Int. Agrophysics, 2007, 21, 67-72

INTERNATIONAL
Agrophysics
www.ipan.lublin.pl/int-agrophysics

Colour of paprika powders with different moisture content

Zs.H. Horváth and C. Hodúr*

College of Food Engineering, University of Szeged, Szegedi Tudomanyegyetem, Szegedi Élelmiszeripari Foiskolai Kar, Szeged, Mars ter 7, 6275, Hungary

Received June 13, 2006; accepted November 23, 2006

A b s t r a c t. The colour characteristics of paprika powder with different moisture contents were analysed. The colour, determined by using the CIELab colour system, was measured with a Minolta CR-300 tristimulus colorimeter. We investigated several quality Hungarian paprika powders. The moisture contents of these paprika powders were increased by 1, 2, 3, 4 and 5% relative to the initial sample.

Increase of moisture content caused significant change in L^*, b^*, C^*_{ab} and h^o_{ab} colour values. The moisture content increase of 3-5% caused decrease of hue angle by 2-4°, decrease of lightness coordinate by 1.5-2 unit, and decrease of chroma by 1.5-2 unit. The ΔE^*_{ab} colour difference calculated between the initial samples and the samples with various added moisture contents crossed over the minimum perceptible (threshold) of total colour difference 1.5, when added moisture was 3-5%.

K e y w o r d s: paprika powder, colour, moisture content

INTRODUCTION

The use of natural food colours is preferred to that of artificial dyestuffs for modern alimentary purposes. Paprika is a spice plant grown and consumed in considerable quantities worldwide, and also used as a natural food colour. Hungarian paprika powder is still regarded as a 'Hungaricum' today. Paprika is cultivated in areas of the world such as Spain, South Africa and South America, where the weather is favourable for the growth of this plant and for the development of its red colouring agents. Hungarian paprika has unique aroma and a specific smell, but the production of powder with a good red colour is a considerable problem. The colour of paprika powder is very important too, because the consumer concludes its colouring intensity is based on its colour, although the relation between them is not unequivocal (Horváth and Halász-Fekete, 2005). The colouring intensity is directly determined by the composition of the colouring agent in the grist, but the colour is influenced by many other factors, too. A number of investigations have been performed on the relation between the colouring agent content of the grist and the colour characteristics measured with different instrumental techniques (Navarro *et al*., 1993, Nieto-Sandoval *et al*., 1999). These investigations yielded partial results, but there is no formula that describes the relationship between the colouring agent content and the colour characteristics. Since the 1970s a number of papers have been published on measurements of the colour of paprika powders (Drdak *et al*., 1989; 1990; Huszka *et al*., 1985). Huszka *et al.* (1985) dealt with the relationship of the colour characteristics observed visually and measured instrumentally on paprika grist. Measurements have been made relating to the changes in the colour components X, Y and Z of the mixtures of different grist samples (Huszka *et al*., 1990). The effects of ionizing irradiation on the colour of paprika powder were investigated by Fekete-Halász *et al*. (1996). Minguez *et al.* (1997) analysed how the colour of the powder is changed by the ratio of the yellow and red pigments within the total colouring agent content. Chen *et al.* (1999) investigated the effects of particle size in Korean cultivars and established that the lightness coordinate of the powder was influenced by the particle size. Applying a Hungarian milling technique, Horváth *et al*. (2006) demonstrated that the particle size exerts a significant influence on all three colouring characteristics of powders made from Hungarian, South African and South American paprika. Kispéter *et al.* (2003) investigated the influence exerted on the colour by saturated steam used

*Corresponding author's e-mail: horvatzs@szef.u-szeged.hu

for germ reduction. Simal *et al*. (2005) examined the effect of drying temperature on colour characteristics of paprika powder. Ergüneş and Tarhan (2006) investigated the effects of different chemical solutions and drying method on the colour of paprika.The colour of the powder was observed to turn into darker and deeper red with increasing moisture content. In the case of Korean cultivars, no significant change in colour characteristics was detected when the moisture content varied between 10 and 15% (Chen *et al*., 1999).

