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Fruit coloration of apple cultivars

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Summary: One of the most important parameter of apple cultivars is the scale and the intensity of the coloration of fruits. Nowadays among the bicolour cultivars those are the most saleable which have the highest and darkest fruit coloration. In our three years old study cultivars born with bud mutation and cross breading were examined, which have superior coloration peculiarities than their parental cultivars. According to our results among the observed cultivars the cvs. 'Gala Decarli-Fendeca', 'Galaval', 'Wilton's Red Jonaprince', 'Early Red One' and 'Red Cap Valtod' reached favourable high fruit surface colour (80-100%) regardless the vintage effect. Concerning the colour intensity, that is the darkness of the red colour most of the cultivars ('Gala Venus Fengal', 'Gala Fendeca-Fendeca', 'Galaval', 'Jeromine', 'Red Topaz', 'Early Red One', 'Crimson Crisp', 'Wilton's Red Jonaprince') showed excellent values (4,5-5,0). Based on the fruit surface colour and the fruit colour intensity a new index number, the fruit coloration index was created by us, which describes the coloration features in a complex way.

Keywords: apple cultivars, fruit surface colour, fruit colour intensity, fruit coloration index

Introduction

First impression of the consumers about a food is judged by vision, as the curiosity on consuming of the product is highly influenced by the colour. Namely customers "eat with their eyes" (Arthey, 1981).

The colour of the apple skin is one of the most determining factor regarding the market acceptance. In general cultivars with red skin are more favoured, in turn inside a cultivar the fruits with better coloration have higher demand (SAURE, 1990). The fruit surface colour, the type and the darkness of the coloration are not only important cultivar features, but even elementary quality parameters (Kállay, 1994).

Soltész & Szabó (1997) claim that the coloration of the apple fruit is a complex property, which is created by the darkness of the colour, the colour tinge and the wash of colours. Fruit surface colour can be striped or blushed or can be its combinations.

The Hungarian apple (besides several valuable properties) gained prestige in the European market with its attractive red colour. In the case of the export apples it is essential that the greater part of the fruit surface must be covered with red colour meanwhile the storability does not decrease (Harmat & Szabó, 1980; Harmat, 1983).

Scale of the coloration is influenced by several factors. WALTER (1967) stated that every single factor has effect on the coloration which determines directly or indirectly the growing and the maturing of the apple fruit. Creacy (1968) claims that temperature fluctuation between days and night is the most important factor on apple coloration. According to Douglas's (1983) opinion the altitude has also an important role on the coloration, as fruits produced in the higher sites are better coloured, then fruits derived from plan areas. Based on Harmat (1983) observations adequate fruit colour is the result of the lower dawn temperatures, the moisture condensation on fruits and the sufficient sunlight. These phenomenons can occur more likely in production sites with lower temperatures and in cooler morning hours in October.

In many places around the world breeding programmes aim to select cultivars with higher fruit surface colour (Dickinson & White, 1986; White & Johnstone, 1991; Arakawa, 1998; Guerra, 2007; Claudio et al., 2011). Highly coloured strains develop red colour on both fruit sides with greater average of fruit surface coloured, while less coloured strains exhibit different coloration between sides, more bicolour fruits and lower average of fruit coloured (Iglesias et al., 2008). New mutants of some sports have been reached the maximum level of the fruit surface colour which can not be elevated anymore. In the case of Gala sports real innovation of the future just could be if total fruit surface colour would be coupled with larger fruit size and earlier ripening time (Guerra & Sansavini, 2012).

Materials and methods

Location of the experiments

Location of the examinations is placed in Nyírbátor (North-East Hungary), 55 km far from Debrecen. The experimental orchard represents adequately the ecological conditions of the surrounding areas, so the gained result can

be easily adapted in the largest apple production site of the country, in the Northern Great Plain.

Main temperature of the year of the examined area is 10-11 °C, the sunshine hours are 1900-2050 hours/year. Average precipitation is about 400-450 mm/year. Humus content of the soil is low (under 1%), as the soil is slightly acid (pH 6,5-6,9).

Among the ecological conditions the summer temperatures have a significant role on the coloration of the fruits. In the observed period (***Figure 1***) the summer of 2015 (July-September) can be described with extreme high temperatures and drought which had negative on the coloration process. The year of 2014 was more moderate, as the coloration was also more favourable. In 2013 the summer was similar than in 2014, only September was colder.

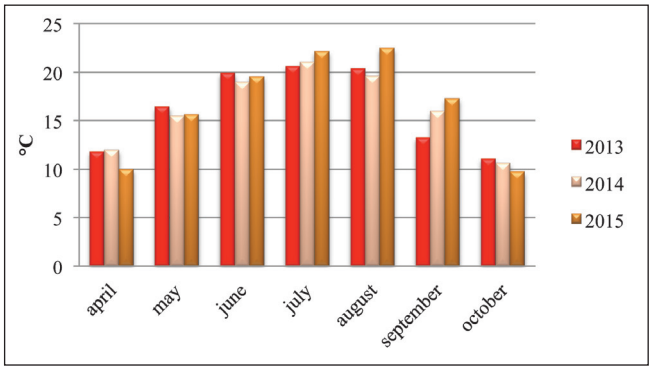

Figure 1: Mean temperatures per month during the vegetation period (Nyírbátor, 2013-2015).

