Objective

Fruits' ripening goes along with a change of organoleptic properties, in particular the visual aspect. For instance, the flesh of apples can turn brown over storage. Some treatments are investigated to try to avoid flesh browning. To evaluate and compare the effectiveness of various treatments, a precise measurement of browning extent and color is required.
This study proposes to assess apples being treated by different processes with IRIS visual analyzer.

IRIS Electronic Eye

IRIS analyzer achieves a detailed visual assessment of both color and shape parameters of the overall products or selected portions of these products.

Camera imaging

- 16 million colors imaging
- Integrated zoom
- Automated monitoring by software

Light cabin

- Reproducible lighting conditions, D65 compliant, 6700°K color temperature
- Top and bottom lighting (backlighting to avoid shadow effects)
- Large measurement surface (420 x 560mm)

E-Eye Alphasoft software

- Data acquisition
- Automated color calibration
- Data processing (color and shape analysis)
- Multivariate Statistics (Principal Components Analysis, Statistical Quality Control, etc).

Figure 1: IRIS Electronic Eye

Samples & Analytical Method

Ten apples having been treated by different means were analyzed. For that, apples were cut in two pieces and a picture of one half was taken (fig. 2).

Figure 2: Picture of apple halves for flesh browning evaluation

To evaluate the browning defect, the pictures were pre-processed first by removing the background, then by applying a color filter to isolate the brown area (fig. 3).

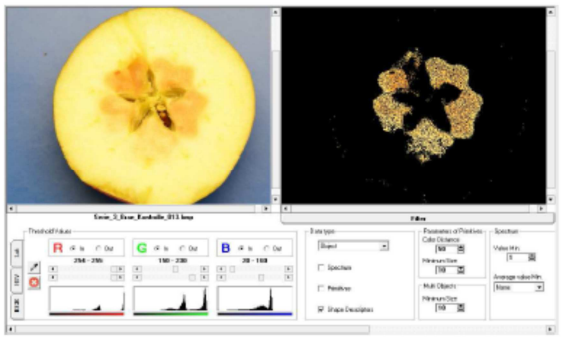

Figure 3: Pre-processed picture of apples (background removal and color filtering for brown area selection)

Global Color Analysis

With IRIS electronic eye, it is possible to analyze colors on the whole surface of apple halves, in one acquisition.

The picture of apples can be processed as a color spectrum (fig.4). This bar graph represents the proportion of each color (percentage) in the picture, within a fixed scale of 4096 colors.

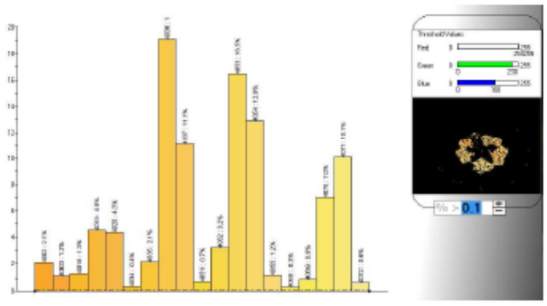

Figure 4: Color spectrum of an apple half

To rapidly compare the global color profile of all samples, the color spectrum data are processed by Principal Components Analysis (fig. 5).

The differences can be linked with the proportion of individual colors from the color spectrum.

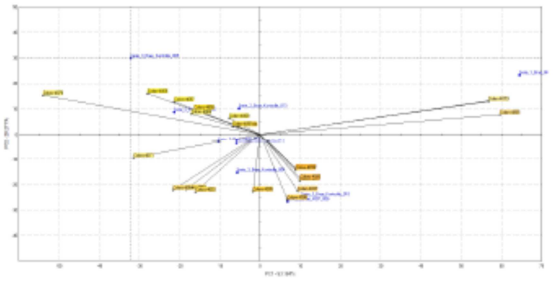

Figure 5: Principal Components Analysis of apple halves based on color parameters

Brown Defect Quantification

After having applied the color filter to separate the brown defect, the surface of the brown area was quantified (table 1). The proportion of brown area was calculated against the total apple surface.

The proportions measured with IRIS visual analyzer were consistent with visual assessment.

Sample	Apple surface (pixels)	Brown surface (pixels)	% of brown area
S1_020	1845223	1712	0.1
S1_023	1499881	0	0.0
S2_013	2318533	105165	4.5
S2_005	1407813	51	0.0
S2_006	1754579	104726	6.0
S3_004	1953262	24899	1.3
S3_009	1617301	35437	2.2
S3_010	1524917	147	0.0
S3_013	1875721	209076	11.1
S3_021	2432749	70446	2.9

Table 1: Proportion of brown color in each apple picture

Visual Quality Control Model

To evaluate the extent of brown defect in blind samples, a Quality Control model based on Statistical Quality Control model was build up.

The criterion of acceptable quality was set up at 1 % of brown area maximum on the whole apple surface (fig. 6).

On this map, all samples plotted in the green area are conform to the desired quality, whereas samples plotted outside are out of specifications.

Based on this model, it can be observed that three samples comply with the quality standards.

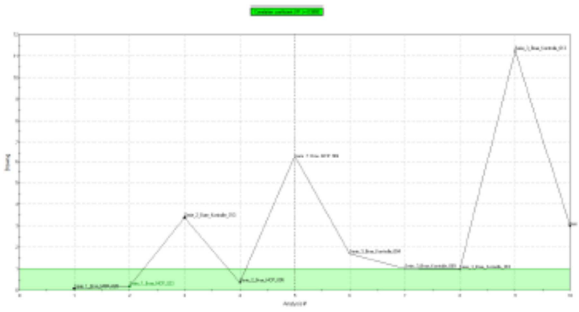

Figure 6: Quality control map of apple browning with a conformity limit set at 1% of the whole apple surface

Conclusion

Using IRIS visual analyzer, the extent of browning in apples can be determined very precisely by applying specific color filters. In addition, Quality Control models can be set up for a fast and objective assessment of a number of new samples.