The aim of the present work was to study how the colour characteristics of Hungarian paprika powders change following increase of their moisture content.

MATERIALS AND METHODS

Ten powder samples were prepared from different Hungarian paprika varieties. Samples were taken immediately after milling, before adjustment of the moisture content. The average particle size of the powders was between 260 and 320 μm. In the first step, the moisture contents of the powders were determined according to Hungarian Standard MSZ 9681-3 relating to paprika powders. 5 g of powder in a scale pan was weighed with an accuracy of 0.002 g. The open pan was then placed in a drying oven and the sample was dried for 4.5 h at 95±2°C. Thereafter the covered scale pan was cooled in a desiccator for 30 min, and the total mass of the pan and the sample was measured. The moisture content was calculated from the measured mass loss. The moisture content values of the initial paprika powders was between 6.85 and 7.56%. The moisture content of each of the samples was increased by 1, 2, 3, 4 and 5% relative to the initial sample. The moisture contents of the samples were increased in the following way: Eq. (1) was used to calculate how many grams of water must be taken up (x) to increase the moisture content by p% for a given mass (m) relative to the moisture contents of the initial powders (n_0):

$$x = \frac{m\,p}{100 - n_0 - p} . \tag{1}$$

Thereafter, samples of 5 g of powder were weighed on an analytical balance, and then placed in a desiccator, the lower part of which was filled with water at 70-80°C. The samples were kept in the desiccator until the mass increased by 1, 2, 3, 4 or 5% through moisture uptake. The moisture content of the measured powders, therefore, ranged from 6.85 to 12.56%. The colour characteristics of these samples were determined in 3 parallel measurements.

Colour measurements were performed with a Minolta CR-300 tristimulus colour measuring instrument. The CIELab colour system was used for colour characterization. In this colour space the colour points are characterized by three colour coordinates. L^* is the lightness coordinate ranging from no reflection for black (L^*=0) to perfect diffuse reflection for white (L^*=100). a^* is the 'redness' coordinate ranging from negative values for green to positive values for red. b^* is the 'yellowness' coordinate ranging from negative values for blue to positive values for yellow.

The total colour change is given by the colour difference (ΔE^*_{ab}) in terms of the spatial distance between two colour points interpreted in the colour space (Hunter, 1987):

$$\Delta E^*_{ab} = \left[\left(L_1^* - L_2^*\right)^2 + \left(a_1^* - a_2^*\right)^2 + \left(b_1^* - b_2^*\right)\right]^{1/2} . \tag{2}$$

If $\Delta E^*_{ab} > 1.5$, then the colour difference between two paprika grists can be visually distinguished (Horváth *et al.*, 2005).

The hue angle (h^o_{ab}) and chroma (C^*_{ab}) were used to determine the change of colour.

Hue angle Eq. (3):

$$h^o_{ab} = \text{arctg}\,\frac{b^*}{a^*} . \tag{3}$$

The hue angle is defined as a colour wheel, with red-purple at the angle of 0°, yellow at 90°, bluish-green at 180° and blue at 270°.

Chroma Eq. (4):

$$C^*_{ab} = \left((a^*)^2 + (b^*)^2\right)^{\frac{1}{2}} . \tag{4}$$

The chroma represents colour saturation which varies from dull at low chroma values to vivid colour at high chroma values (Hunter, 1987).

The Shapiro-Wilks test was used to control the conformance of data to the Gaussian distribution. The homogeneity of variances in the different groups was checked using the Cochran test and the Bartlett test. The data obtained were evaluated by using variance analysis of one factor or Friedman one-way analysis depending on the results of Shapiro-Wilk test, Cochran and Bartlett tests.

