausages, following a standard recipe. The three remaining batches were stored at -18 °C. After three, six, and nine months of storage, the same recipe as for the first batch was used to produce more cooked sausages.

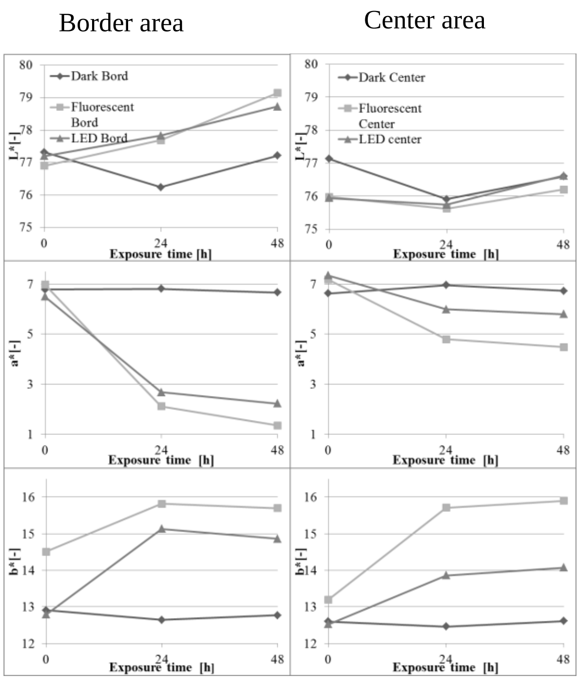
Directly after production, the cooked sausages were cut into slices (5 cm x 5 cm x 1.5 cm), vacuum packed (foil PA/PE/20/70), and exposed to fluorescent light (Philips Master TL-D 36 W/830) or LED light (ALTO 500 HCRI), both at 2000 lx and 8 °C for a 48 h duration. Color measurements (CIE-L*a*b* color system) of the center and border areas of the slides were performed after 0 h, 24 h, and 48 h. Peroxide value (according to Wheeler [5]), TBARS (according to Crackel *et al.* [6]) and hexanal value (according to Mallia *et al.* [7]) were determined after 0 h and 48 h of exposure and from lard as a raw material.

Statistical analysis was performed using single factor ANOVA ($\alpha = 0.05$), carried out with Excel 2011.

III. RESULTS AND DISCUSSION

As expected, the color dimensions (L*a*b*) of the cooked sausage changed (a* dimension from 6.5 to 2.5, Figure 1) after exposure to fluorescent and LED light. This change in the a* value was also described by Andersen *et al.* [8] for cured meat, as a consequence of light induced oxidation of the color pigment. The storage time of the raw material had no significant influence on color change. The borders of the slices were more affected than the centers, which could be explained by residual oxygen in the side folds of the packaging. LED light seemed to have less of an effect on color than fluorescent light (change in dimensions a* and b*). After 24 h of exposure, color changes in the border areas were clearly visible to the human eye for both light sources (data not shown).

Figure 1. Changes in L*a*b* dimensions of cooked sausage slices (six-month storage of raw material) during exposure to light (fluorescent or LED) and storage in darkness. The border areas (figures on the left side) were more affected than the centers of the slices. (The values are means from three measurements.)



The peroxide values of lard were low even after nine months of freeze storage (1.1 mEq O_2/kg). The peroxide values of cooked sausages (with/without light exposure) ranged from 0.1 to 13.25 mEq O_2/kg after zero, three, and six months of raw material deep-freeze storage (Table 1). Cooked sausages made with raw material stored for nine months had very high peroxide values (>100 mEq O_2/kg).

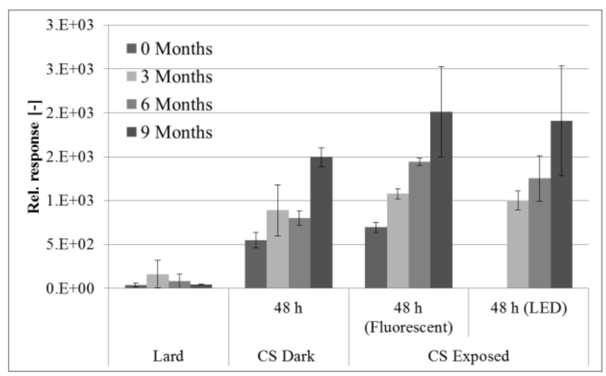
Table 1. Peroxide values (POZ) and TBARS of cooked sausage slices after different storage times (Mo = months) and exposure to fluorescent light for 48 h. (The values are means from two measurements ± SD.)

	0 Mo	3 Mo	6 Mo	9 Mo
POZ [mEq O_2/Kg]	0.55 ± 0.1	4.05 ± 0.9	0.45 ± 0.3	>100
TBARS [mg/Kg]	0.07 ± 0.02	0.19 ± 0.06	0.16 ± 0.01	0.47 ± 0.02

TBARS values tended to increase with increase in storage time (Table 1). Cooked sausages made from raw material stored for nine months reached values close to 0.5 mg MDA/kg, which has been suggested as a limit for the threshold of consumer detection of rancidity [9]. However, an acceptable limit for TBARS may be 1.0 mg MDA/kg for sausage products [10].

Finally, hexanal value increased significantly ($p = 0.00041$) in all cooked sausage samples with increase in storage time of raw material. Increased hexanal levels were found for the samples stored in darkness as well as for the samples exposed to the fluorescent and LED light (Figure 2).

Figure 2. Hexanal relative response [-] of cooked sausages (CS) produced with raw material that has been stored for zero, three, six, and nine months. The raw material was transformed into CS and either stored in the dark or exposed to fluorescent or LED light for 48 h.
(Values are represented as mean ±SD.)



IV. CONCLUSION

Storage time did not seem to have a distinct influence on color change. However, the border area of the cooked sausages was more affected than the center, which could have been due to residual oxygen in the side folds of the packaging [11, 12].

With increase in storage time of the raw material, increased lipid oxidation could be observed. Nonetheless, peroxide values and hexanal levels of raw material were still low and did not serve as indicators of oxidation stability of the end product. The oxidation stability of the cooked sausage produced with the raw material stored for nine months was obviously lower and led to very high peroxide values and elevated TBARS and hexanal levels. These results were confirmed through smell by trained sensory experts, who detected a clear off-flavor after light exposure. These were described to be rancid and oxidized.

The present results confirm the general experience of the industry that deep-freeze storage of raw material up to six months is possible but that longer storage times lead to quality problems.

Further investigation is necessary to confirm the findings mentioned above, clarify the influence of LED on color and lipid oxidation, and improve packaging.

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