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INFLUENCE OF PHOTOSELECTIVE PROTECTIVE NETS ON THE SENSORY CHARACTERISTICS OF FRUITS OF THE FLORINA APPLE CULTIVAR

Sava TABAKOV[1], Petya IVANOVA[2], Galya DOBREVSKA[1], Anton YORDANOV[1], Manol DALLEV[1]

[1]Agriculture University - Plovdiv, 12 Mendeleev Blvd, Plovdiv, Bulgaria
[2]Institute of Food Preservation and Quality, Plovdiv, Bulgaria., 154 V. Aprilov Blvd, Plovdiv, Bulgaria

Corresponding author email: manol_dallev@abv.bg

Abstract

Changing the light regime during the growing season by using photoselective nets in devices protecting against hail can have an impact on the yield and its quality. The white and black used nets do not change the spectral composition of the light passing through the grids, but act as shades, reducing the amount of light that passes through the grids. The influence of this effect on the sensory characteristics of Florina apple fruits was studied in an orchard with a support structure located in Northern Bulgaria.
The sensory evaluation of the Florina cultivar shows that the fruits under the most commonly used black net in orchards in terms of taste, aroma and consistency do not differ significantly from those grown under yellow and red coverings. Only the influence of different types of nets on the appearance and skin colour of the fruits of the Florina apple variety has been statistically proven.

Key words*: Florina, photoselective nets, sensory analysis, appearance, colour, taste, aroma.*

INTRODUCTION

The use of photoselective nets in modern fruit growing is increasingly being applied as a safe alternative to successfully address the challenges of various stressors threatening fruit producing.
Net systems are usually used to protect orchards from hail. Nowadays the systems are also designed to screen spectral bands of solar radiation and transform some of the direct light into diffuse. This process controls the physiological changes occurring in the plants and can direct them in the direction desired by the producer related to fruit quality (Raveh et al., 2003).
According to Meena et al. (2016), photoselective nets are able to scatter light and this results in improved solar radiation utilization efficiency of fruit plants. This would change metabolic processes and positively affect flower bud formation, flowering intensity and ultimately better retention and development of quality fruits (Sivakumar et al., 2017).
The relationship between fruit trees and environmental conditions affecting fruit quality differed for open areas and areas covered with flower anti-hail nets. The reason for this is the change of the microclimate under the nets, which affects differently the coloring of the fruit surface and the influence of chlorophyll on the quality of the fruit flesh (Bosco et al., 2015; Brglez Sever et al., 2015; Dussi et al., 2005; Reay et al., 1998).
The characteristics determining the quality of the fruit flesh - firmness, ripeness, sugar content and acidity - are less affected in the studies on the influence of the anti-hail nets, compared to the parameters determining the appearance of the fruit - size and color. The flesh firmness varies according different types of nets. Differently colored photoselective nets stimulate variable responses to fruit flesh substances in different fruit species. Giaccone et al. (2012) reported that fruits grown under white nets had higher sugar content than those grown under red nets. Many authors did not find differences in the acidity of the fruits of trees covered with differently colored nets (Ordóñez et al., 2016).
The quality of the fruits can also be reduced by the presence of sunburn. They can adversely affect 10-50% of apple fruit yield (Wünsche et

al., 2001; Kalcsits et al., 2017). Moreover, some cultivars are considered very susceptible to this type of damage (Dussi et al., 2005). According to some authors, black nets are more effective than white nets in reducing these damages (Amarante et al., 2011).

From what has been summarized so far, it is clear that the nets used in fruit growing, in addition to protection, can also be designed to screen spectral bands of solar radiation and transform part of the direct light into diffuse, contributing to increasing the quality of fruit production from various fruit species and their cultivars. This puts intensive fruit growing at a higher level in its development. Studies on the influence of photoselective nets on the physico-chemical and sensory quality characteristics of fruits in apple cultivars are insufficient. The aim of the study is the accumulation of knowledge and information to evaluate the influence of photoselective nets on the sensory characteristics of fruits of the Florina apple cultivar, based on the overall sensory evaluation and the average evaluations of the appearance, color, consistency, aroma and taste indicators.

The apple cultivar Florina was introduced in Bulgaria in 1977. The cultivar is early bearing and productive. It is resistant to the economically important diseases scab and powdery mildew. Harvest maturity occurs at the end of September (Lichev et al., 2012).

MATERIALS AND METHODS

The physico-chemical and sensory quality characteristics of apple fruits of Florina cultivar budded on M9 T337 rootstock and grown in an orchard located in Northern Bulgaria were monitored. The planting density is 250 trees per decare. A sod-mulch system is applied to maintain the soil surface and trees are drip irrigated. Anti-hail net system has been built in black, white, yellow and red colouring.

