Eur Food Res Technol (2001) 213:99–103
DOI 10.1007/s002170100359

ORIGINAL ARTICLE

Carlos Calvo · Ana Salvador · Susana M. Fiszman

Influence of colour intensity on the perception of colour and sweetness in various fruit-flavoured yoghurts

Received: 4 April 2001 / Published online: 15 June 2001

Abstract A study was made of the influence of colour concentration on the perception of flavour, sweetness and colour intensity, and also of opinions about colour suitability, in yoghurts with strawberry, lemon, fruit of the forest and orange flavours. The results indicated that, even with the same content of each fruit flavour and sugar, the greater the concentration of colourant, the greater was the intensity of taste perceived by the assessors in yoghurts with strawberry, orange and fruit of the forest flavours. With regard to perception of sweetness, only in the yoghurts with fruit of the forest flavour was it found that the greater the concentration of colourant, the greater was the sensation of sweetness.In the range of colourant concentrations studied for the four flavours, it was found that the colour considered most suitable corresponded to the yoghurts with intermediate colourant concentrations and that, for the four flavours studied, the greater the concentration of colourant, the greater was the sensation of intensity of colour.

Keywords Yoghurt · Colourant · Flavour · Taste intensity · Sweetness

Introduction

When a food product is evaluated for consumption, all the senses play a part, not only that of taste. A food product is accepted or rejected and valued higher or lower in accordance with the impression that it produces on all the senses. In addition to taste and touch (in handling as well as mouthfeel), even the crunchy sound of biting a potato crisp or a carrot can affect product acceptance by the consumer. Similarly, the colour of orange peel, for example, creates a predisposition to perceive a certain intensity of sweetness.

C. Calvo (✉) · A. Salvador · S.M. Fiszman
Instituto de Agroquímica y Tecnología de Alimentos (CSIC),
Apartado de Correos 73, 46100 Burjasot, Valencia, Spain
e-mail: ccalvo@iata.csic.es
Tel.: +34-96-3900022, Fax: +34-96-3636301

Some time ago, the FAO/WHO Joint Expert Committee on Food Additives [1] recognised that colour affects the selection of food products. Even though this statement appears self-evident, it has been questioned for some products. In the case of soft drinks with pear and strawberry flavours, it was found that sugar and flavour have an effect on acceptance, but that colour has little or no influence [2].

However, colour is an intrinsic characteristic of each food product and helps to identify it, to the extent that the consumer is disconcerted if the colour changes. This has been seen in sensory evaluations with beer and with orange, grape, lime and lemon drinks, in which presentation with altered colours led the assessors to make mistaken identifications [3]. Similar results were obtained later with strawberry and orange drinks [4].

The influence of colour was also shown in the case of various fruit-flavoured yoghurts, for which there was a sharp drop in consumption when they were marketed without added colourants, proving the influence of colour on identification and acceptance of the product [5].

Various authors have attempted to demonstrate the general statement that colour influences acceptance of products, although the results obtained have not always been conclusive or in agreement. Pangborn [6] did not find any relationship between sweetness and the colour green or sweetness and peppermint-flavoured solutions of sugar in water. Shortly afterwards, however, the same team [7] observed that green pear nectars were considered less sweet than pear nectars that had the same concentration of sugar but were not green, an effect confirmed in sweetness thresholds [8], which were greater in the presence of the colour green. The addition of yellow to cherry and strawberry drinks reduced the sensation of sweetness, whereas the addition of red increased it [9]. Other authors found a significant effect between colour and sweetness, but concluded that the relationship is complex and is connected with concentration of sucrose, intensity of colour and acceptance [10].

The aim of the present work was to study the influence of colourant concentration on the perception of the

intensity of flavour and sweetness, suitability of colour and intensity of colour in stirred yoghurt with lemon, strawberry, fruit of the forest and orange flavours.

