

# Colour appearance in led lighting

Pablo IXTAINA,<sup>1</sup> Matías PRESSO,<sup>1</sup> Fausto BREDICE,<sup>2</sup> Pedro A. BAZALAR VIDAL<sup>1</sup>

<sup>1</sup>Laboratorio de Acústica y Luminotecnia, Comisión de Investigaciones Científicas (LAL-CIC)

<sup>2</sup>Centro de Investigaciones Ópticas (CIOp)

## ABSTRACT

The paper shows a comparative study of colour comparison between white LED lamps and conventional ones (incandescent and compact fluorescent). The LED lamps used were a model designed by the direct replaces of halogen incandescent lamps. The technology used for white light generation was based on short waves emitter chips and secondary emission. As result of the experience, significant object colour coordinates displacements in LEDs lighting were observed. As it was predictable from LEDs spectral distribution, orange – red colours were poorly reproduced. However, the subjective experience did not show a remarkable preference to the conventional light sources. Furthermore, several observers qualified the objects under LEDs light as “more naturals”.

## 1. INTRODUCTION

The development of white solid light emitters (white Light Emitting Diodes, LEDs) with improved light characteristics is helping to spread this new light technology in the domestic and commercial lighting fields. In the analyzed LED lamp model, several individual LEDs are encapsulated together, in order to obtain a shape similar to a conventional lamp (incandescent or halogen incandescent lamp). In this way, a non-specialist user can easily have access to this new technology. He only needs replacing the old lamp without the need of changes in the lighting device (luminaire).

The studied model was a 21 LEDs lamp with dichroic reflector, 220 Volt, 1.5 watt power consumption, warm light. The technology used for LEDs white light generation is based on short waves (violet – blue) emitter chips. This radiation is later changed to white light through a secondary emission of a thin phosphorous coat into the LED encapsulate [Luo and Kim 2006].

The normal use of these lamps is in ornamental lighting and in many cases, the usual applications involve food lighting: bars, restaurants, home kitchens and supermarket stands.

## 2. EXPERIMENT

In general, the information about the light chromatic characteristics of commercial devices is scarce and it is strongly determined by the properties of the used phosphoric compound. In order to characterizing the colour reproduction of LEDS lamps, the light emitted by samples commercially known as “warm light” lamps was spectrally measured in the visible region of the spectrum using a Mechelle 900 spectrometer [MK Photonics Inc. 2006]. Figure 1 show a used LED lamp together with the measured spectrum.

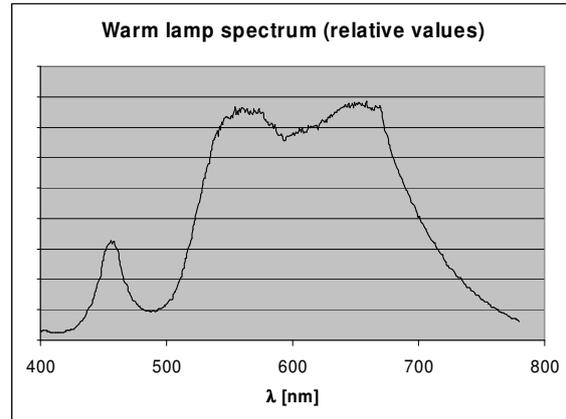


Figure 1. LED lamp used and its measured spectrum

## 2.1. Experimental set up

Three similar adjacent compartments designed as showcases were built for the experience. The showcases were 0.60 m wide by 0.80 m deep boxes with white walls and top. Two of them were illuminated by conventional lamps. In the first box, a compact fluorescent lamp (CFL), 18 W, warm light was used. A halogen incandescent (IH) with reflector lamp, 50 W, 2800K was used in the second box. LED reflector lamps were used for the third compartment.

The lamps were mounted in holes made on the box roofs and they were adjusted, using screens and diaphragms, in order to obtain the same illuminance and luminance levels in the three compartments. The illuminance level was adjusted around 600 lux (average level), a typical illuminance indoor value. Figure 2 shows the experimental set up.