The application of sensory analyzes is to describe raw materials/products using a language that is close to that of the consumer, to characterize them in an objective way qualitatively and quantitatively, or to explain the overall profile and perceived quality of the food (Murray et al., 2001; Seppä et al., 2012; Swahn et al., 2010). For these reasons, sensory analyzes require scientific expertise and appropriate laboratories equipped to perform sensory tests (ISO 8589:2007).

The analyzes were carried out in the Food Testing Laboratory at the Institute of Food Preservation and Quality - Plovdiv in a training room by a committee including five trained experts, who were provided with apple fruits, as coded samples of the four growing variants and the specific descriptions of the indicators with weighting factor respectively for: appearance - 0.30; color - 0.20; consistency - 0.20; taste - 0.20 and aroma - 0.10.

Five fruits per variant were obtained on the day of harvest and stored for one day at 20°C ± 5°C until the sensory evaluation. When assessing the quality of Florina apple friuts, a descriptive method was used with a specific description of the sensory indicators appearance, color, consistency, taste and aroma depending on the characteristics of the cultivar and according to Regulation (EU) No. 1580/2007 of the Commission of December 21, 2007 for determining the rules for the implementation of Council Regulation (EU) No. 2200/96, (EU) No. 2201/96 and (EU) No. 1182/2007 in the fruit and vegetable sector (Table 1). The advantage of this method is that it is carried out by experienced professionals.

The evaluation was carried out terminologically, then quantified on a five-point hedonic rating scale, in which these indicators are present in the considered sample, by awarding points or by constructing graphs. All fruits in the quality determination group were measured for weight, height and width. The weight of the fruit was determined with a laboratory technical balance A200 S, in grams (g). Fruit height and width were measured with a digital calliper, values were expressed in millimetres (mm). The data are averaged for each variant.

The physicochemical indicators were determined: the soluble dry matter - BDS 17257:1991, the content of titratable acidity - BDS 6996:1993 and the content of total sugars - BDS 7169:1989, to determine the relatively objective state of the fruits and to facilitate the trained professionals to interpret the degree of sensations of taste, sweetness and acidity.

Table 1. Description of the studied sensory indicators of apple fruits, cultivar Florina

Parameters	Description
Appearance - Fruit shape;	Flat-conical to globose-conical, asymmetric with weak ribbing or asymmetric shape. Handle fossa - wide, deep with gentle gray-brown rust, fairly regular. Calyx fossa - medium to large, irregular, with small ridges along the rim
- Size	Medium to large, according to the size in Commission Regulation (EU) No. 1580/2007 of December 21, 2007, the fruits belong to group L - Section diameter: = extra-65mm/70mm; = 1st quality - 60 mm/65 mm. - Weight: = extra 110 g/140 g = 1st quality - 90 g/ 110g.
Skin colour	General surface of the fruit is a mixed red coloration with a pale green to pale yellow base color and red fuzzy or streaked covering color, with large gray-brown rusty dots or yellow green ground color, almost entirely covered with bright red to violet red streaks and fuzzy color with numerous white subcutaneous dots or yellow green main color, the roof fuzzy in stripes red to dark red covering almost the entire fruit, according to Commission Regulation (EU) No. 1580/2007 of December 21, 2007, the fruits belong to group B-varieties with mixed red coloration or range of coloration for :
Strength of fruit skin	= extra 1/2; = 1st quality- 1/13; = 2nd quality -1/10. Firm, medium-thick, slightly greasy, with a waxy coating and with large gray (brown) rusty dots or numerous white subcutaneous dots.
Colour of fruit flesh	White to cream
Consistency	Tender, crispy, juicy
Taste	Sweet, slightly acid
Aroma	Slightly aromatic

Mathematical and statistical processing

Results presented are arithmetic means of at least three parallel determinations, with coefficients of variation less than 5%. The statistical processing of the data was carried out with the STATISTICA and ANOVA program, Microsoft Excel.

RESULTS AND DISCUSSIONS

Figure 1 shows the average evaluation of the experts for the appearance of the fruits (shape, uniformity, size, background scin color and surface defects). The committee of experts evaluated the appearance of Florina apple fruits from all growing variants with scores from 3.35 for fruits grown under the white net to the maximum score of 4.90 for fruits under the yellow net (Figure 1).