Materials and methods

Samples

Four batches of yoghurts were prepared, with lemon, strawberry, fruit of the forest and orange flavours. Commercial plain yoghurt was used to make them [Danone, bought in a local supermarket (7.5°Brix)], and colourant was added. For the lemon-flavoured yoghurt, yellow colourant (tartrazine, Impex Química, Barcelona) was added; for the strawberry-flavoured yoghurt, red colourant (cochineal, Xantoflor, Monteagudo); for the yoghurt with fruit of the forest flavour, a mixture of colourants [violet, raspberry and purple B (Rhoa-Epsa, Valencia), and annatto (Xantoflor); and for the orange-flavoured yoghurt, the orange colourant annatto (Xantoflor)]. In order to flavour the yoghurts of each variety, the flavour corresponding to each fruit was added in the same concentration for all the samples of the same taste (Lucta, Barcelona). The colourant concentrations used are shown in Table 1. The ranges of the colourant concentrations were selected by taking plain yoghurt without added colourant as the extreme with least colour, and a concentration with a colouring that was strong but not of an "artificially dyed" hue for the extreme with most colour. Within each range, four equally spaced concentrations were selected. In all cases a flavour concentration of 0.09 ml/100 g was used.

After addition of sugar (until a final concentration of 16°Brix had been reached), and the corresponding colourant and flavour, the samples were shaken, avoiding the introduction of air, in order to obtain homogeneous samples of stirred yoghurt. Batches of yoghurt of each flavour were prepared and placed in individual 100-ml glass jars.

Sensory evaluation panel

From a group of people of both sexes, with ages ranging from 22 to 51 years, 25 assessors were selected on the basis of their colour discrimination ability by means of the Farnsworth-Munsell test [11].

Measurement of taste

The prepared samples of yoghurt were presented for evaluation at a temperature of 7±2 °C. The assessors evaluated the five samples (always only one flavour per session) with reference to a control, both for intensity of taste of each of the fruit flavours, and for sweetness. The controls for the yoghurts of each flavour were the samples with an intermediate concentration of each of the colourants. For the measurement of taste, an evaluation sheet with an unstructured scale was used, and on it the samples were evaluated for their intensity of taste and intensity of sweetness (Fig. 1).

Measurement of colour

Sensory measurement. The same sensory panel then evaluated the samples for the suitability of the colour for a yoghurt tasting of the fruit in question, and for intensity of colour, without reference to a control. An evaluation sheet with an unstructured scale was used (Fig. 2).

Instrumental measurement. The instrumental measurement of colour was performed with a Hunter Labscan II colorimeter, and the results were expressed in accordance with the CIELAB system [12] with reference to illuminant D65 and a viewing angle of 10°. The measurements were made in triplicate in a 65-mm-diameter tray with a sample thickness of 30 mm, using a 13-mm-diameter diaphragm. The parameters measured were the lightness coefficient, L^*, a^* (positive values indicate red, negative values indicate green), b^* (positive values indicate yellow, negative values indicate blue) and difference in colour, ΔE^*, where:

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Name……Date……

Taste the control sample and then evaluate the first 2 or 3 samples for **intensity of flavour**. Taste the control sample again and then evaluate the remaining samples for intensity of lemon flavour.

You may drink water whenever you consider it necessary.

very faint control intense

Taste the control sample again and then evaluate the first 2 or 3 samples for intensity of **sweetness**. Taste the control sample again and then evaluate the remaining samples for intensity of sweetness.

You may drink water whenever you consider it necessary.

very faint control intense

Fig. 1 Sheet for evaluating intensity of flavour and sweetness in the yoghurts studied

Table 1 Type and proportion of colourant in each of the yoghurts studied

Lemon Tartrazine (%)	Strawberry Cochineal (%)	Fruit of the forest Mixture[a] (%)	Orange Annatto (%)
0.0	0.0	0.0	0.0
0.5	0.5	0.5	0.02
1.0	1.0	1.0	0.04
1.5	1.5	1.5	0.06
2.0	2.0	2.0	0.08
2.5	2.5	2.5	0.10

[a] Mixture: 25% violet (0.4%), 25% red (0.4%), 24% purple (0.4%) and 1% annatto

Statistical analysis

An analysis of variance (ANOVA) was performed to study differences in the parameters of intensity of flavour, intensity of sweetness, intensity of colour and suitability of colour, using the SAS software system [13]. Each analysis was performed separately for each of the four flavours studied.

