POSSIBILITY TO EVALUATE MEAT COLOUR USING PHOTOGRAPHIC REFERENCES

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Abstract –This study is aimed to develop a reliable procedure for meat color evaluation in quality control. Colour was measured on samples 5x5x4 cm of *longissimus thoracis* steaks from Piemontese (A), Aberdeen Angus (B), Charolaise (C), Piemontese x Limousine (D), Blonde Aquitaine (E), Friesian (F), using a Minolta 331C chroma meter. Simultaneously, meat samples were photographed and printed in previously tested conditions. Then the colour was evaluated by a consumer panel with a ranking test. Panel also carried out a matching test to verify the correspondence of meat picture colour with colour of raw meat. Consumers preferred the colour of E, A and D, which showed higher Lightness and Hue. F and B had the darker colour. The 63% of consumers correctly matched picture with meat colour of E. In the other cases panel had more or less difficulties in matching picture and meat sample. Instrumental colour measurement discriminated two groups of meat. Consequently, the panel had difficulties to discriminate meat colours within each group due to very similar colorimetric characteristics. Nevertheless, these results do not invalidate the possibility of meat colour assessment by pictures, if standard operating procedures for acquisition of the images are followed.

I. INTRODUCTION

The colour of fresh red meat is of utmost importance in meat marketing being the first quality attribute considered by the consumer who uses it as an indication of freshness and wholesomeness. Therefore the presentation of fresh red meats with appropriate colour at retail is of extreme importance as consumers will discriminate negatively meat that does not appear to match expectations. Sensory evaluation is the best method of measuring consumer response to meat colour but it is slow and requires a large investment in people and facilities. Moreover, environmental conditions such as light intensity, light colour, background colour and meat surface discoloration due to oxidation influence the evaluation.

Efficient, cost-effective and highly sensitive instrumentation is available to measure color and is often used instead of sensory measurement. But sensory perception of color is multidimensional and may be difficult to measure with an instrument. In fact, these instruments express the colour numerically but does not give any information about consumer's meat colour liking/preference.

To overcome these problems we have studied the possibility to use photographs instead of fresh meat for the sensory evaluation of meat colour. Therefore the objective of this work was to attempt to develop a reliable, simple, rapid procedure for meat color analysis to be used for quality control.

II. MATERIALS AND METHODS

Six *m. longissimus thoracis* steaks from dairy and beef breeds (A: Piemontese; B: Aberdeen Angus; C: Charolaise; D: Piemontese x Limousine; E: Blonde Aquitaine; F: Friesian) were purchased at local supermarkets and butcher shops. Upon arrival at the laboratory, each steak was cut into samples 5x5x4 cm, and the fresh surface was allowed to "bloom" for 60 min at 3°C (1). Immediately after, the colour of each sample was determined objectively by a Minolta colorimeter CR-331 C with a 30-mm-diameter measurement area, using the D_{65} illuminant and the 2° standard observer. The considered parameters were lightness (L*), redness (a*), yellowness (b*) in the CIELAB colour space model (2). Chroma (C*), Hue (H*) and colour differences (ΔL*; ΔE*; ΔC*; ΔH*) were calculated according to the following equations (3):

Chroma = $(a^{*2} + b^{*2})^{0.5}$
Hue = $\tan^{-1}$ (b/a)
$\Delta L_{ab}^* = L_a^* - L_b^*$
$\Delta E_{ab}^* = [\Delta L_{ab}^{*2} + \Delta a_{ab}^{*2} + \Delta b_{ab}^{*2}]^{0.5}$
$\Delta C_{ab}^* = (a_1^{*2}+b_1^{*2})^{0.5} - (a_2^{*2}+b_2^{*2})^{0.5}$
$\Delta H_{ab}^* = (\Delta E_{ab}^{*2} - \Delta L_{ab}^{*2} - \Delta C_{ab}^{*2})^{0.5}$

