PHILIPS

White paper

Discoloration of sliced meat

At a time when more and more people are doing their shopping online, with the added convenience of home delivery or collection from a pick-up point, the fresh food section is often the main reason why a customer chooses to actually go to a particular supermarket, in preference to any other. More than anywhere else, the fresh food section is where customer loyalty is forged.

As such, the fresh food section offers supermarket retailers the ideal opportunity to differentiate themselves from the competition. It is where they can demonstrate the level of service they provide and the quality of the produce they sell. Shoppers naturally associate the look of fresh produce with its taste, and they know from experience that if food looks good, it will most likely taste good as well.

However, as things stand at present, there is also a significant downside associated with the wide choice of appetizing produce on offer – the issue of food waste. According to an FAO-commissioned study[1], roughly one third of the food produced in the world for human consumption every year – approximately 1.3 billion tonnes – gets lost or wasted. And according to the UN, over 20% of the 263 million tonnes of meat produced globally each year is lost or wasted. That's equivalent to 75 million cattle!

Reduction in the amount of food waste promised by the UN and EU **by 2025.**

1 http://www.fao.org/news/story/en/item/74192/icode/

Food waste on this scale is something today's increasingly empowered, sustainability-conscious consumer is no longer prepared to accept. Hence the United Nations and European Union committing to reduce the amount of food waste by 50% by 2025. And in France, for example, the Parliament has adopted a series of measures designed to reduce food waste. Retailers are no longer allowed to destroy produce approaching its best-before date and must donate it to charity. The sanction for breaking this law is up to EUR 75,000, and the group that proposed this legislation aims to extend it to the entire EU.

As reported by the European Retail Forum, in many cases food waste is also having a significant impact on retailers' revenues, with meat products being one of the biggest areas of concern.

Although light-induced discoloration of sliced meat presents no hygiene or health problems, it can put customers off buying the product.

And as stated above, because the fresh food section is often the main reason a customer prefers a particular supermarket, discolored sliced meat can have a serious impact on consumer loyalty.

Light-induced meat discoloration

Some sliced meat products discolor faster than others: the rate of color change is specific to each product. The first process that occurs is dehydration. This causes the meat to become paler and lighter in color. Following this, oxidation of the primary pigment that gives meat its color (called myoglobin) is triggered by light. This pigment can change into metmyoglobin, which generally changes the color of the meat from red to brown. Lastly, bacteria start to grow, and this bacterial activity leads to changes in both the quality and the color of the meat products.

The speed at which discoloration processes occur is determined by several factors, including atmosphere (oxygen level, preserving gases, moisture, …), temperature, light, and the acidity of the meat. Only the oxygenation/oxidation of myoglobin referred to above is affected by light; light level and exposure time are important parameters.

Summary outline and objectives of **the research**

In order to gain a greater understanding of the effect that the 'light recipe' – a specific combination of light level and light spectrum – has on the discoloration of sliced meat, we decided to conduct an extensive series of laboratory experiments. To corroborate this laboratory research, we conducted tests in the field with two renowned parties in the fresh food sector.

Specifically, the objective of the research was twofold, namely to define:

1. The optimal 'light recipe' for illuminating sliced meat

2. The right light spectrum that would not only improve the presentation of meat, but would also have beneficial biological effects, for example slowing down discoloration.

In a second research phase, we commissioned the University of Leuven (KU Leuven) to conduct a study to determine the optimal color appearance of various types of meat.

1. Visible discoloration of sliced meat

We began by conducting laboratory research into the effect of oxygen, light level and the blue, green, red and yellow parts of the light spectrum on the discoloration of sliced meat. The research was carried out on two strongly discoloring types of sliced meat: liver sausage (extra-fine, 'Berliner') and luncheon meat ('Boterhamworst'). The aim was to translate the findings into the best possible white spectra for the market.

In due course, this research – which included measuring the effect of those white spectra on the discoloration of sliced meat and benchmarking against White SON – led to the definition of the dedicated light recipe fresh food rosé.

In parallel with the laboratory research, a test was carried out in cooperation with Stegeman Netherlands, part of the European Campofrio Food Group (top-5 meat processing company). The aim was to quantify customer acceptance of different levels of discoloration of sliced meat. To this end, a total of 29 respondents judged whether the discoloration of several differently discolored samples of liver sausage and luncheon meat was acceptable or not.

In this test, the acceptance of discoloration varied according to the type of sliced meat: the color change of liver sausage was evaluated as more acceptable than the smaller color change of luncheon meat. The color change did not bother 10% of the test subjects.

The 50% acceptance level for the discoloration was then used for further analysis of the results of the laboratory experiments. The data from this supermarket test was important in adding application value. Presentation is also a relevant parameter in supermarket applications.

Results and conclusions

The research and field test outlined above lead to a number of very clear conclusions. Firstly, the level of discoloration varies according to the type of sliced meat. Secondly, the effect of light level on the discoloration of sliced meat is greater than that of spectrum.