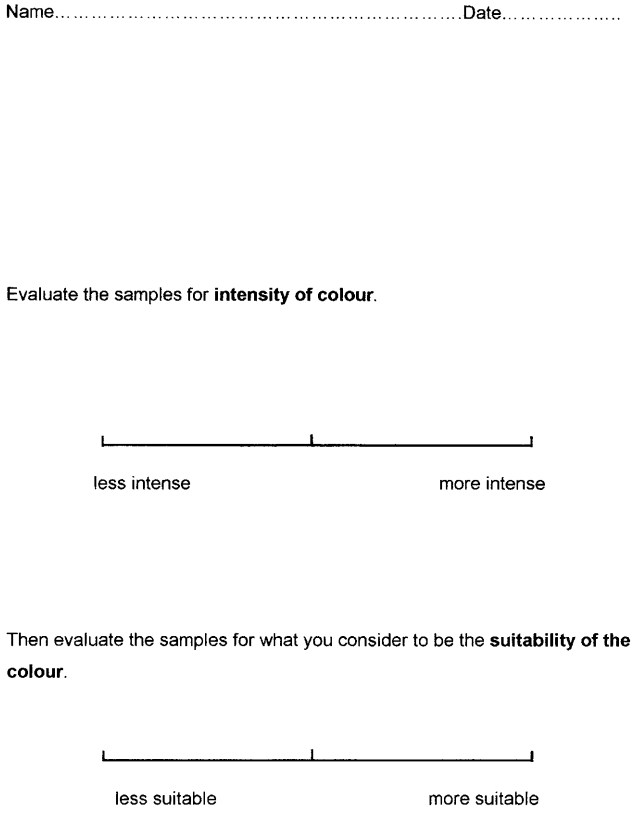

Fig. 2 Sheet for evaluating colour intensity and colour suitability in the yoghurts studied

Results and discussion

Intensity of fruit flavour

The results obtained for each of the four yoghurt flavours studied were analysed statistically. In the evaluation of the intensity of fruit flavour perceived, statistically significant differences ($P<0.05$) were found between the samples with different concentrations of colourant (Table 2). Even though all the samples had the same concentration of sugar and flavouring, in general, the greater the concentration of colourant, the stronger was the fruit flavour perceived by the assessors. This occurred in the yoghurts with strawberry, orange and fruit of the forest flavours, but not in the lemon-flavoured yoghurts with added yellow colourant (Fig. 3).

A greater intensity of pink, orange or purple was associated with a greater quantity of fruit, and therefore the assessor perceived a greater intensity of flavour of strawberry, orange or fruit of the forest, respectively. The exception was provided by the lemon-flavoured sample, for which an increase in colour intensity was not reflected by perception of a stronger lemon flavour. The data obtained for the intensity of flavour of each fruit in relation to colourant concentration were fitted to lines for which the equations are given in Table 3.

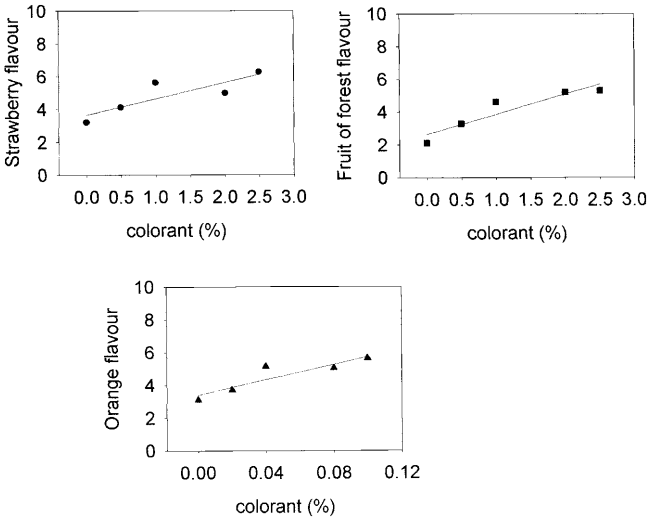

Fig. 3 Values for intensity of flavour of strawberry, orange and fruit of the forest in relation to colourant concentration