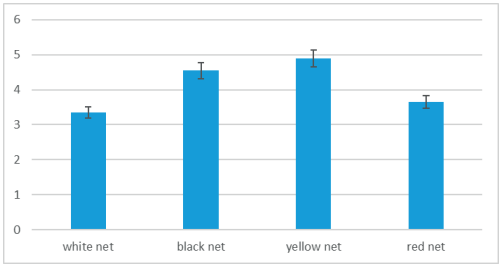

Figure 1. Appearance of fruits of cultivar Florina grown under different photoselective nets

The description of the appearance indicator characteristic of the cultivar is that the fruits are not uniform, with a flat-conical to spherically-conical, asymmetrical shape, with an average 0. According to the description under Commission Regulation (EU) No. 1580/2007 of December 21, 2007, all apple fruits meet the requirements for "Extra" quality. With the maximum values for weight and overall average evaluation for appearance are the apple fruits grown under a yellow net respectively: 193.74 g and 4.90, followed by the fruits grown under the black net (overall evaluation - 4.55, weight - 140.99 g and section diameter - 82.40 mm). The apple fruits grown under the white net have the lowest values according to the measured indicators, respectively: overall rating - 3.35; weight - 128.45 g and diameter of the section - 65.46 mm.

The handle fossa is wide, deep with gray-brown rust, relatively regular and varies from d = 15.26 mm in fruits under the yellow net to d = 31.01 mm in fruits under the red net.

Calyx fossa is medium-sized, irregular, with small protrusions on the rim.

Photo 1. Apple fruits of Florina cultivar, grown under a yellow net

Photo 2. Apple fruits of Florina cultivar, grown under a black net

Photo 3. Apple fruits of Florina cultivar, grown under a white net

Photo 4. Apple fruits of Florina cultivar, grown under a red net

The experts defined the descriptions of the skin color of the apple fruits on the differently colored nets and gave an average rating above 4.0 (Figure 2). Fruits under the yellow, red and black nets have no statistically significant differences and their maximum rating is 4.8. According to Commission Regulation (EU) No. 1580/2007 of December 21, 2007, the apple fruits belongs to group B - cultivars with mixed red fruit coloring and correspond to "Extra" quality.

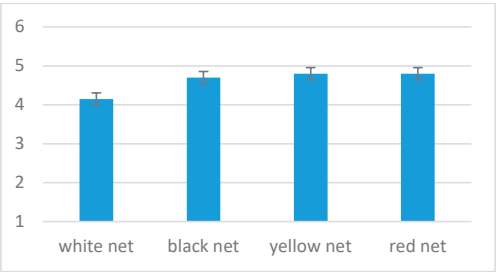

Figure 2. Skin color of fruits of cultivar Florina grown under different photoselective nets

Apple fruits of the Florina cultivar grown under yellow net (Photo 1) have a pale green main color and a red fuzzy colored integument with white dots and a wax coating.

Apple fruits of the Florina cultivar grown under black net (Photo 2) have a yellow main color, almost completely covered surface with a bright red to violet red fuzzy color, with numerous white subcutaneous dots, with medium to medium gray-brown rusty spots and a wax coating.

Apple fruits of the Florina cultivar grown under white net (Photo 3) have a yellow-green main color, almost completely covered with a bright red to violet red fuzzy color, with numerous white subcutaneous dots and a wax coating.

Apple fruits of the Florina cultivar grown under red net (Photo 4) have a pale green to pale yellow main and a red fuzzy covering color, with large gray-brown rusty spots and a wax coating.

The color of the fruit flesh of the studied variants varieties from white to cream.

Textural properties can be considered as the main factors responsible for fruit freshness and are related to consumer choice (Harker et al., 2008; Péneau et al., 2006; 2007). Texture consists of many different properties perceived by the human senses and its definition implies sensory evaluation (Bourne, 2002). Consumer preferences for a product are generally based on a combination of texture, taste and aroma (Daillant-Spinnler et al., 1996; Gatti et al., 2011; Harker et al., 2003).

For the consistency indicator, the experts determined that it was juicy, crunchy for all the tested variants and gave a rating above 4 (Figure 3).

The fruits under the yellow net have the highest rating (5.0), the fruits under the white net (4.3) have the lowest, and the rest of the fruits from

the two versions of the black and red net have statistically indistinguishable ratings (4.6).

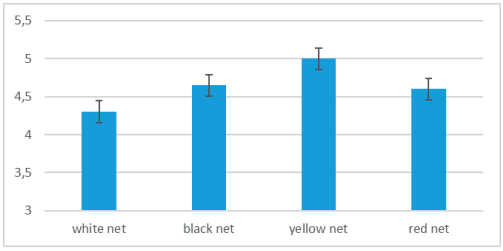

Figure 3. Consistency of fruits of cultivar Florina grown under different photoselective nets.

Chemical indicators that are used to determine fruit quality are concentration of soluble solids, total acidity, total sugars, but indicators such as appearance, surface defects, fruit firmness have a greater influence on the choice of consumers and traders and effectively making them unsellable.