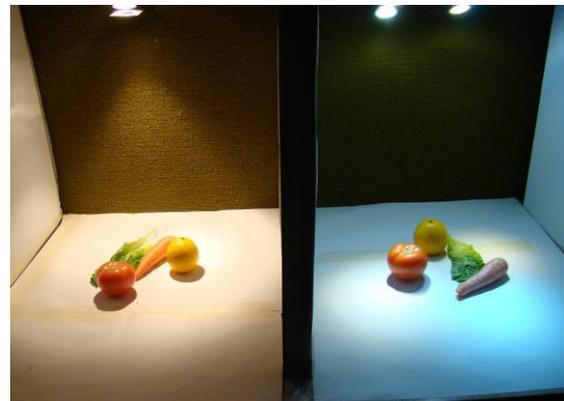
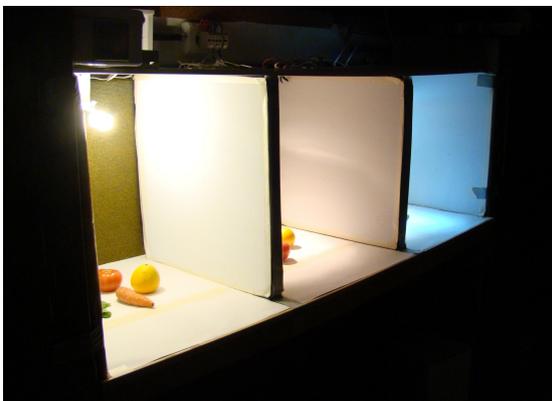


Figure 2. Experimental set up

Different objects, mainly diverse kinds of food (vegetables, fruits, raw and cooked meat) were introduced in the compartments. Then, the colours reproduced by the three light sources were comparatively evaluated objectively and subjectively.

## 2.2. Chromaticity coordinates evaluation

The CIE chromaticity coordinates  $x$ ,  $y$ ,  $z$  [CIE 2004, Malacara 2002] were obtained for each object in the boxes using a Pritchard Photometer [Photo Research Inc. 2009]. The instrument had three colorimetric response filters that made possible relative and absolute colour measurements. That is why, colour coordinates for each object in the different boxes were

obtained. Figure 3 shows the obtained colour changes on vegetables and fruits (lettuce, tomato, lemon, etc.).

