The sensory quality of seafood as affected by intense light pulses

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SUMMARY

The study represents systematical evaluation of the intense light pulses (ILP) on sensory quality of seafood. Four seafood species (tuna, salmon, flounder and crab) were treated with 1 and 5 light pulses (pulse duration of 300 μs and pulse intensity of 3.4 J/cm2) at a rate of one pulse per 2 seconds. All the seafood samples were assessed as very acceptable, with the total score value equal or greater than 4.6 regardless of the ILP treatment applied. The most sensitive sensory attribute to the ILP treatment was odor. Pulsed light decreased L values in tuna but only after the higher treatment (17 J/cm2) was applied while a* and b* values were not significantly different to the control samples. The lower dose of pulsed light (3.4 J/cm2) had no effect on the color values of tuna in our study. The salmon samples exhibited significantly lower L* values even after the lower dose was applied while a* and b* values remained unaffected by the ILP treatment. Flounder and crab meat samples revealed that its yellowness was more sensitive to ILP compared to lightness and redness. Study revealed that ILP can affect the color of seafood but not to the extent of significantly disturbing total sensory scores.*

Keywords: *light pulses, pulsed light, sea food, fish, sensory quality, color*

INTRODUCTION

Food safety has become an essential priority for authorities and consumers worldwide, especially concerning perishable products such as those of animal origin. Raw meats are the most perishable of all important foods and meat products also must be safe and have the right composition, color, taste and appearance (Wambura & Verghese, 2011).

This is why a number of thermal and non-thermal decontamination and preservation methods are developed and have been developing in order to sustain meat safety and quality (Aymerich, Picouet, & Monfort, 2008; Loretz, Stephan, & Zweifel, 2010). The fact that not only the shelf life but also the quality of food is important to consumers gave birth to the concept of preserving foods using non-thermal methods. Non-thermal methods of food preservation are being developed to eliminate or at least minimize the quality degradation of foods that results from thermal processing. They are expected to induce only minimum quality degradation of food. It is therefore necessary to evaluate changes in sensory attributes of foods (Barbosa-Cánovas, 1998).

Intense light pulses (ILP), also known as pulsed light (Oms-Oliu, Martín-Belloso, & Soliva-Fortuny, 2010), high intensity broad spectrum pulsed light (Roberts & Hope, 2003), pulsed white light (Kaack & Lyager, 2007; Marquenie, Michiels, Van Impe, Schrevens, & Nicolaı, 2003) and pulsed UV light (Bialka & Demirci, 2007, 2008; Keklik, Demirci, & Puri, 2009) are included among the emerging technologies that are intensely investigated as an alternative to thermal treatment for killing pathogenic and spoilage microorganisms (Barbosa-Canovas, Schaffner, Pierson, & Zhang, 2000; Elmnasser, et al., 2007; Gomez-Lopez, Ragaert, Debevere, & Devlieghere, 2007; Palmieri & Cacace, 2005; Woodling & Moraru, 2005).

Although microbial inactivation is a critical requirement, it is also essential to keep the nutritional and sensory properties of the product, minimizing the possible loss of quality caused by the treatment (Hierro, Ganan, Barroso, & Fernández, 2012). Yet, most of the literature concerning the application of ILP for the preservation of food mainly deals with microbiological inactivation and few data are reported on sensory analysis. So far and to the best of our knowledge, it was examined on beef and tuna (Hierro, et al., 2012), cooked ham and bologna (Hierro, et al., 2011), salchichon and loin (Ganan, Hierro, Hospital, Barroso, & Fernandez, 2013) and chicken (Paskeviciute, Buchovec, & Luksiene, 2011). Colorimetric analysis

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of the ILP-treated flat fish, salmon and shrimp (C. I. Cheigh, H. J. Hwang, & M. S. Chung, 2013), sliced ham (Wambura & Verghese, 2011), chicken (Keklik, Demirci, & Puri, 2010) and chicken frankfurters (Keklik, et al., 2009) were also previously reported.

The aim of this study was to systematically evaluate the effect of intense light pulses (ILP) on sensory quality of seafood. Since the seafood (meat) purchasing decisions are influenced by color more than any other quality factor, because consumers use discoloration as an indicator of freshness and wholesomeness (Mancini & Hunt, 2005), special attention in our investigation was paid to the effect of ILP on the color.

MATERIAL AND METHODS

Samples preparation

Four seafood species (tuna, salmon, flounder and crab) were used in this study. All of the samples used were purchased from a local retailer and kept refrigerated at 2±2 °C until treated. Fish fillets and crab meat chunks were sampled as purchased.

ILP equipment and treatment

The ILP treatments were performed using a laboratory-scale batch-fed pulsed-light system unit: Tecum - Mobile Decontamination Unit (Claranor, Manosque - France). Light pulses with duration of 300 µs and pulse intensity of 3.4 J/cm2, measured with SOLO 2 - Power and Energy Meter (Gentec Electro-Optics, Inc., Quebec, Canada), were generated by four 20 cm cylindrical Xenon flash lamps (Flashlamps Verre & Quartz, Bondy, France), with an input voltage of 3000 V. The spectral intensity distribution of the light, as reported by Claranor, is shown in Figure 1.

