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Ashton, H. E.

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by

H. E. Ashton

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Preparing Egg Yolk Color Standards

Problems of matching and techniques involved in producing standards are described in detail

BY H. E. ASHTON
Division of Building Research
National Research Council

• Color standards for grading eggs as to yolk color have been developed at the request of the Federal Department of Agriculture by the Paint Laboratory of the Division of Building Research, National Research Council. These consist of a range of 15 colors applied to suitable forms which were selected after trial and error matching against freshly broken eggs in the laboratory, followed by field trials. Some of the problems encountered as well as the procedures and techniques used in preparation mainly of interest to paint chemists are described. A paper has been prepared which describes the trials carried out for the selection of colors, together with a discussion of the use of the color standards and of the problems of standardization[1].

Egg yolk color which can be controlled by the hen's diet is important largely because of consumer preference, the nutritional value being about the same regardless of color. The Department of Agriculture and others considered its importance to be sufficient to justify studies of the factors affecting it as well as of the colors preferred by consumers. The lack of an appropriate series of color standards made it difficult to record and report results, and led to the request for the work which was subsequently carried out by the Paint Laboratory of the Division of Building Research. The available color atlases were not considered suitable for this work because they contain many colors which are not in the egg yolk range.

Interest in yolk color standards has developed rapidly and continues to grow. They are used in dietary and consumer preference studies by Canadian research workers in agriculture and workers in other countries are also greatly interested. There is also a proposal that the standards be incorporated in a new Canadian specification for eggs, requiring that yolk colors fall in the centre of the color range. Some manufacturers of food products are using the standards for quality control purposes. Increasing interest in the standards makes it necessary to describe the basis on which they were established and the details of their preparation and measurement.

The original request called for a series of 15 colors to cover the range of egg yolks produced in Canada. These colors were to be applied to small forms which could be held over or beside the yolk for color matching. Because of difficulties with instrumental color measurement, it was considered necessary to match colors visually against actual yolks. In preliminary work small amounts of yellow, orange and white pigments were ground on an automatic muller to get colors similar to the range of yolks in eggs supplied to the laboratory for matching. Base enamels of yellow, orange, white and black were then prepared for intermixing to provide colors which were assessed in the laboratory against a further number of eggs. Fifteen sets of 15 colors were prepared for field trials at stations where large numbers of eggs were regularly broken for test purposes. Modifications were made on the basis of the comments received and a second series of colors was prepared. Meanwhile interest in the color standards had grown and this time 35 sets were prepared. These were resubmitted for field trials and a final modification was made before the colors were considered satisfactory.

MATCHING DIFFICULTIES — In color matching many difficulties were encountered that had to be resolved. The first of these arose because eggs which had been stored for some time before breaking changed color rapidly and gave insufficient time for the preparation of intermixes for close matches. Eggs which were fresh when broken, however, did not show color changes for up to two weeks when kept in a refrigerator. Matching of yolks which were broken to remove surface color changes led to intermixes which did not match the colors of whole yolks; some initial batches had to be discarded on this account.

In a second series of intermixes there was great difficulty in achieving suitable color matches against fresh unbroken yolks when the colors were applied to flat forms. The use of a watchglass which has a contour similar to that of a yolk on a plate was then adopted. Enamels were flowed

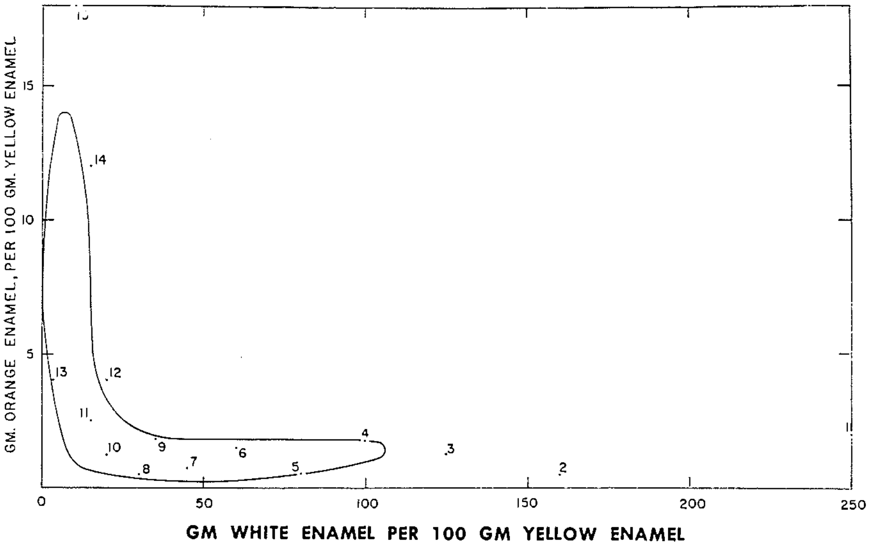

FIG. 1. Area of matched yolks and final colors.