Then meat samples were placed on a uniform non-glare black background and illuminated with two daylight fluorescent lamps (with a colour temperature of 5400K) set at an angle of 45°. The samples were photographed simultaneously using a NIKON Coolpix 990 digital camera mounted on a photographic bench. The camera was set up with the lens aligned 50 cm from the meat surface and the focus set at 50 cm. The image was saved into TIFF file format to keep the high quality resolution.
Preliminary experiments were carried out to test different setting conditions. The best one was: aperture priority mode, with the lens aperture value set at f/3.1 and the exposure corrected to +0.7 stop to achieve high uniformity and repeatability.
A professional photo lab printed the photo (20x30 cm) on glossy paper. The colour-reproduction capability of the camera was tested with the aid of the GretagMacbeth Color-Checker, which is a chart containing 24 colored patches, photographed with the meat samples. Then, the six images of the meats were cut from the photo and sticked on a black cardboard.
The meat samples, coded with random three-digit numbers, were placed on black trays and a consumer panel consisting of 103 people (regular meat buyers), of different sex, age and status, evaluated the beef colour. Sensory evaluation was performed by a ranking test (4) and each consumer was asked to rank samples in decreasing order of preference for colour (1 corresponded to the highest preference; 6 to the lowest preference). Rank sums for each sample were calculated and evaluated statistically with the Friedman's test (5).
In addition a matching test was performed to test the colour fidelity of printed meat images with colour of real meat samples. Therefore consumers were asked to match the six images to the corresponding meat samples. To test the precision of the test the percentages were elaborated with chi-square test.

III. RESULTS AND DISCUSSION

The results of the instrumental analysis of colour are reported in table 1. Highest Lightness values were observed in E, D and A samples. The other three meats had lowest L* values indicating a darker meat colour.

Table 1 Instrumental colour measurements

Breeds	L*	a*	b*	Chroma	Hue
A	42.76	26.52	8.77	27.93	18.29
B	39.36	27.34	8.60	28.65	17.45
C	38.07	27.85	8.95	29.25	17.81
D	44.44	25.75	9.05	27.28	19.36
E	49.20	24.69	9.13	26.32	20.29
F	38.49	25.07	6.82	25.97	15.21
Mean	42.05	26.20	8.55	27.57	18.07
S.D.	4.31	1.26	0.87	1.29	1.75
Min	38.07	24.69	6.82	25.97	15.20
Max	49.20	27.85	9.13	29.25	20.29
C.V. (%)	10.26	4.79	10.18	4.68	9.67

Breeds: A (Piemontese); B (Aberdeen Angus); C (Charolaise); D (Piemontese x Limousine); E (Blonde d'Aquitaine); F (Friesian).

C and E meat samples showed the highest and the lowest a* value, respectively. The low variability of a* indicated that the samples did not differ greatly from one another for this parameter. One beef breed, (E), and the dairy breed, (F), showed the highest and the lowest b* values. Therefore F sample showed a dull colour and the lowest hue angle. The two French beef breed, C and E, had the most vivid colour and the highest hue angle, respectively. These results are not surprising because the lighter beef is for late maturing breeds while the darker one is for early maturing breeds, like F or animals reared at pasture, like B. Colour determined instrumentally showed that it was possible to discriminate two groups of meat. The first one included E, D and A samples, the second B, F, and C, which had the highest and the lowest L* and Hue values, respectively.
The results of colour differences are reported in table 2.
Some ΔE* values were very high (>10) as in E *vs* C, F *vs* E, and B *vs* E, others fell between 7

and 3 while only two values were below 3 (A *vs* D and B *vs* C). As Chroma (ΔC*) and Hue (ΔH*) differences values were very low, the colour differences between samples depends mainly on Lightness differences.

Table 2 Colour differences between meats

	ΔE*	ΔL*	ΔC*	ΔH*
F *vs* A	4.91	4.27	1.95	1.45
F *vs* B	3.01	0.87	2.68	1.07
F *vs* E	10.96	10.71	0.34	2.32
F *vs* C	3.53	-0.42	3.27	1.25
F *vs* D	6.39	5.95	1.31	1.93
A *vs* B	3.50	-3.40	0.73	0.41
A *vs* E	6.70	6.44	-1.61	0.94
A *vs* C	4.88	-4.69	1.32	0.24
A *vs* D	1.87	1.68	-0.65	0.52
B *vs* E	10.20	9.84	-2.34	1.36
B *vs* C	1.43	-1.29	0.59	0.18
B *vs* D	5.34	5.08	-1.38	0.93
E *vs* C	11.57	-11.13	2.93	1.20
E *vs* D	4.88	-4.76	0.96	0.43
C *vs* D	6.71	6.37	-1.97	0.77

Breeds: A (Piemontese); B (Aberdeen Angus); C (Charolaise); D (Piemontese x Limousine); E (Blonde d'Aquitaine); F (Friesian).