Table 2 Values of P in the analysis of variance performed for the parameters of flavour, sweetness, colour suitability and colour intensity in relation to colourant concentration. *NS* Differences not significant

Variety	Intensity of flavour	Sweetness	Colour suitability	Colour intensity
Lemon	0.8335 NS	0.1222 NS	0.0001*	0.0001*
Strawberry	0.0006*	0.5788 NS	0.0001*	0.0001*
Fruit of the forest	0.0001*	0.0207*	0.0001*	0.0001*
Orange	0.0069*	0.3621 NS	0.0001*	0.0001*

*$P<0.05$

Perception of sweetness

In the evaluation of sweetness, the results show that only in the case of the yoghurt with fruit of the forest flavour was it found that the greater the quantity of colourant, the greater was the sensation of sweetness perceived (Table 2). This point appears in the literature, where some authors consider that a stronger intensity of the colour red is associated with a greater sensation of sweetness, perhaps owing to the subconscious idea that the colour of many fruits changes from green to red when they ripen [9]. The results for the other flavours – lemon, strawberry and orange – did not show significant differences in the perception of sweetness in relation to colourant concentration.

Suitability of colour

For each of the four yoghurt flavours studied, statistically significant differences ($P<0.05$) were found in the opinions about suitability of colour in the samples with different concentrations of colourant (Table 2).

Table 3 Equations of the regression lines obtained for the parameters of flavour, colour suitability and colour intensity (y) as a function of colourant concentration (x)

Parameter	Yoghurt	Equation	Coefficient of regression
Intensity of flavour	Strawberry	y=3.64+0.99x	R^2=0.724
	Fruit of the forest	y=2.62+1.23x	R^2=0.864
	Orange	y=3.39+23.31x	R^2=0.818
Colour suitability	Lemon	$y = 7.79e^{\left[-0.5\left(\frac{x-1.19}{0.81}\right)^2\right]}$	R^2=0.983
	Strawberry	$y = 8.17e^{\left[-0.5\left(\frac{x-1.66}{0.82}\right)^2\right]}$	R^2=0.996
	Fruit of the forest	$y = 7.97e^{\left[-0.5\left(\frac{x-1.66}{0.78}\right)^2\right]}$	R^2=0.970
	Orange	$y = 8.09e^{\left[-0.5\left(\frac{x-0.07}{0.04}\right)^2\right]}$	R^2=0.924
Colour intensity	Lemon	y=0.32+3.86x	R^2=0.998
	Strawberry	y=0.54+3.70x	R^2=0.971
	Fruit of the forest	y=0.18+3.95x	R^2=0.998
	Orange	y=0.23+95.47x	R^2=0.998

Table 4 Instrumental values for the colour of prepared yoghurt samples and commercial samples