Table I — Composition of enamels, lb per 100 gal

Color	Yellow	Orange
NRC Code	672-R	673-B
Golden cadmium lithophone Harshaw #40	145 lb	...
Light red cadmium lithophone Harshaw #80	9 oz*	139 lb
Troykyd Colloidisperse #1	8.7 lb	8.3 lb
Alkyd resin 50% solution Duraplex C-55	730 lb	724 lb
Mineral spirits	113 lb	120 lb
24% Lead naphthenate	8.7 lb	8.7 lb
6% Cobalt naphthenate	3.5 lb	3.5 lb
Anti-skinning agent	2.3 lb	2.3 lb
Color	**Black**	**Reduced Black****
NRC Code	697	697 A
Bear lampblack	46 lb	...
Troykyd Colloidisperse #1	10 lb	...
Alkyd resin 50% solution Duraplex C-55	680 lb	639 lb
Mineral spirits	170 lb	167 lb
24% Lead naphthenate	10 lb	7.1 lb
6% Cobalt naphthenate	4 lb	...
Anti-skinning agent	...	3.55 lb
Black enamel 697	...	71 lb
Color	**White**	**Yellow Undercoat**
NRC Code	694	724
Rutile titanium dioxide Titanox RA-50	160 lb	80 lb
Ferrite yellow Norpico 305	...	25 lb
Amorphous silica #0	...	325 lb
Aluminum silicate ASP 100	...	100 lb
Diatomaceous silica Celite 281	...	45 lb
Alkyd resin 50% solution Duraplex C-55	802 lb	...
Glyptal G2509	...	575 lb
Amsco-Solv. B	...	115 lb
Shell TS-28	45.5 lb	32 lb
24% Lead naphthenate	11 lb	6 lb
6% Cobalt naphthenate	4.3 lb	2.4 lb
Anti-skinning agent	1.9 lb	1.5 lb

* Required to bring later batches to same shade as original
** Equivalent to 1 lb lampblack in 250 lb reduced enamel

out either on the convex or the concave side of the watchglasses, and the convex side was compared to the yolks. Coating the convex side proved most satisfactory as enamels which did not resemble yolks when spread out flat gave closer matches when applied on the watchglass.

The next problem was that colors that did not contain much white enamel did not hide very well. When applied to a watchglass, the film thickness had more effect on color than changes in the composition. Actually, the semi-transparent effect helped duplicate the depth of color that yolks possess. Glass, however, was not considered practical for field use due to breakage, and it was intended to use aluminum forms. Consequently it was necessary to make the watchglasses opaque and they were

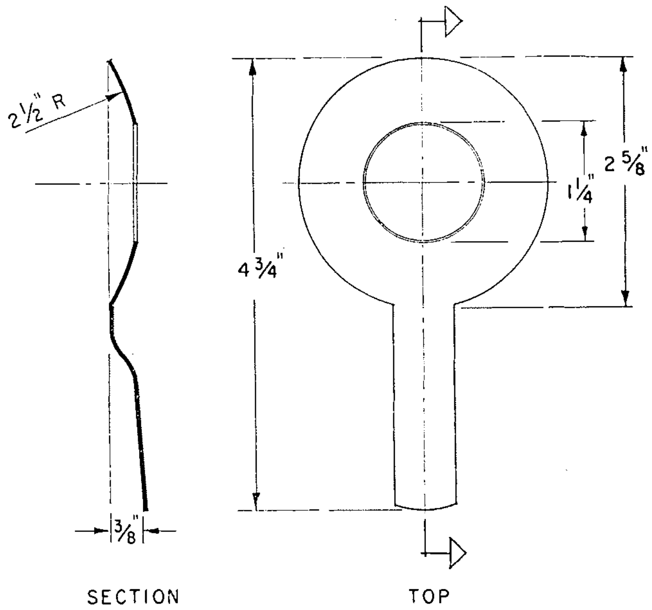

FIG. 2. Diagram of ring form.