RESULTS AND DISCUSSION

Table 1 present the results of Shapiro-Wilk tests. It can be established that values of L^* (lightness), a^* (redness) and b^* (yellowness) coordinates conformed to the Gaussian distribution, while the values of C^*_{ab} (chroma) and h^o_{ab} (hue angle) were non-Gaussian data. Therefore, the data were evaluated using Friedman one-way analysis and Mann-Whitney u-test in the case of chroma and hue angle. Then the homogeneity of variances of L^*, a^* and b^* values was investigated. The results of Cochran and Bartlett test can be seen in Table 2. The values demonstrate homogeneity of variance in the case of L^*, a^* and b^* coordinates. So the ANOVA one-way analysis was useful to evaluate the L^*, a^* and b^* coordinates data.

T a b l e 1. Results of Shapiro Wilk-test for colour values of paprika powder

Colour coordinates	Added moisture content (%)					
	0	1	2	3	4	5
L*	0.9009	0.9100	0.9056	0.9075	0.9120	0.9008
a*	0.9120	0.9020	0.9211	0.9120	0.9211	0.9101
b*	0.9012	0.9231	0.9105	0.9023	0.9063	0.9111
C^{*}_{ab} [1]	0.8923**	0.8815**	0.8750**	0.9012	0.8745**	0.8970**
h^{o}_{ab} [2]	0.8907**	0.9008	0.8354**	0.8523**	0.8808**	0.8590**

**p = 0.01, C^{*}_{ab} [1] – chroma, h^{o}_{ab} [2] – hue angle

T a b l e 2. The results of Cochran- and Bartlett-test for colour coordinates of paprika powder

Colour coordinates	Cochran		Bartlett	
	value	p-level	value	p-level
*L**	0.2158	0.6872	1.0160	0.7175
*a**	0.1765	1	1.0014	0.9985
*b**	0.1787	1	1.0012	0.9987

The results of ANOVA analysis performed on *L**, *a** and *b** coordinates demonstrate that the lightness (F=2.23, p=0.0534) and yellowness (F=3.88, p=0.0023) coordinates were significantly influenced by moisture content increase, whereas there was no influence on the redness coordinate (F=0.69, p=0.6228). Detailed analysis of the lightness and yellowness coordinates average values is presented in Fig. 1, differences being taken as significant at the level of p=0.05.

It can be seen that the lightness coordinate *L** progressively decreased with increasing moisture content. An added 3% of moisture content caused a significant change. Further added water did not induce any additional significant decrease. The average of lightness coordinate of samples with added 5% of moisture content was smaller than that of initial samples by 1.5 unit. The yellowness coordinate *b** changed definitely. With increasing moisture content, the average values of *b** decreased significantly: by 1.7 and 2.2 units at added moisture contents of 3 and 5%, respectively.

The results of Friedman analysis for chroma and hue angle values are shown in Table 3. It can be detected that the chroma and hue angle values were influenced by the