Sample of flavoured yoghurt	Concentration of colourant %	L^*	a^*	b^*	ΔE^*
Lemon	0.5	93.02	–4.25	21.20	7.94
	1.0[a]	92.59	–4.96	26.85	8.75
	1.5	92.05	–5.50	32.41	12.31
	2.0	91.81	–5.74	35.95	15.28
	2.5	91.60	–5.85	38.84	17.85
	Commercial	85.17	–4.85	22.22	0
Strawberry	0.5	90.67	4.61	6.40	8.94
	1.0	88.12	8.70	4.64	7.66
	1.5[a]	86.52	11.43	3.68	8.62
	2.0	85.00	13.49	3.12	9.92
	2.5	83.83	15.38	2.76	11.52
	Commercial	82.01	4.10	4.22	0
Orange	0.02	81.99	0.81	17.36	7.03
	0.04	79.42	2.92	23.51	2.95
	0.06[a]	79.00	4.04	23.99	2.53
	0.08	76.71	5.33	28.14	6.80
	0.1	74.70	7.44	34.37	13.41
	Commercial	80.09	5.50	22.24	0
Fruit of the forest	0.5	79.14	7.07	3.35	19.25
	1.0	71.34	10.15	2.81	11.25
	1.5[a]	67.15	11.53	2.49	7.29
	2.0	63.86	12.46	2.73	4.55
	2.5	61.14	13.20	2.73	3.46
	Commercial	60.14	10.09	3.86	0

[a] The samples with the colourant concentration that the assessors considered "most suitable" for the corresponding flavour

Figure 4 shows that, for the yoghurts with lemon, strawberry and fruit of the forest flavours, the assessors' evaluation for the most suitable colour follows a gaussian pattern, with the colours preferred being those that had intermediate concentrations of colourant (1% for lemon flavour, 1.5% for strawberry and fruit of the forest flavours, and 0.06% for orange flavour) (Table 3). It is very interesting to note that the samples with greater concentrations of colourant were scored more favourably than those with lower concentrations. Despite the campaigns that advocate reducing or suppressing the use of colourants in food, our results show that the assessors preferred to find a shade of colour that was slightly high rather than too pale. Table 3 gives the equations relating opinion on suitability of colour to the concentration of colourant used to make each of the samples. As can be seen, the equations obtained are similar in all cases.

Instrumental measurements of colour (L^*, a^*, b^*) were made for all the samples and for commercial yoghurts with lemon, strawberry and orange flavours that contained the same colourant as the one studied. The difference in colour, ΔE^*, for each sample was calculated with respect to the commercial sample of the corresponding fruit flavour, including the case of the commercial sample with fruit of the forest flavour, despite the fact that it had no added colourant (Table 4). The analysis of the results indicates that in the orange-flavoured sample the most suitable colour coincided with the

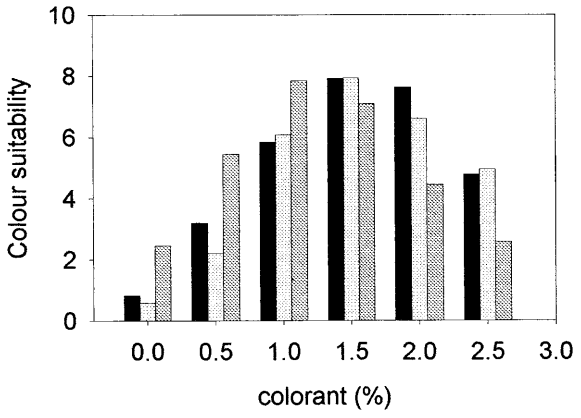

Fig. 4 Evaluation of colour suitability for lemon (*dark*), strawberry (*black*) and fruit of the forest (*light*) in relation to colourant concentration

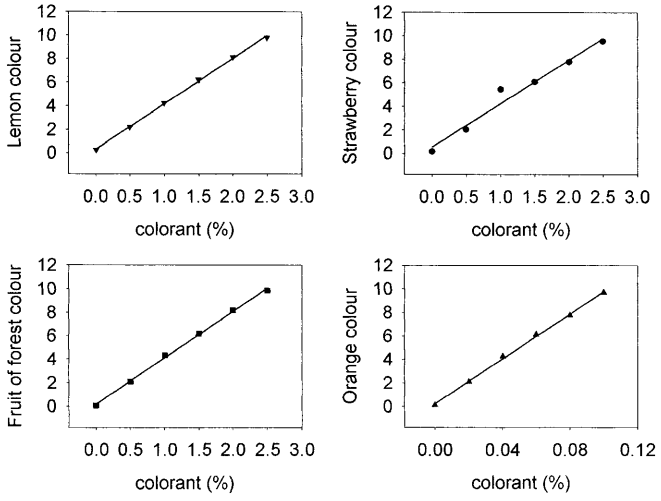

Fig. 5 Values of intensity of colour for lemon, orange and fruit of the forest in relation to colourant concentration