However, it is important to note that there is also a definite beneficial effect of optimizing the spectrum. The spectrum of fresh food rosé leads to less discoloration of sliced meat than the conventional White SON spectrum.

With an optimized spectrum, retailers can either delay discoloration for a longer shelf life or, use higher light levels for more eye-catching displays. In the first case, shelf life can be extended by up to 20% at illuminance levels equivalent to conventional lighting. In the latter case, the retailer can apply light levels up to 30% higher, for a shelf life that is the same as with conventional lighting.

The research also confirmed that UV filters do not stop the discoloration of sliced meat, as the spectra of the relevant lamps (White SON, LED, etc.) already contain no or only very small amounts of long-wavelength UV. An observed beneficial effect can be attributed to the fact that use of UV or red filters lowers the light level and so may influence the visibility of the discoloration – but it does not stop the discoloration itself.

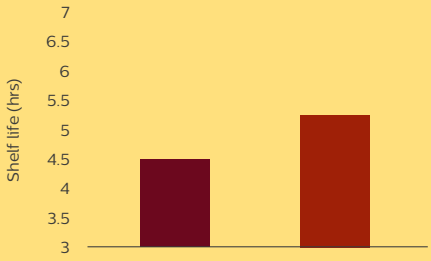
Exploring the effect of light level on waste

To further corroborate the research outlined above, we conducted a test in cooperation with the Amersfoort branch of the PLUS supermarket chain in the Netherlands. Here, the goal was to measure the effect of light level on waste due to discoloration of sliced meat.

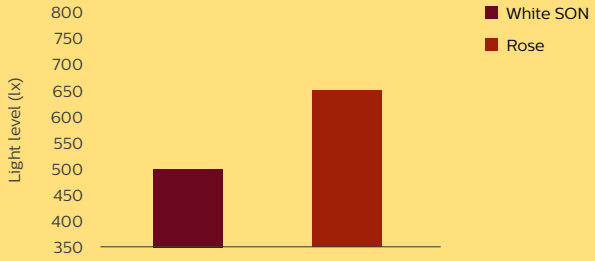
Over a period of 16 weeks, tests were carried out at three different levels of light (low: 400-500 lux; middle: 700-800 lux; high: 1000-1100 lux), with the spectrum being tuned each day with Philips StyliD fresh food rosé.

Here too, the results and conclusions are consistent with the previous findings. This test demonstrated that light level has a significant effect on waste due to discoloration. The high level of 1000-1100 lux led to significantly higher waste than the low and middle levels of 400-500 lux and 700-800 lux respectively. And the low and middle levels were not significantly different with respect to waste due to discoloration.

Shelf life*
@ equal light level (500 lx)



Light level*
@ equal shelf life (4.5 hrs)



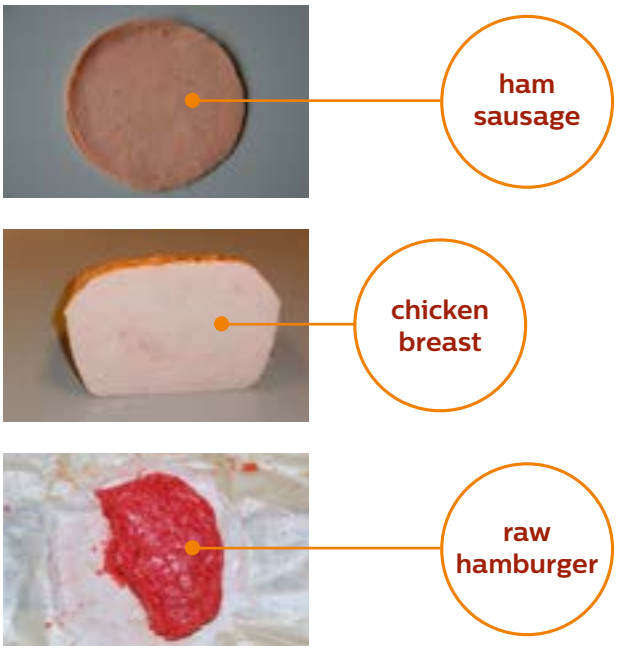
* Based on 50% acceptance level of discoloration of liver sausage as tested by Stegeman

Note:
› Rose is the best Accent Lighting Meat solution

2. Perception benefit of Fresh Food recipes – preference and memory color

In the next phase of its research, we commissioned the 'Laboratorium voor Lichttechnologie' (Light & Lighting Laboratory) of KU Leuven to conduct a study of the perception of meat, specifically to determine the optimal color appearance of various types of meat. This optimal color appearance was determined based on preference and memory in a series of visual experiments with a large number of test subjects. Based on the experimental results, a model was compiled in the CIE xy chromaticity diagram to predict the similarity between an observed meat color and the optimal color.