Table II — Composition of intermixes by weight

Color Number	Yellow 672-R	Orange 673-B	White 674	Reduced Black 697A
1	100	2	250	5
2	100	0.5	160	3
3	100	1.25	125	3
4	100	1.8	100	3
5	100	0.5	80	2
6	100	1.5	60	2
7	100	0.75	45	2
8	100	0.5	30	0.5
9	100	1.8	35	0.75
10	100	1.25	20	0.1
11	100	2.5	15	0.1
12	100	4	20	0.1
13	100	4	3.5	..
14	100	12	15	0.25
15	100	18	10	0.1

coated with a yellow undercoat that could also be applied to the aluminum.

After solving these initial problems, as many egg yolks as possible were matched. In this work the amount of black to be added presented some difficulty because 0.5-gm reduced black enamel had a noticeable effect on 200-gm yellow enamel. The Department of Agriculture also had difficulty finding eggs on the extremes of the color range. Nevertheless, 35 intermixes were produced which matched one or more egg yolks. The trend in colors appeared to be that where a large amount of white was needed only a small amount of orange was required and vice versa, as illustrated in Fig. 1, which also shows the intermixes finally chosen after field trials. Fifteen colors were selected to cover this range, with more in the middle because most yolk colors were in this area. The differences between successive colors which were evident to trained observers, however, were not great enough for those unfamiliar with color observation. It was suggested that a color be added at each end of the range, and two deleted from the middle.

Further matching problems were discovered when the enamel intermixes, developed by matching on watchglasses, were applied to the convex side of curved ring forms. These forms, (Fig. 2), were selected after trials and retained the original idea of a plate with a hole in the centre, which could be placed around a yolk but incorporated the curved surface found suitable for color matching. When the colors that had been selected with watchglasses were applied to these forms, it was found that they were too bright; black had to be added because the ring forms shaded the yolks and made them appear darker. Six of the light colors had to be changed.

The first field trials resulted in the removal of one color and the modification of another to increase the separation in the middle of the range. Two very light colors were also added, although it can be noted from **Fig. 1** that these are outside the area of yolk colors matched in the laboratory.

The second series of trials resulted in requests that two of the colors be reversed. Since color is three-dimensional, it is difficult to arrange in a one-dimensional system. The colors were numbered in the Paint Laboratory in order of their composition; No. 1 had the most white, and No. 15 the most orange. In the intermix system the black content increased in steps with increasing white content. At one stage, depending on how the observer judged color, the combinations of orange, black and white made one color with more white appear darker than the following color. It was considered necessary to change the order to the satisfaction of the users. One

Table III

Color No.	General Electric Spectrophotometer						Colormaster Colorimeter					
	x	y	Y	L	a	b	L	a	b	x	y	Y
1	.401	.420	63.66	82.51	—3.8	48.5	84.13	—5.0	51.0	.402	.424	66.72
2	.413	.437	63.9	82.64	—5.4	56.9	84.14	—6.6	59.7	.414	.442	66.75
3	.423	.442	60.94	81.03	—3.3	59.7	82.55	—4.6	62.4	.424	.446	63.72
4	.431	.444	58.15	79.46	—1.6	61.4	80.98	—2.6	63.7	.431	.447	60.84
5	.435	.455	60.33	80.68	—3.4	67.1	82.29	—4.8	70.2	.435	.459	63.25
6	.446	.456	55.83	78.12	—0.3	68.5	79.62	—1.3	71.9	.447	.460	58.41
7	.451	.464	55.35	77.83	—1.2	72.9	79.34	—2.6	77.1	.452	.470	57.94
8	.460	.471	56.2	78.34	—0.4	79.4	79.76	—1.9	84.7	.462	.478	58.67
9	.465	.462	53.08	76.48	3.6	75.5	77.96	2.8	80.1	.467	.467	55.57
10	.478	.467	53.21	76.55	5.6	83.0	78.03	4.7	89.2	.481	.474	55.68
11	.487	.464	48.17	73.4	9.0	82.2	74.74	8.8	88.4	.491	.469	50.26
12	.488	.454	46.84	72.55	12.0	77.3	73.83	11.9	82.7	.492	.459	48.82
13	.510	.456	41.65	69.01	16.6	85.8	70.21	17.0	93.8	.516	.461	43.36
14	.515	.429	36.89	65.62	24.8	70.7	66.6	25.3	76.2	.521	.433	38.31
15	.534	.418	32.38	61.96	31.2	70.2	62.83	32.3	75.7	.541	.421	33.45

of the colors was also altered slightly to emphasize the new arrangement.

PREPARATION OF STANDARDS —Because the method of preparation of a film can markedly affect its color, the complete details of coating application are described. The formulations are also given although paint chemists will realize that following a formula does not always give exactly the same color.