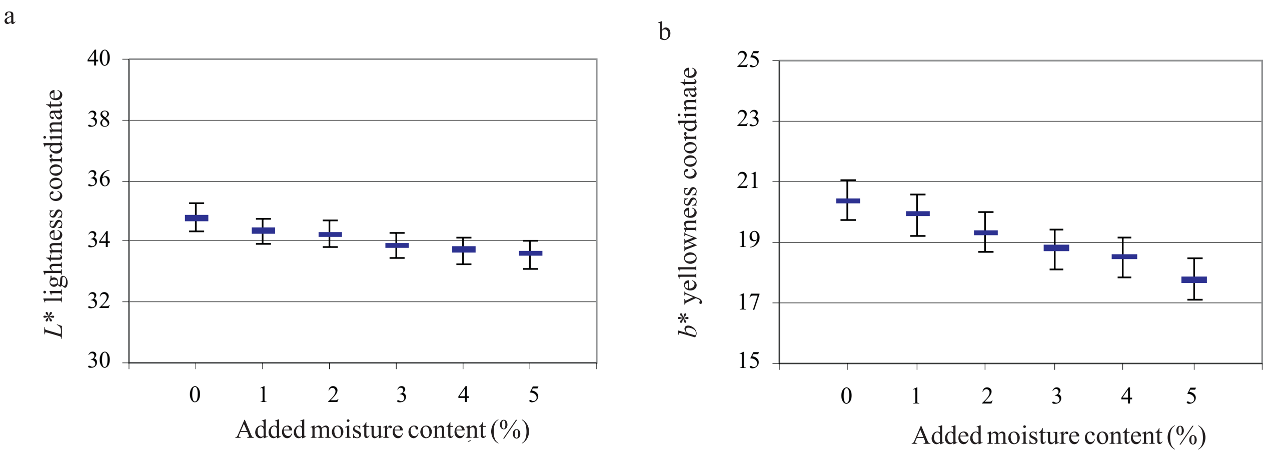

Fig. 1. Average values of: a – the lightness (*L**), and b – the yellowness (*b**) of paprika powder at different moisture levels.

T a b l e 3. Results of Friedman analysis for chroma (*C*) and hue angle (*h*) values of paprika powder

Parameters	N	DF	Chi sqr.	p-level
C^*_{ab}	29	5	112.36	0.0000
h^o_{ab}	29	5	94.91	0.0000

moisture content significantly ($p< 0.00001$). The medians, quartiles (the 25th and 75th percentiles), maximum and minimum values of chroma and hue angle calculated for samples with various added moisture contents are presented in Fig. 2.

It can be said that the median of chroma values decreased with 1 unit effect on added 3% of moisture content. The change was 1.8 unit effect of added 5% of moisture content. The median of initial samples (0%) and samples with various added moisture contents were compared using the Mann-Whitney u-test. The results are shown in Table 4. It can be seen that the difference is not significant between the median of the initial sample and the median of samples with added 1 and 2% of moisture content ($p>0.05$), but the difference is significant between the median of the initial sample and the median of samples with added 3% or more than 3% of moisture content ($p<0.01$). The difference is not significant between the median of the sample with added 3% and the median of the samples with added 5% of moisture content ($p>0.05$). The chroma is an indicator of colour saturation and intensity, so its lower value means that paprika powder samples with higher moisture content are less coloured.

The median of the hue angle value progressively decreased with increasing moisture content (Fig. 2). The difference between the median of the initial sample and the

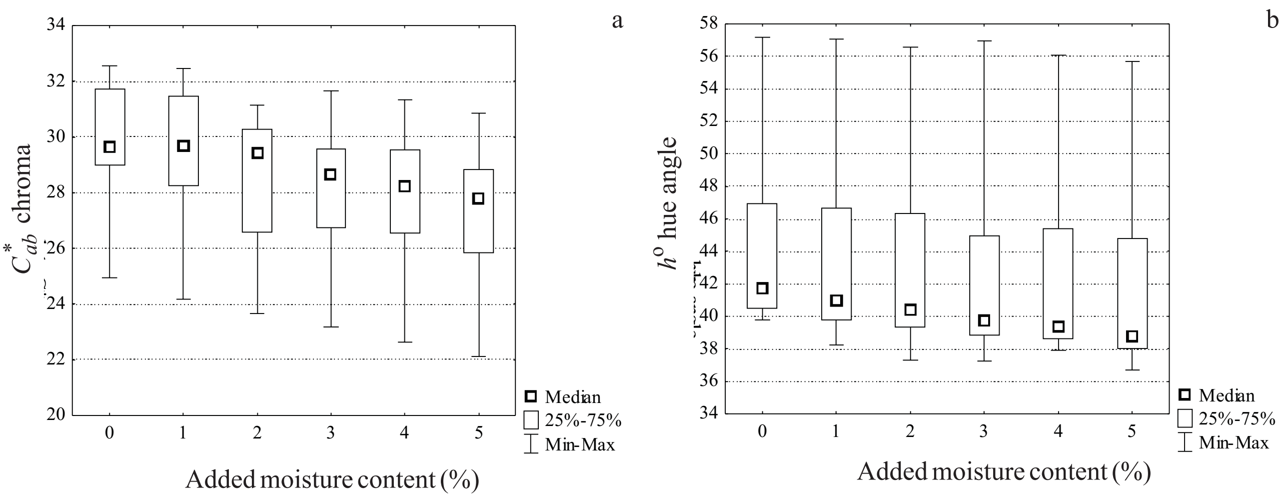

Fig. 2. Chroma (C^*_{ab}) (a) and hue angle (h^o_{ab}) (b) of paprika powder samples at different moisture levels.