All variants of tested apple fruits are sweet in taste. Fruits under the yellow net were rated by the experts with a maximum score of 4.8 and determined to be of moderate to weak acidity. Fruits under the red and black nets had a sweet-sour taste and statistically indistinguishable scores (4.6), and the fruits grown under the white net were defined as slightly sour and rated with the lowest score of 3.85 (Figure 4).

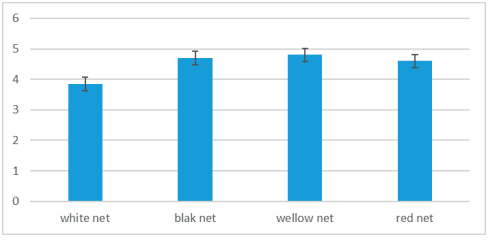

Figure 4. Taste of fruits of cultivar Florina grown under different photoselective nets

With the maximum percentages of dry matter, total sugars and sugar-acid ratio are the fruits grown under the red net, and with the lowest are the fruits under the black net, but these results are not directly related to the sensory evaluation given by the taste experts. Harker et al. (2002) also found a lack of correlation between measured soluble solids concentrations and expert perception of flavor intensity-sweetness and support the claim that the sensory parameter "taste" should remain a critical part of the evaluation of fruit quality, as sweetness intensity is one of the most important factors influencing consumer liking.

The multi-sensory character in defining an acceptable perception of apple fruit includes taste, smell and other sensory properties.

For the aroma indicator, the experts evaluated the fruits as aromatic the average evaluations are above 4.0, with the maximum evaluations of the apple fruits under the black, red, and yellow nets being statistically indistinguishable, and the fruits under the white net having the lowest evaluation (Figure 5). A positive linear relationship with an average coefficient of determination $R^2 = 0.54$ was established between the evaluations given by the experts for taste and aroma of the investigated variants of apple fruits of Florina cultivar.

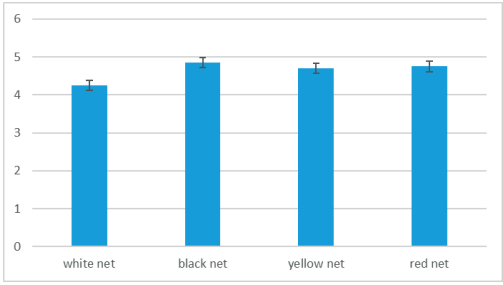

Figure 5. Aroma of fruits of cultivar Florina grown under different photoselective nets

From the conducted sensory analysis and the generalized average evaluations according to appearance, colour, consistency, taste and aroma indicators with the corresponding weighting coefficients, the total sensory evaluation presented in Figure 6.

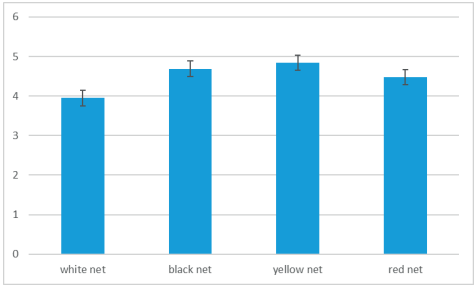

Figure 6. Summary sensory evaluation of fruits of cultivar Florina grown under different photoselective nets

The data show that apple fruits grown under the yellow net have the highest overall sensory score, followed by fruits grown under the black net. The fruits grown under the white net have the lowest sensory evaluation. A positive linear relationship was established with an average coefficient of determination between the overall tasting score and the aroma and color scores, respectively $R^2 = 0.67$ and $R^2 = 0.51$.

A study was conducted to evaluate the influence of photoselective nets on the sensory characteristics of apple fruits of the Florina cultivar based on the overall sensory evaluation and the average evaluations of the appearance, color, consistency, aroma and taste indicators.

The average ratings of apple fruits according to the studied indicators can be summarized as follows:

- the fruits grown under a yellow net have maximum ratings for all the investigated indicators;
- fruits under the red net have the highest percentages of soluble solids and total sugars;
- the apple fruits grown under the black net are rated as high as possible in terms of aroma indicator;
- apple fruits grown under a white net have minimal evaluations according to the indicators of appearance, consistency, taste and aroma;

From the analysis of variance conducted at a significance level $\alpha = 0.05$ to establish the influence of the color of the photoselective nets on the sensory indicators of the studied apple cultivar, it was found that the factor of the color of the net has an effect on the appearance and skin color of the fruits.

The summary sensory evaluations were statistically indistinguishable for fruit from the yellow, black and red nets, and statistically distinguishable for fruit under the white net, suggesting that Florina cultivar is suitable for growing under these differently coloured photoselective nets.

CONCLUSIONS

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