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Importance of the supraoptimal radiance supply and sunburn effects on apple fruit quality

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ABSTRACT The aim of this author's study to research the effect of sunburn on apple fruit quality parameters (skin colour, depth of damaged tissue, fruit flesh firmness, dry matter content). The symptoms of sunburn injury appeared concentric rings shape, differed from together and surface skin colour. This can connect with the ratio of injury. The authors observed the following colours on the fruit surface (from epicentre of blotch on transversal diameter of fruit) dark brown (typical damaged), light brown (moderately damaged), pale red transition (lightly damaged), red surface colour-coverage (not damaged). Sunburn of apple fruits is a surface injury caused by solar radiation, heat and low air relative humidity. That in the initial phase results in a light corky layer, golden or bronze discolouration and injuries of the epidermal tissue, in the surface exposed to radiation. Thus it detracts from its appearance, but in most of the cases it would not cause serious damages in the epidermal tissue. The depth of suffered tissue is not considerable, its values are between 1.5-2.0 mm generally. It is commonly known, that tissue structure of apple fruit is not homogeneous. Accordingly, the degree of injury shows some differences under the different parts of fruit surface. On the basis of the flesh firmness researches, the authors established, that the measure of flesh firmness of suffered part of apple fruit increases under sunburn effect. The consequence of this is the suffered plant cells will die, the water content of this tissue decreases and gets harder. This water-loss caused the increase of soluble solids contant.

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KEY WORDS

apple fruits
sunburn injury
fruit flesh firmness
dry matter content

Sunburn causes golden-bronze discolouration on the sunlit side of apple fruit. However, although it may negatively affect the appearance of fruits, in most cases, it does not cause serious damage to the epidermal tissue (Meyer 1932; Barber and Sharpe 1971). In fact, sub-epidermal tissues , no serious change. The sunlit area of the fruit is firmer, but tends to soften quickly during storage (Arndt 1992). True „sunscalding" occurs when fruit growing in the shade is suddenly exposed to strong sunlight (Gurnsey and Lawes 1999). The effect of the expose is light or yellowish-brown patches appearing on the apple fruit's surface and serious damage which can occur to surface tissues. This damage is most common on fruits on the southern and south-western sides of the tree. These symptoms can be observed on apple fruits that have fallen from the tree and those expose to strong radiation over long periods (Brooks and Fisher 1926). During storage, a bright surface patches appear, but the underlaying flesh becomes brown, hard and the surface later sags (Reay and Lancaster, 2001). The flesh later becomes spongy in texture (Simpson et al. 1988). These kinds of incidences are called „delayed sunscalds, and often serve as entrance points for fungi (e.g. *Alternaria* rot; Piskolczi et al. 2004). The more severe form of this damage indicates serious changes in the cuticle, in the epidermal and sub-epidermal tissues (Schrader et al. 2001). The cell walls thicken. The volume phenols increases intercellularly and the structure of plastids and thylakoids alters (Racskó et al. 2005).

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Materials and Methods

Assessments were made in a commercial apple orchard at Derecske, in Eastern Hungary. The orchard was planted with a tree spacing of 3.2 × 0.54 m in 1999. Trees were grafted on M9 (weak growing vigour) rootstock. The Idared cultivar was selected. Trees were pruned to a spindle shape and grass alleyways were used in the rows.

Assessments were made in four replicates with 5 trees per replicate in 2003-2004. The assessed parameters were: depth (mm) of sunburn injury in fruit flesh, flesh firmness (kg/cm2), dry matter contant (%). The direction of the section on the fruit surface can be seen on Figure 1.

Results and Discussion

Effect of sunburn on fruit colour

Results of this experiment showed, that sunburn effects chiefly appeared on that part of the fruit which were high coloured. This comes from the high colourization on the fruit surface and high anthocyanin content emerge only under high light provision. On the one hand, this is a sort feature, but on the other hand, this is a natural defence reaction of the fruit. However, extreme light can cause damage and principally appears as a blotch. Symptoms usually occur in different

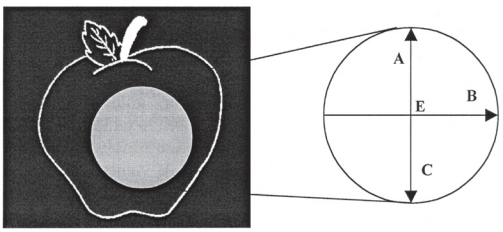

Figure 1. Direction of examination within the sunscald. From epicentre of blotch to peduncle (A), from epicentre of blotch on transversal diameter of fruit (B), from epicentre to dried petals (C), epicentre of sunburned blotch (E).

shades shades, but nevertheless these shading's diverge from the colour of the fruit surface and from each other can be seen as concentric circles, which evolve from tissue damage. Rings are nearly concentric (Fig. 2). Therefore, the colour's appearance stands in relation to ratio of the damage.

From the epicentre of the sunburned blotch namely, from the epicentre of the most intensively damaged point to the peduncle on the fruit surface we can observe the following tones: dark brown (typical damage), light brown (moderately damaged), pale red (lightly damaged), red surface (not damaged).

The depth of sunburn injury in the fruit flesh

Most of the cells under the epidermal tissue we observed were damaged by the low moisture content, regardless of the strength and heat of the sun.The depth of this damage is not significant, it is generally between 1,5-2,0 mm (Fig. 3).

Commonly known, that the structure of the apple tissue is not homogeneous, hance the intensity of the damage shows differences under the different parts of the fruit surface. Fruit position on the tree increase the inhomogeneous of damage, which shown in devious shadeness.