T a b l e 4. Result of Mann-Whitney u-test for chroma values of paprika powder

Compared samples (% added moisture)	u-value	z-value	p-level
0 - 1	408	-0.6209	0.5346
0 - 2	347	-1.5228	0.1278
0 - 3	275	-2.5872	0.0096
0 - 4	268	-2.6907	0.0071
0 - 5	203	-3.6517	0.0002
3 - 5	336	-1.6801	0.0919

median of samples with added 5% of moisture content is 3.5 unit. The median of the initial samples (0%) and samples with various added moisture content were compared using the Mann-Whitney u-test. The results are shown in Table 5. The results show that the difference is not significant between the median of the initial sample and the median of samples with added 1 and 2% of moisture content ($p<0.05$), but the difference is significant between the median of the initial sample and the median of samples with added 3 % or more than 3% of moisture content ($p<0.01$). The difference is not significant between the median of the sample with added 3% and the median of samples with added 5% of moisture content ($p>0.05$). Lowering of hue angle values shows that the colour of paprika powder tends towards the red region of the colour space.

The colour differences of the initial samples and the samples with various added moisture contents were calculated to determine the changes in colour. The values are shown in Fig. 3. The ΔE^*_{ab} colour difference increased progressively with increase of the added moisture content. The value of ΔE^*_{ab} >1.5 for 8 samples at an added moisture content of 3%, and for all samples at an added moisture content of 4%, therefore the added 3 or 4% of moisture content caused a significant and perceptible change.

T a b l e 5. Result of Mann-Whitney u-test for hue angle values of paprika powder

Compared samples (% added moisture)	u-value	z-value	p-level
0 - 1	373	-1.1384	0.2549
0 - 2	319	-1.9367	0.0527
0 - 3	267	-2.7055	0.0068
0 - 4	257	-2.8533	0.0043
0 - 5	243	-3.0603	0.0022
3 - 5	330	-1.7741	0.0760

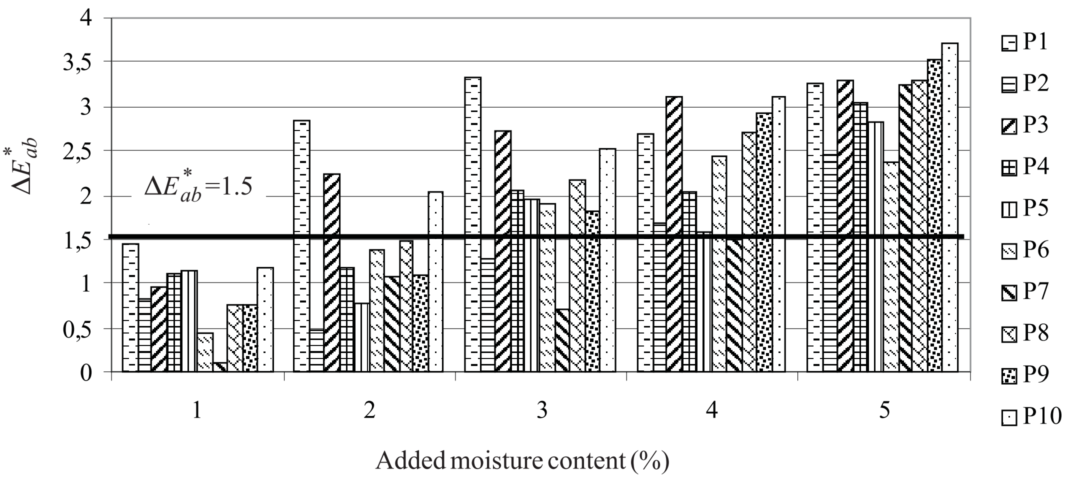

Fig. 3. Total colour differences (ΔE^*_{ab}) for 10 different samples and the same samples with added moisture content.