The results of the sensory analysis are reported in table 3.

Table 3 Rank sums of ranking test

Breeds	E	A	D	C	F	B
Rank sum	264a	264a	295a	366b	460c	514d

Breeds: A (Piemontese); B (Aberdeen Angus); C (Charolaise); D (Piemontese x Limousine); E (Blonde d'Aquitaine); F (Friesian).
a, b, c, d differences between ranks on the same row: $P<0.05$.

Three test sheets were eliminated due to error in the evaluation.
Consumers preferred the meat colour of E, A and D, which reached the lowest ranks sum ($P<0.05$). C was preferred to F and B was judged as the worst ($P<0.05$). The three most preferred samples, E, A and D, showed a higher L* and H* values in comparison with the other three breeds (table 1). In other words, consumer preferred lighter colour with a Hue that shift from red to yellow.
In agreement with this finding, among the three preferred meats, E, in particular, showed the largest colour differences in comparison with C, F and B (table 2).
The results of the matching test (photo/meat) are reported in table 4.

Table 4 Matching test between photo and meat

		Meat					
		F	**A**	**B**	**E**	**C**	**D**
Photo	**F**	**19b**	3a	49c	2a	19b	8a
	A	23b	**25b**	7a	9ab	16b	20b
	B	20c	5ab	**22c**	1a	43d	9b
	E	1a	11b	0a	**63d**	0a	25c
	C	34c	11ab	19b	8a	**17ab**	11ab
	D	3a	45c	3a	17b	5a	**27b**

Breeds: A (Piemontese); B (Aberdeen Angus); C (Charolaise); D (Piemontese x Limousine); E (Blonde d'Aquitaine); F (Friesian).
a, b, c, d differences on the same row: $P<0.05$.

The matching Blonde d'Aquitaine showed the best result. In fact 63% of consumers recognized from the photo the meat colour of E. Consumers had no difficulties to recognize meat colour of Blonde d'Aquitaine, because showed highest Lightness and Hue values. Consumers had more difficulties to match the colour of Friesian and Aberdeen Angus breeds. The colours of these two breed were often mixed up and considered similar to that of Charolaise breed. In fact meat colour of Friesian, Aberdeen Angus and Charolaise breeds had low Lightness and Hue values, therefore the consumers considered these three colours almost the same. As regard Piemontese x Limousine, the photo was matched to Piemontese and Bonde d'Aquitaine in 45% and 17% of cases, respectively. The meat colour of these three samples was similar being characterized by a high Lightness value and a Hue that shifts towards yellow. Unsatisfactory results were obtained from Piemontese and Charolaise. It can be assumed that panel had some difficulties to correctly assign the photo to meat with intermediate Hue values.

IV. CONCLUSION

Sensory evaluation of meat colour using photographs is a promising tool to overcome the difficulties when the raw meat is evaluated. By photographs it is possible to "freeze" the meat colour exactly in the moment of the instrumental measurement. Photographs can be used for a long time, with the possibility to collect a large number of ratings from many consumers.

Colour determined instrumentally showed that it was possible to discriminate two groups of meat. The first included meat from Blonde d'Aquitaine, Piemontese and Piemontese x Limousine breeds, which showed a light colour and a Hue that shift in the yellow region. The second group included meat of the other three breeds which, on the contrary, showed a dark colour and a Hue that shift in the red region. Within each group, meat colour showed similar colorimetric characteristics.

The sensory evaluation confirmed the existence of little differences within each group of meat. This explains the difficulties encountered by the panel to discriminate very similar meat colours.

On the other hand, consumers were able to match photo with the corresponding raw meat if colour differences in meat were sufficiently appreciable. Therefore, these results support the possibility of assessing meat colour by photographic images, if standard operating procedures for acquisition of the images are followed.

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