DIGITAL RGB COLORIMETRY FOR OBJECTIVE COLOUR CONTROL OF BEETROOT-BASED DISHES

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Abstract. Colour is the main consumer-facing indicator of how well betanin is preserved in beetroot-based dishes, yet sensory scoring and bulk optical density give inconsistent results for heterogeneous products. A digital RGB procedure was developed and tested on four borscht samples prepared to standard catering recipes. The liquid phase gave the most stable readings, and the red channel (R) was adopted as the control parameter, with an acceptance limit of R ≥ 160 on the 0–255 scale, equivalent to an optical density of at least 2.2.

Keywords: beetroot, betanin, digital colorimetry, RGB, borscht, quality control.

Introduction. Beetroot-containing dishes are judged first by their colour. A saturated crimson-red tone signals correct processing, while a pale or brownish tone signals pigment loss. The colour is formed mainly by betanin, a water-soluble betacyanin that degrades under heat, oxygen and light and readily leaches into cooking water [1, 2]. Colour is therefore a quick, integral indicator of how well a technology preserves the pigment.

Classical instrumental methods – colorimetry and spectrophotometry – were designed for smooth, opaque, uniformly coloured surfaces [3, 4]. Culinary products are multicomponent heterogeneous systems with no colour reference standards, and their colour differs between the pieces, the liquid and the mixed mass. In our study of borscht, sensory colour scores differed between samples by 10.2 %, while optical density differed by 23 %, so neither method alone gave an objective picture. Digital image analysis records colour as R, G and B values for every pixel, which makes it possible to measure this heterogeneity instead of averaging it away.

The aim of the work was to develop a digital RGB procedure for instrumental colour control of beetroot-containing products and to set a quantitative acceptance limit.

Materials and methods

The objects were four samples of borscht prepared according to recipes No. 154, 155, 116 and 164 of the collections of technological standards for public catering. The samples differed in beetroot pre-treatment and cutting. In sample No. 2 (recipe No. 155) the beetroot was boiled whole with the peel on; in the other samples it was cut before stewing or poaching.

Each sample was analysed in three fractions: the solid phase, the liquid phase and the homogenised mass (blender, 1 min, product-to-water ratio 1:1). Digital images of each fraction were processed to obtain the mean values of the R, G and B channels, expressed as relative intensity (% of the scale maximum of 255). In parallel, optical density was

measured spectrophotometrically, and colour was scored by an expert panel on a five-point scale. Experiments were run in four replicates; data were processed in Microsoft Excel and STATISTICA 8 at a confidence level of p = 0.99.

Results and discussion

The sensory colour score correlated almost linearly with optical density (r = 0.98). The highest colour score (4.9 points) and the highest optical density (2.92) were found in sample No. 2. Boiling the root whole in its peel limits the leaching of betanin, so the dish keeps an intense crimson-red colour. When beetroot is cooked cut and in water, part of the betanin passes into the cooking liquid and the tissue colour weakens.

Table 1 shows how the colour channels differ between fractions of the same product.

Table 1. Relative intensity of colour channels in borscht fractions, % of the 0–255 scale

Fraction	R, %	G, %	B, %
Liquid phase	63–73	28–31	28–32
Solid phase	42–66	6–15	4–15
Homogenised mass	29–33	11–15	11–16

The solid phase was dominated by the red channel, with the maximum value R = 167 ± 20 recorded for sample No. 2. However, it also showed the largest spread between samples: 35.3 % for R, 57 % for G and 54 % for B. This spread reflects differences in the structure of the solid part – cutting shape, piece size and light transmission of individual ingredients – and helps explain why panellists perceive the colour of the same dish differently. Homogenisation evened out the colour but lowered the red share to 29–33 %, which masks differences between samples.

The liquid phase gave the most stable R, G and B values, and its red channel (63–73 %) best reflects the characteristic crimson-red tone of borscht. The liquid phase was therefore chosen as the measuring medium and the R channel as the main control parameter. Comparison of instrumental and sensory data set the lower acceptance limit at R ≥ 160, i.e. about 63 % of the scale, which corresponds to an optical density of at least 2.2.

The criterion was then applied in chilled-storage tests. The optical density of a dish made from a multicomponent base semi-finished product fell from 3.8 to 3.1 (by 18.4 %) during 21 days at 4 ± 2 °C, but stayed above the acceptance limit.

Conclusions

1. For heterogeneous beetroot dishes, neither sensory colour scores (10.2 % spread) nor bulk optical density (23 % spread) is sufficient on its own; digital RGB analysis of separate product fractions resolves this.

2. The liquid phase is the most reproducible measuring medium. The solid phase varies between samples by up to 57 % across channels and is unsuitable for routine control.

3. The R channel of the liquid phase is proposed as the control parameter, with an acceptance limit of R ≥ 160 (optical density ≥ 2.2). The procedure can be implemented with standard digital imaging equipment at catering and food-processing enterprises.

References

1. Stintzing F.C., Carle R. Betalains – emerging prospects for food scientists // Trends in Food Science & Technology. – 2007. – Vol. 18, No. 10. – P. 514–525.

2. Саенко И.И., Тарасенко О.В., Дейнека В.И., Дейнека Л.А. Бетацианины корнеплодов красной столовой свеклы // Научные ведомости. Серия: Естественные науки. – 2012. – № 3 (122), вып. 18. – С. 194–199.

3. MacDougall D.B. (ed.). Colour in Food: Improving Quality. – Cambridge: Woodhead Publishing, 2002. – 378 p.

4. Ким И.Н., Ким Г.Н., Сафронова Т.М., Мегеда Е.В. Сенсорный анализ продуктов из гидробионтов. – М.: Колос, 2008. – 552 с.

5. Вытовтов А.А. Теоретические и практические основы органолептического анализа продуктов питания. – СПб.: ГИОРД, 2010. – 232 с.