Three types of meat were tested:



Test set-up and experimental procedure

The optimal color of a type of meat was determined by presenting the meat in over 100 different colors (chromaticities) in a specially designed test set-up (see Figure 1 and Figure 2) to a group of test subjects (15-20). The participants were asked to assess each presented color based on preference (how attractive it looked) and, in a separate experiment, memory (how well it resembled what they remember that type of meat looking like), and to give it a score on a scale between 0-10.

The color of the meat could be adjusted by lighting it with three RGBY (Red, Green, Blue, Yellow) LED modules. The adaptation status of the test subjects was checked by presenting the meat in front of a sufficiently intense illuminating background (white point with correlated color temperature, CCT ≈ 3400 K) and by having the test subjects look into a light box (see Figure 1) with the same CCT when the stimulus was being switched. In addition, all indications that might reveal the color of the lighting were masked as well as possible by presenting the meat between two parallel glass plates and orienting it in such a way that the mirrored reflection could not be seen (see Figure 2). The second glass plate on top was intended to prevent dehydration and subsequent discoloration.

Figure 1: Test set-up with a telescope linked to a spectrograph on the left, and on the right a light box which test subjects must look into to erase the color from their retinas.

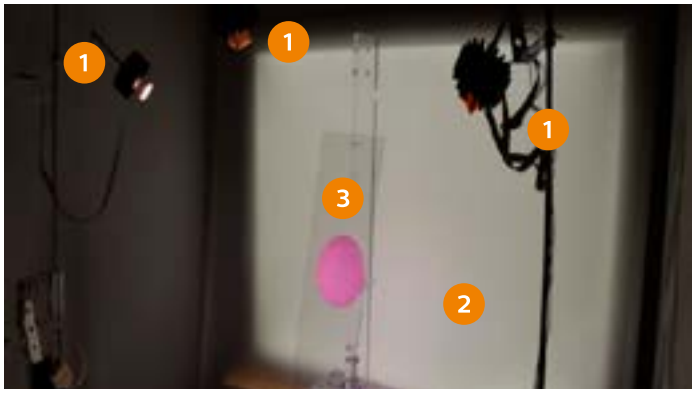


Figure 2: Inside of box. 1 = 3 RGBY LEDs, 2 = background panel (CCT = 3400 K), 3 = meat between glass plates

Preference and memory color: conclusions
The research demonstrated that in terms of the perception of meat, the saturation of color is of key importance. Interestingly, people remember the color of meat as being more saturated, and the color they prefer is even more saturated still – effectively an enhanced version of their memory.

This is consistent with previous studies on other types of fresh food done at KU Leuven and with the 2012 study conducted by us and the Independent Retail Institute in Cologne, Germany, in which it was found that lighting can have a positive impact on sales in a supermarket's fresh produce department.

If you know the memory and preference color point for the specific meat types and the reflection spectra of the meat, you can calculate the extent to which a specific light spectrum matches these color points.

When evaluating our dedicated fresh-food light recipes on preference and memory color these spectra scored 'excellent' whereas other non-dedicated LED spectra scored 'average'. The difference in score was observed for all meat colors studied. The difference was greatest for the more reddish types of meat. The 'excellent' score for the fresh food light recipes was independent of illuminance level (evaluated up to 1000 lux).

Key take-aways from this research

The level of discoloration is different for different types of sliced meat (research done on very sensitive kinds of meat).

The effect of light level on the discoloration of sliced meat is greater than that of spectrum. However, there is also a beneficial effect of optimizing the spectrum:

With an optimized spectrum, retailers can opt for a longer shelf life or, alternatively, higher light levels:

Extended selling period
› Illuminance equivalent to conventional lighting
› Up to 20% longer shelf life

or

More eye-catching displays
› Shelf life equivalent to conventional lighting
› Up to 30% more light

UV filters do not stop discoloration of sliced meat, because the spectra of the relevant light sources (White SON, LED, etc.) already contain little or no long-wavelength UV.

An observed beneficial effect can be attributed to the fact that use of UV or red filters lowers the light level and so influences the visibility of the discoloration – but it does not stop the discoloration itself.

Lighting application **guidance**

Today's leading-edge LED lighting is a powerful sales tool. As the research outlined above has shown, the right light recipe can slow down the visible discoloration of sliced meat, or enable brighter, more eye-catching displays, while also reducing the psychological gap between the actual colors of produce and the much more saturated colors people have in mind when they think of fresh food.

On the basis of this research, we have been able to develop a number of recommendations for the lighting design of supermarket fresh-food sections displaying sliced meat:

- **Use products with the Philips light recipe fresh food rosé**
- **Take maintenance factor = 1 (for meat display area)**
- **Respect E_{max} = ~750 lux (not E_{ave})**
- **Use an oval beam (2600 or 1900 lm)**
- **If you go for 36D: 1900 lm (assuming spacing is 1.80 m and mounting height is 3 m)**
- **Dim if needed for fine tuning (DALI driver)**

The consistent application of these guidelines will help fresh food retailers to optimize their displays of sliced meat – thus increasing sales while at the same time reducing food waste. This will in turn enable them to maintain the green brand image and customer loyalty that are key to continued success.

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