The composition of the base enamels and the yellow undercoat are listed in **Table I.** Cadmium lithopones were chosen for the yellow and orange enamels because of their resistance to darkening. Rutile titanium dioxide and lampblack were used for the other enamels. An air-drying alkyd reported to have very good color- and gloss-retention was selected for the vehicle. It was a 32% phthalic anhydride, 55% castor alkyd with a viscosity of Z-2 at 50% solids in mineral spirits. A baking enamel, which theoretically should have even better color retention, was not used because it was thought that it would be more difficult to match colors with the changes that baking usually causes.

The proportions of base enamels used to prepare the final 15 intermixes are given in **Table II.** The visual matching of intermixes against egg yolks was made in a Macbeth unit which provides north sky daylight of a correlated color temperature of approximately 7,500 deg K. Horizon sunlight was not suitable because the yellow light (2,500 deg K) obscured the differences between yellow colors.

Before the final sets were prepared three different methods of application were tried—dip, flow-out and spray. Spraying proved to be necessary with the ring forms because the other methods resulted in ridges and curtains where the enamel flowed around the opening. Unfortunately the deeper yellow and orange colors required three coats to obtain the same color produced with one coat of dip or flow-out.

The standard colors were first applied to the ring forms. To ensure adhesion of the coating system to aluminum, the forms were etched in a hot trisodium phosphate solution followed by a phosphoric acid bath similar to that outlined in CGSB Specification 31-GP-107. After drying, zinc chromate primer, 1-GP-132 Type I was applied, followed in six hours by yellow undercoat. The latter was allowed to dry at least 24 hours and was sanded lightly with No. 400 silicon-carbide paper. The enamels were reduced with xylene to 20-28 seconds on a No. 4 Ford cup, and applied in three spray coats with about 30 minutes between coats. Drying conditions were 73 deg F and 50 percent R.H. as specified in method 103.1 of 1-GP-71[2]. The sprayed forms were visually checked for color against the flow-out of the unthinned enamel on a coated watchglass or form.

Since the colors of the ring forms could not be measured instrumentally due to the shape of the surface and the hole in the centre, it was necessary to prepare a set of flat panels for color measurement. Aluminum sheets were used without pretreatment or primer. Yellow undercoat was first applied to a wet film 2 mils thick and after 3 days' drying was sanded as before. The unthinned enamels were filtered through a silk screen and applied at a wet film thickness of 3 mils. All applications to flat panels for the instrumental measurements were by automatic drawblade. The panels were held flat on a suction plate to avoid slight variations in thickness. The enamels were allowed to dry six days under standard conditions before the first color measurements were taken.

MEASUREMENT OF STANDARDS —Measurements were first made on the Colormaster Differential Colorimeter and the final values obtained according to A.S.T.M. D1536. Color difference meters are easy to use and the calculations are simple, but they are generally only accurate for measuring differences between colors with similar spectral reflectance curves. The readings are included because paint chemists are more familiar with this type of instrument.

To define a color exactly the complete spectral curve is required. The curves for the 15 intermixes were prepared for the Paint Laboratory by the Radiation Optics Laboratory, Division of Applied Physics, National Research Council. A General Electric recording spectrophotometer was used excluding the specular component. The complicated calculations required to obtain the CIE color co-ordinates were based on the spectral reflectance curves, CIE standard source C (average daylight) and the CIE standard observer. The weighted ordinate method as described by Wyszecki[3] and similar to that by Judd[4] was used.

The color co-ordinates obtained from measurements on the two instruments are given in Table III. The CIE x, y, Y color space is not uniform, i.e. visual color differences do not correlate linearly with distances in that system. For that reason the x, y, Y co-ordinates have been transformed into the L, a, b color space which provides a fair approximation of a uniform color space. In the latter system a given color difference reading will be visually about the same in all regions. As the two systems are in common use, the color co-ordinates are given for both. ASTM method D1536 gives the formulae relating the CIE tristimulus values X, Y, Z to the L, a, b values measured on the Colormaster. The formulae were used to obtain the x, y, Y values for the Colormaster and used in reverse to obtain the L, a, b values for the General Electric spectrophotometer.

It should be noted that the colors on the ring forms are not necessarily the same as those described by the instrumental readings. Drawdown application was used in preparing the flat panels because it was considered to be more reproducible than spray application. The curved forms, however, had been prepared by spraying. It was subsequently decided to determine if the method of application would cause a difference in color. A few of the enamels were applied by spray and by drawblade to flat panels and, after six days' drying, measured on the Colormaster. It was found that there was a moderate color difference which makes it essential to follow precisely the methods of preparing the forms and the panels, when attempting to duplicate the standards.

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