smallest difference in colour with respect to the commercial sample. In the samples with lemon and strawberry flavours, the most suitable colour selected by the assessors was somewhat more intense than that of the commercial sample. It is interesting to draw attention to the case of the yoghurt with fruit of the forest flavour, for which the sample with the most suitable colour was indicated as being the one with the intermediate concentration of colour, whereas the commercial sample had the most intense colour, even though, as mentioned earlier, it contained no added colourant.

Intensity of colour

Statistically significant differences ($P<0.05$) were found between the colour intensities perceived for the yoghurt samples with each of the four flavours studied (Table 2).

Within the colourant concentration ranges used, in which there were no exaggeratedly high values, there were colour differences that were clearly perceptible, so that the logical relationship between perception of colour intensity and concentration of colourant was found; the greater the concentration of colourant, the greater was the intensity of colour perceived. The equations of the lines that describe this kind of relationship are given in Table 3 (Fig. 5), and they all have high values for R^2.

With regard to the instrumental measurements of colour (Table 4), it can be seen that as the concentration of colourant increased the L^* parameter decreased. In the case of the lemon-flavoured sample, a^* decreased and b^* increased; in the samples with strawberry and fruit of the forest flavours, a^* increased and b^* decreased; and in the orange-flavoured samples, both a^* and b^* increased as the concentration of colourant increased. These results are as expected, since the parameter that determines red is a^* and the one that determines yellow is b^*.

In conclusion, the intensity of colour does influence perception of the intensity of fruit flavour in yoghurts. In the three yoghurt flavours associated with a colour range from red to orange (fruit of the forest, strawberry and orange), the greater the concentration of colourant, the greater was the intensity of fruit flavour perceived. The influence of colour on perception of sweetness was found only in the yoghurt with a very intense colour: the one with fruit of the forest flavour. Colour preferences for yoghurts lie in the intermediate intensities of colour, generally colours similar to those of commercial products, with strong hues being preferred to weak hues.

Acknowledgements This work forms part of project AGL2000-1553-C02-01 of the CICYT, to which the authors are grateful for its assistance. They also wish to thank Epsa, Impex Química and Xantoflor for supplying colourants, and Lucta for the fruit flavours used for preparing the samples.

References

1. FAO/WHO Joint Expert Committee on Food Additives, (1957) WHO Tech Rep Ser No. 129:7
2. Tuirila-Ollikainen T, Mahlamäki-Kultanen S, Kurkela R (1984) J Food Sci 49:1598–1600, 1603
3. DuBose CN, Cardello AV, Maller O (1980) J Food Sci 45:1393–1339, 1415
4. Stillman JA (1993) J Food Sci 58:810–812
5. Rolls BJ, Rowe EA, Rolls ET, Kingston B, Megson B, Gunary R (1963) Physiol Behav 26:215
6. Pangborn RM (1960) Am J Psychol 73:299
7. Pangborn RM, Hansen B (1963) Am J Psychol 76:315
8. Maga JA (1978) Chem Senses Flavor 1:115
9. Kostyla AS, Clydesdale FM (1978) Crit Rev Food Sci Nutr 10:303
10. Roth HA, Radle LJ, Gifford SR, Clydesdale, FM (1988) J Food Sci 53:1116–1119, 1162
11. Farnsworth D (1957) The Farnsworth-Munsell 100-hue test for the examination of color discrimination. Munsell Color, Baltimore, Md.
12. Hutchings JB (1994) Food colour and appearance. Blackie, Glasgow
13. SAS (1990) SAS / Stat User's Guide Version 6, 4th edn. SAS Institute, Cary, N. C.