Materials of the experiments

Our experiments focus on evaluation of new cultivars born with bud mutation ('Gala Venus Fengal', 'Gala Decarli-Fendeca', 'Galaval', 'Jugala', 'Gala Schnitzer-Schniga', 'Early Red One', 'Red Cap Valtod', 'Jeromine', 'Red Topaz', 'Wilton's Red Jonaprince', 'Red Idared', 'Fuji September Wonder') and cross breeding ('Crimson Crisp'). Each cultivar has higher fruit surface colour than their parental cultivar, therefore they can insure better saleability.

Methods of the experiments

Determination of fruit surface colour was performed with visual estimation of 70 fruits per each cultivar in a percentage form. The intensity (darkness) of the surface colour was measured with similar method in a scale varies from 1 to 5, where value 1 means weak, value 5 means strong colour intensity.

Based on the fruit surface colour and the colour intensity a new index number, the fruit coloration index was created by us, which describes the coloration features in a complex way. The method of the calculation is the next:

- the value of the colour intensity varies from 1 to 5 is converted to percentage form, where value 1 means 20%, value 5 means 100%,
- the percentage form of the colour intensity is multiplied by the hundredth of the percentage form of the fruit surface colour

Based on the above mentioned:
fruit coloration index = colour intensity (%) x (surface colour (%)/100).

E.g.: In the case of an apple with 90% surface colour and 4,0 colour intensity, the calculation is next:

- 4,0 colour intensity means 80%,
- ***fruit coloration index*** = 80 (%) x (90 (%)/100) = 72.

The fruit coloration index expresses the coloration features of the fruits by the way that both surface colour and both colour intensity are taken into consideration equally when judging a cultivar.

In this paper apple cultivars originated from abroad were studied, concentrating on their coloration peculiarities which determine significantly the market acceptance.

Results

Harvest of the observed cultivars started at the end of August (***Table 1***). 'Gala' sport (cvs 'Fengal', 'Fendeca' 'Galaval', 'Jugala', 'Schniga') was picked first, their ripening time took 6-8 days inside a year. In the middle of September the 'Red Delicious' sport (cvs 'Early Red One', 'Red Cap', 'Jeromine'), cvs 'Fuji SW', 'Crimson Crisp' and 'Red Jonaprince' were harvested. Cvs 'Red Idared', 'Red Topaz' and club cultivar ripened at the end of September.

Table 1: Harvest time of the cultivars (Nyírbátor, 2013-2015).

	2013	2014	2015
'Fengal'	27/8	26/8	4/9
'Fendeca'	27/8	26/8	4/9
'Galaval'	30/8	24/8	30/8
'Jugala'	3/9	24/8	30/8
'Schniga'	3/9	29/8	11/9
'Early Red One'	13/9	17/9	24/9
'Red Cap'	15/9	–	24/9
'Jeromine'	13/9	17/9	–
'Fuji SW'	19/9	11/9	21/9
'Red Jonaprince'	13/9	17/9	24/9
club cultivar	30/9	25/9	6/10
'Red Idared'	30/9	3/10	13/10
'Crimson Crisp'	12/9	11/9	16/9
'Red Topaz'	30/9	28/9	6/10

Picking time of cv 'Jugala' differs notably among the years. This is due to the fact, that in 2013 this cultivar was harvested too late in overripe condition, namely the expected high surface colour did not appear. In optimal maturity state

the coloration of the fruits was weak and pale. Choosing the harvest time in 2014 and 2015 the optimal maturity state was taken into consideration. This time the scale of the coloration was weak also similarly than in 2013. Although according to several cultivar description the main advantage of cv 'Jugala' is the early and high scale coloration. Based on our study these peculiarities do not prevail in Hungary.

All of the cultivars were harvested with one pick, except one, cv. 'Schniga'. Namely thanks to its slow and heterogeneous coloration 2-3 picks were necessary.

Most of the cultivars are characterised by high percentage of fruit surface colour and high colour intensity (***Table 2***). In all examined years cvs 'Fendeca', 'Galaval', 'Red Jonaprince', 'Early Red One' and 'Red Cap' showed excellent (80-100%) fruit surface colour regardless the vintage. Cvs 'Crimson Crisp', 'Fengal', 'Jugala' and club cultivar achieved 70-90% coloration. Cvs 'Red Idared' and 'Red Topaz' displayed also good values (60-85%), which are higher than their parental cultivar (cvs 'Idared' and 'Topaz'). Cvs 'Fuji SW' and 'Schniga' performed beyond under expectations (40-70%).