The samples were ILP-treated with 1 pulse (1P) and 5 pulses (5P) at a rate of one pulse per 2 seconds, respectively. During treatments, samples were placed in the system unit at a distance of 6 cm from the top and bottom lamps, and 10 cm from the left-hand and right-hand lamps. No treatment was applied to the control groups of samples.

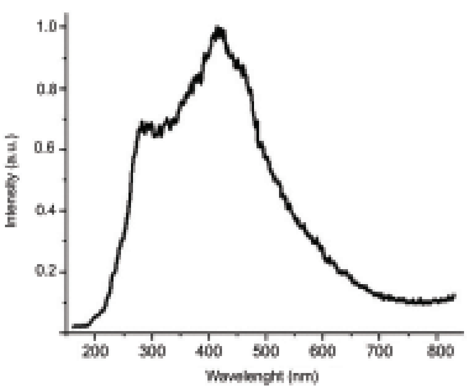

Figure 1 Spectral distribution of the xenon lamp used. Source: Claranor, France.

Sensory Analyses

Sensory evaluation was performed by a professional panel of eight panelists. The panel was trained according to international standards (ISO, 1993) and additionally trained for three days in the sensory assessment of meat and meat products by a panel leader with over 2,000 h of sensory testing experience of meat and meat products. The samples used in the additional training were over-treated with ILP (about 30 pulses per sample) and presented to the panelists in order to become acquainted with the effect of the treatment on a sample sensory profile. Each sample was identified by a three digit random code written on the serving plate.

The analyses were performed between meals. In all tests unsalted crackers and water were used to rinse the mouth between samples, which were presented about 10 min apart. Continual monitoring and investigation for any fatigue effect of individual results was performed to ensure satisfactory performance. Sensory tests were performed in a controlled sensory analysis laboratory (Food Safety and Food Quality Department/University of Ghent - Belgium) built in accordance to the general guidance for the design of test rooms intended for the sensory analysis of products (ISO, 2007) with individual booths equipped with computer terminals and provided with red light to mask any differences in color when needed.

Five-Point-Scale Scoring Method

The test was carried out as described by Tomic et al. (2008) with slight modifications. Selected sensory attributes were assessed using the 5-point scale with the following descriptions: 5=(excellent, typical quality, without visible defects); 4=(good quality, with minimal visible defects); 3=(neither good nor poor quality, still can be used for its intended purpose); 2=(poor quality, reworked could be used for its intended purpose); and l=(unacceptable, extremely poor quality, cannot be used for its intended purpose), with ability of giving semi scores (4.5, 3.5, 2.5 and 1.5). Scores given to each of assessed attributes were corrected by corresponding coefficients of importance (Table 1).

Coefficients of importance (CI) show the relative importance of a single sensory attribute to the total sensory quality. Sum of all CIs is arranged to be 20, and in that way the sum of corrected scores gives the "percentage of total sensory quality" in a given situation. Dividing the total value by the sum of CI gives the "pondered average value of total sensory quality". A section in the score card was included for panelists to leave their comments.

Instrumental color measurement

Instrumental color readings of samples were measured using a Konica Minolta spectrophotometer CM-2500d (Konica Minolta, Osaka, Japan), operating in the CIE L*a*b* color space.

Table 1 Selected sensory attributes of the samples assessed using the 5-point scale, with corresponding coefficients of importance (CI)

Attribute	CI
Appearance	7
Color	8
Odor	5

The L* (lightness), a* (redness) and b* (yellowness) values (a single repetition) were determined from the mean of 10 random readings on the surface of each sample, using D65 illuminant and 10° standard observer. The measurement was repeated in triplicate (n=3) and the values averaged. The instrument was calibrated with a white calibration tile and black calibration box. Data acquisition was performed using the Spectramagic NX color data software, version 1.52 (Osaka, Japan).

Statistical analysis

Data entry and decoding were 100% verified. A one-way ANOVA was conducted to compare the results of the different assays, using SPSS Statistics 17.0 (Chicago, Illinois, USA) data analysis software. An alpha level of $p<0.05$ was used to determine significance.

RESULTS AND DISCUSSION

Five-Point-Scale Scoring Method

When the fluence of 3.4 J/cm2 was applied to tuna samples no significant changes to appearance, color or odor were observed (Table 2). This is in concurrence with the results of Hierro, et al. (2012) where the fluence applied was 4.2 J/cm2 or lower and no significant changes in either color or odor ($p>0.05$) of tuna carpaccio samples were observed, also. However, higher fluences in this experiment affected the product at a great extent since these samples were given scores below 5 and were considered unacceptable. In our investigation, even when the highest fluence of 17 J/cm2 was applied the only significant change noticed concerned the odor of tuna samples. This alteration contributed to the decrease of total score value that have dropped down from excellent to the level of good quality but far away from being unacceptable. Also, we could not confirm the development of sulphur notes in tuna induced by the fluences higher than 8.4 J/cm2 (Hierro, et al., 2012).