CONCLUSIONS

1. Three percent of added moisture content caused a significant change in L^*, b^*, C^*_{ab} and h^o_{ab} colour values of Hungarian paprika powder samples with initial moisture contents of 6.85-7.56%.

2. The ΔE^*_{ab} colour difference calculated between the initial samples and the samples with various added moisture contents crossed over the minimum perceptible (threshold) of total colour difference by 1.5, when added moisture was 3-5%.

3. Three percent increase of moisture content caused a decrease of hue angle by 2° with resultant more clean red colour, decrease of lightness coordinate by 1.5 unit, the result being darker colour, and decrease of chroma by 1.5 unit, the result of which was less saturated colour.

4. The colour of paprika powder with higher moisture content was darker, clean red colour, so perhaps it entailed better perception, acceptance and choice for the consumer.

REFERENCES

Chen Q., Hak-kyun-koh, and Jae-Bok-Park, 1999. Color evalution of red pepper powder. Transactions of the ASAE, 42(3), 749-752.

Drdak M., Greif G., and Kusy P., 1989. Comparison between the sensory and spectrophotometric method for determination of colour of paprika powder. Nahrung 33(8), 737-742.

Drdak M., Sorman L., Zemkova M., and Schaller A., 1980. Ergebnisse von Studien über denZusammenhang zwischen Zusammensetzung und Farbe von gemahlenem Gewürrz-paprika. Confructa, 25(3/4), 141-146.

Ergüneş G. and Tarhan S., 2006. Color retention of red peppers by chemical pretreatments during greenhouse and open sun drying. J. Food Eng., 76, 446-452.

Fekete-Halász M. and Kispéter J., 1996. Effect of irradiation on colour of ground red paprika. Acta Alimentaria, 25(2), 189-193.

Horváth H.Zs. and Halász-Fekete M., 2005. Instrumental colour measurement of paprika grist. Annals of the Faculty of Eng. Hunedora, 101-107.

Horváth H.Zs., Halász F.M., Záhonyi P.R., and Kispéter J., 2006. Effect of grain size and storage on colour coordinates of paprika grist. J. Food Physics, 17-18, 61-70.

Horváth H.Zs., Véha A., and Halász-Fekete M., 2005. Comparison between evolution of paprika grist and its colour characteristics. Scientific and Technical Bulletin, 10, 38-42.

Hungarian Standard**, 2002.** Investigation of paprika powder, detemination of moisture content. MSZ 9681-3.

Hunter R., 1987. The measurement of appearance. J. Wiley Press, New York, USA.

Huszka T., Halász-Fekete M., and Lukács Gy., 1985. Colour tolerance of red-pepper powders. Hungarian Sci. Instruments, 60, 43-47.

Huszka T., Horvath Zs., Halász-Fekete M., Véha A., and Gyimes E., 1990. Computer aided quality planning and production control of red-pepper powders. Proc. 4th European Seminar of the EOQ Food Section, Berlin, 176-178.

Kispéter J., Bajúsz-Kabók K., Fekete M., Szabó G., Fodor G., and Páli T., 2003. Changes induced in spice paprika powder by treatment with ionizing radiation and saturated stream. Radiation Physics and Chemistry, 68, 893-900.

Minguez-Mosquera M.I. and Perez-Galvez A., 1997. Color quality in paprika oleoresins. J. Agric. Food Chemistry, 46(12), 5124-5127.

Navarro F. and Costa J., 1993. Evalution of paprika pepper color by trisestimulus colorimerty. Revista Espanola de Ciencia y Tecnologia de Alimentos, 33(4), 427-434.

Nieto-Sandoval J.M., Fernandez-Lopez J.A., Almela L., and Munoz J.A., 1999. Dependence betwen apparent color and extractable color in paprika. Color Res. Appl., 24(2), 93-97.

Simal S., Garau C., Femenia A., and Rosselló C., 2005. Drying of red pepper (*Capsicum Annum*): water desorption and quality. Int. J. Food Eng., 1(4), 1-11.