Regarding the colour intensity (darkness of the colour) most of the cultivars (cvs 'Fengal', 'Fendeca', 'Galaval', 'Jeromine', 'Red Topaz', 'Early Red One', 'Crimson Crisp' and 'Red Jonaprince') can be described with excellent values (5,0) in favourable vintage (2014). These cultivars reached also good colour intensity (4,0-5,0) in 2013 and 2015, when the ecological conditions were less optimal. Cvs 'Jugala', 'Schniga' and 'Fuji SW' showed weaker colour intensity in all years (3,5-4,0).

Table 2: Fruit surface colour and colour intensity of apple cultivars (Nyírbátor, 2013-2015).

	Surface cover (%)			Colour intensity (1-5)		
	2013	2014	2015	2013	2014	2015
'Fuji SW'	75	45	50	4,3	4,2	3,9
'Schniga'	68	40	58	3,5	3,6	4,0
'Red Topaz'	85	74	59	5,0	4,9	4,1
'Red Idared'	74	85	60	3,9	5,0	4,4
'Jugala'	68	76	69	3,9	4,9	4,1
'Fengal'	79	89	74	5,0	5,0	4,4
'Galaval'	86	90	82	5,0	5,0	4,4
'Fendeca'	87	90	84	5,0	5,0	4,6
club cultivar	73	88	81	4,2	5,0	5,0
'Red Jonaprince'	79	83	85	4,5	5,0	5,0
'Crimson Crisp'	71	86	90	4,7	5,0	5,0
'Red Cap'	73	_	97	3,2	_	5,0
'Early Red One'	90	99	98	4,8	5,0	5,0
'Jeromine'	95	100	_	5,0	5,0	

Concerning the fruit coloration index (***Figure 2***) it can be seen that cvs 'Jeromine' and 'Early Red One' (Red Delicious sport) reached the highest values (86-100). Among the Gala mutants cvs 'Fendeca' and 'Galaval' displayed excellent fruit coloration index (72-90), as cv 'Fengal' showed 65-88 value. Parameters of cvs 'Jugala' and 'Schniga' are lower (29-75). Cv 'Fuji SW' presented also week results (38-65). Coloration index of other cultivars varied up 58 to 88.

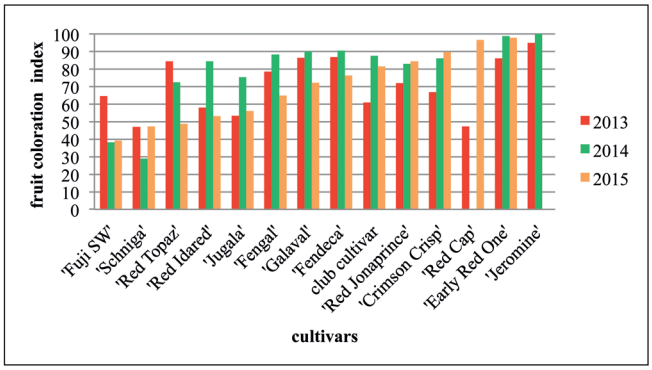

Figure 2: Fruit coloration index of apple cultivars (Nyírbátor, 2013-2015).

Based on the above mentioned the values of the fruit coloration index displayed similar tendency then in the case of the colour cover was seen. It shows that cultivars with higher fruit surface cover can be described even with better colour intensity. This phenomenon is also confirmed by the correlation coefficient (***Figure 3***).

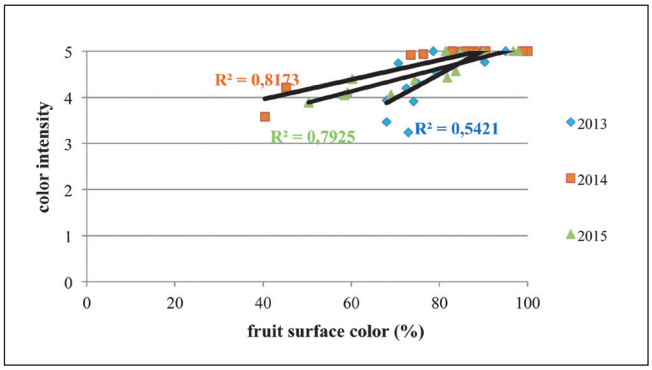

Figure 3: Relationship between fruits surface colour and colour intensity of apple cultivars (Nyírbátor, 2013-2015).

In summary it can be stated that majority of the examined apple cultivars are characterized by favourable fruit surface colour (80-100%), which exceeds the values of the parental cultivars. During our work it was confirmed that improving fruit surface colour is accompanied by better fruit colour intensity. A new parameter was created by us, the fruit coloration index which describes the fruit surface colour and the fruit colour intensity in a complex way. The observed cultivars (except for one) can be picked with one round, which can make much easier the organization of the harvest and reduce its costs.

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