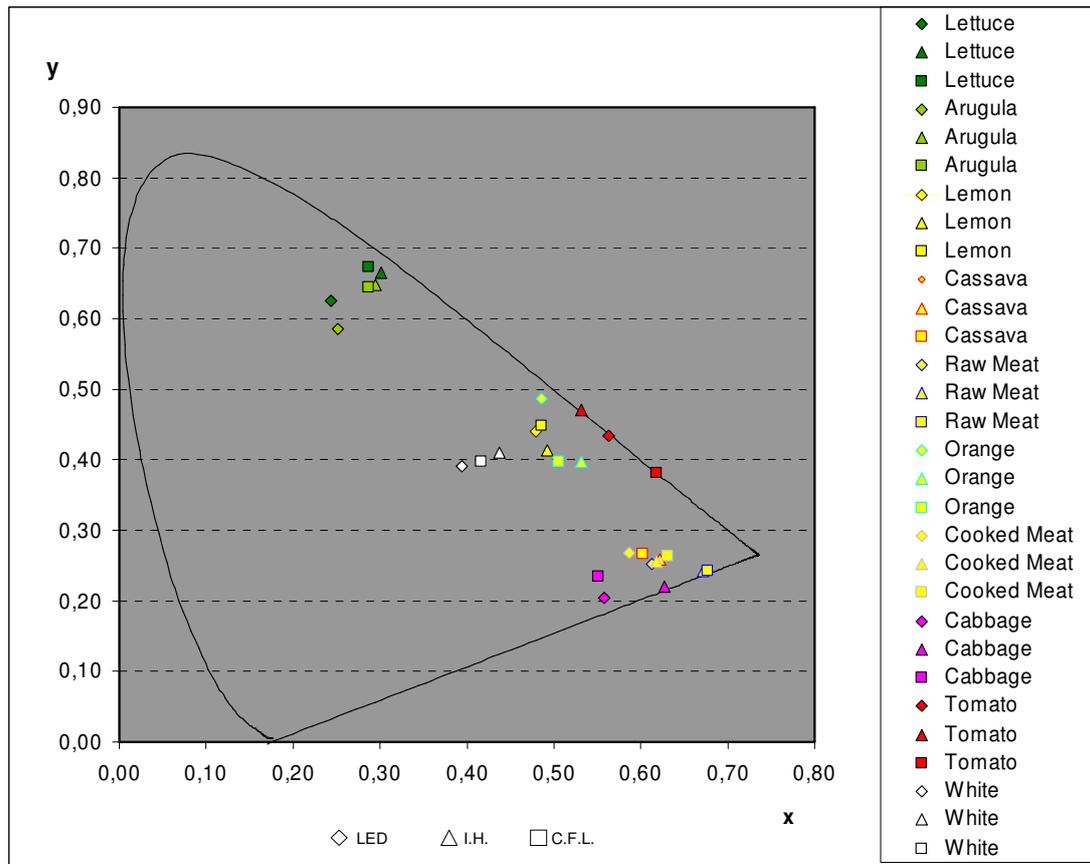
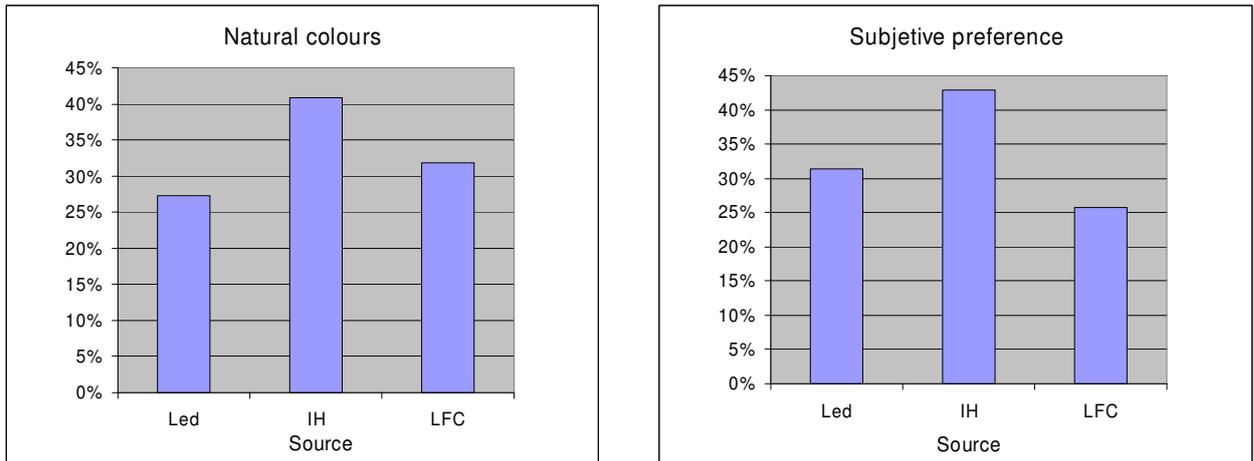


Figure 3 Measured colours by the three light sources

### 2.3. Subjective experiment

In this test, a group of 15 observers assessed subjectively the “appearance” of the LED light and illuminated objects. For that purpose, the three compartments, with vegetables and fruits were shown. In a first case, the boxes were lightened one at a time. After that, the observers compared the three display boxes simultaneously illuminated. During the test, the objects were exposed in similar colour groups: green vegetables (lettuce, arugula), red (apple, tomato), etc.

At the end of the test, the observers answered questions, based on their colour perception, about subjective issues, such as “freshness”, “appeal”, “natural appearance” and “reliability”, and the global light aspect. Figure 4 summarizes two relevant aspects: natural appearance and observer light preference. All colour objects were joined in the graphs shown in the figure. Significant changes in the opinions were found when colours were discriminated, mainly in the red and orange zones.



*Figure 4. Subjective evaluation*

### 3. CONCLUSIONS

Significant object colour coordinate shifts in LED lighting were observed, mainly for green and orange objects. Some perceptive mistakes on objects with similar shape under LED light were detected (e.g. orange was confused with lemon). However, in the subjective test, several observers qualified the objects under LED light as “more natural” and the assay did not show a remarkable preference to the conventional light sources.

In opposition to what can be predicted from LED spectral distribution (poor light contribution in blue-green and red zones) LED light was well qualified and accepted, practically at the same level as fluorescent light.

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*Address: Pablo Ixtaina, Laboratorio de Acústica y Luminotecnia,  
 Comisión de Investigaciones Científicas, Camino Centenario y calle 506,  
 1897, Gonnet. E-mails: Pixtainaahoo.com,  
 faustob@ciop.unlp.edu.ar, matiaspresso@gmail.com*