All of the other seafood samples were assessed as very acceptable, with the total score value equal or greater than 4.6 (Table 2), whether they were ILP treated or not. Even though significant changes in odor ($p<0.05$) were assessed after the 5-pulses treatment in salmon, flounder and crab meat, also they were still described as pleasant and very acceptable. All the other sensory attributes evaluated remained unaffected by the ILP treatments ($p>0.05$).

Instrumental color measurement

Pulsed light decreased L* values in tuna but only after the higher treatment (17 J/cm2) was applied while a* and b* values were not significantly different to the control samples (Table 3). This is contradictory to the results of Eva Hierro et al. (2012) where pulsed light (8.4 J/cm2) significantly increased L* and decreased a* and b* values in tuna carpaccio. The lower dose of pulsed light (3.4 J/cm2) had no effect on the color values in tuna in our study. The salmon samples exhibited significantly lower L* values even after the lower dose was applied while the redness and yellowness remained

Table 2 Sensory evaluation scores (mean±SD) for 5-Point-Scale Scoring test of the ILP treated seafood

		Tuna	Salmon	Flounder	Crab
Control	Appearance	4,9±0,2	4,9±0,2	4,9±0,2	4,9±0,2
	Color	4,9±0,2	4,9±0,2	4,9±0,2	4,9±0,2
	Odor	4,9±0,2a	4,9±0,2a	4,9±0,2a	4,9±0,2a
	Total score	4,9±0,2	4,9±0,2	4,9±0,2	4,9±0,2
1 pulse	Appearance	4,8±0,3	4,9±0,2	4,9±0,2	4,9±0,2
	Color	4,8±0,3	4,9±0,2	4,9±0,2	4,9±0,2
	Odor	4,8±0,4a,b	4,7±0,3a,b	4,9±0,2a	4,6±0,2a,b
	Total score	4,8±0,2	4,9±0,2	4,8±0,1	4.8±0.2
5 pulses	Appearance	4,7±0,4	4,9±0,2	4,9±0,2	4,9±0,2
	Color	4,6±0,4	4,9±0,2	4,9±0,2	4,9±0,2
	Odor	4,4±0,2b	4,4±0,2b	4,1±0,2b	4,4±0,2b
	Total score	4,6±0,2	4,8±0,2	4,7±0,1	4,8±0,2

a,b,c Values in the same column with different letter are significantly different ($p<0.05$)

unaffected by the ILP treatment. Flounder and crab meat samples revealed that its yellowness was more sensitive to ILP compared to lightness and redness (Table 3).

Our results revealed that ILP can affect the color of seafood, although the changes observed were not immense, which is in contrast to the observations reported before. Figueroa-García, Silva, Kim, Boeger, and Cover (2002) did not observe changes in the instrumental color parameters when applying ILP to decontaminate catfish fillets at fluences ranging from 0.5 to 2 J/cm2. Also, the study of Cheigh, Hwang, and Chung (2013) indicated that none of these values differ significantly between the treated and untreated salmon, flatfish and shrimp fillets, and consequently concluded that the ILP treatment causes no observable change to color of the tested seafood. The ILP-treated and untreated samples in this study were analyzed immediately after 6900 pulses at 1.75 mJ/cm2 per pulse. The reasonable explanation for the differences between the previously reported findings and our observations lies in the fact that our experiment used, by far, the highest pulse intensity of 3.4 J/cm2.

CONCLUSION

The previous findings suggest a lot of potential for the commercial application of ILP for the decontamination of seafood products (C. I. Cheigh, et al., 2013) and ILP treatment for foods was approved by the USFDA under code 21CFR 179.41 in 1996. Our study indicated that the sensory quality of se-

Table 3 Instrumental color values (mean±SD) of the ILP treated seafood

		Tuna	Salmon	Flounder	Crab
Control	L*	37,5±0,4 a	50,5±0,2 a	74,9±0,5	63.4±2.1
	a*	10,1±0,5	19.4±0.8	-3.8±0.1	-2.1±0.4
	b*	9,5±0,3	17.4±0.7	4,9±0.1 a,c	3,1±0.0 a,c
1 pulse	L*	37,2±0,6 a	49,5±0,2 b	75,0±0,1	62,0±1,1
	a*	10,4±0,5	19.7±0.1	-3.7±0.2	-2.1±0.4
	b*	9.7±0.1	17.9±1.1	5,4±0,1 b	2,5±0,1 b
5 pulses	L*	36,0±0,3 b	48,6±0,5 b	75.1±0.6	61.4±0.8
	a*	10.4±0.3	19.7±0.8	-3.8±0.1	-2.1±0.4
	b*	9.6±0.3	18.0±1.5	4,6±0,2 c	3,0±0,1 c

a,b,c Values in the same column with different letter are significantly different ($p<0.05$)

afood induced by intense light pulses is almost unaffected and independent on type of seafood and ILP dose applied. Only the odor of all the seafood samples suffered significant changes after the pulsed light treatment. ILP significantly compromised the lightness values in tuna and salmon while only the lower doses applied significantly changed the yellowness of flounder and crab. All of the seafood samples were assessed as very acceptable, with the total score value greater than 4.5, whether they were ILP treated or not. The use of pulsed light on seafood regarding its influence on sensory quality is quite positive.

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