The depth of sunburn injury in the fruit flesh, from the epicentre of suffered blotch along the transversal diameter

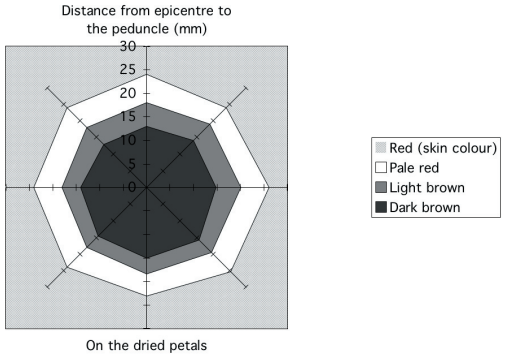

Figure 2. Colouring of sunburn blotch.

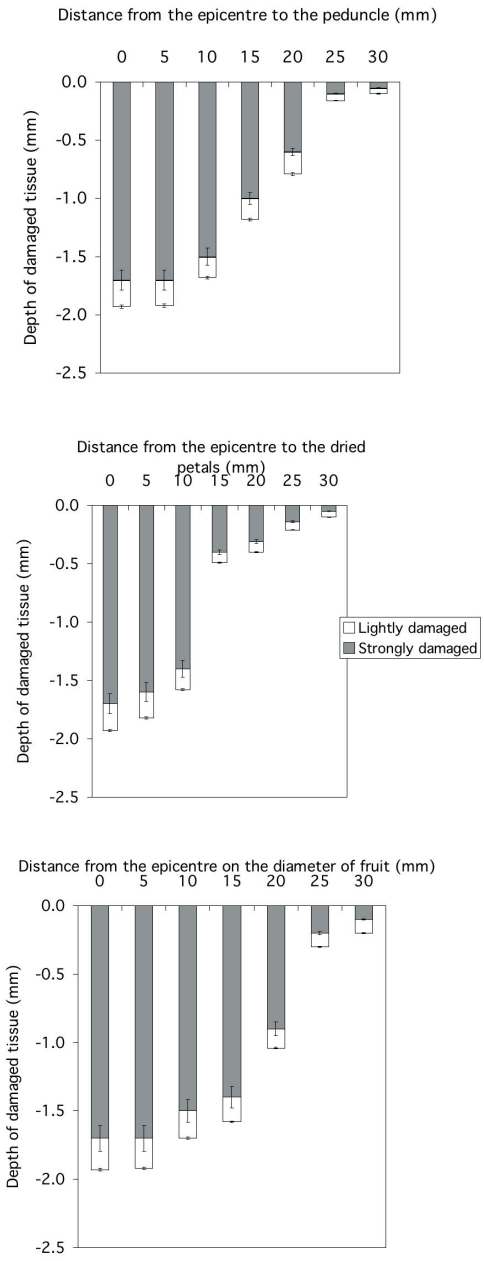

Figure 3. The depth of sunburn injury in fruit flesh.

of fruit was decreased. The damage can be shown until that distance, as – compare with the colour of the fruit surface – colour change can be experienced on the fruit surface. The strongest damage was experienced in the epicentre of sunburned blotch, in a 0.5 mm radius circle. Deterioration showed a low, decreasing tendency from the epicentre. Namely, with 15 mm from the epicentre of damaged blotch, the depth of damaged tissue was 1.5 mm, and the lightly damaged tissue was 0.9 mm. Until 15.0 mm the lightly damaged tissue was

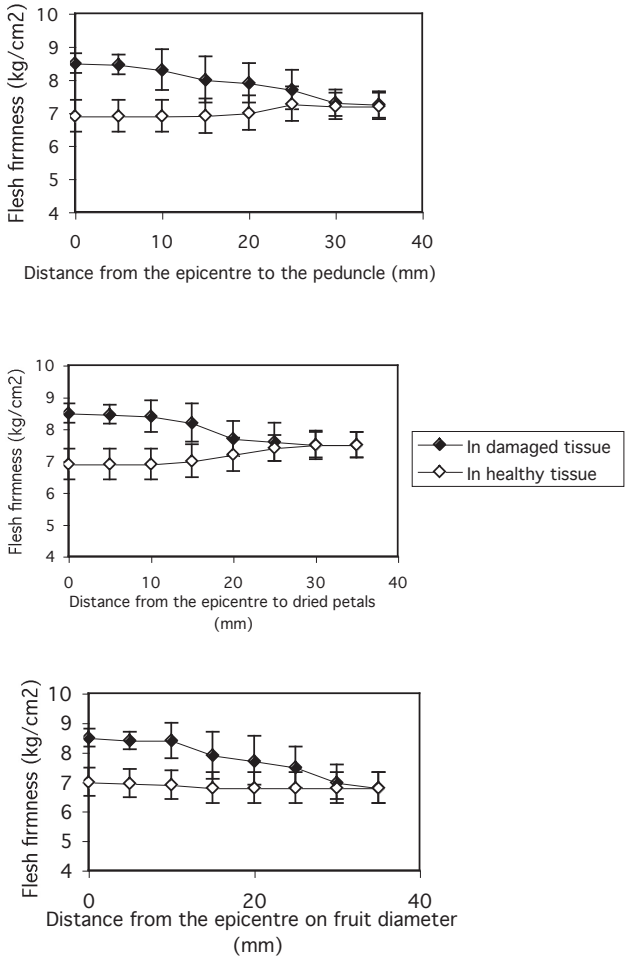

Figure 4. Effect of sunburn injury on fruit flesh firmness.

the same and over this interval was prepresented decrease. We have found, that the strong and light damage are always link together, there was no such a case when only strong or light damage occured alone (within a 30.0 mm radius circle).

There were some differences in the depth of damaged tissue, within the damaged blotch from the epicentre along the fruit flesh. In this direction the decrease was more intensive. This was caused by fruit shape, and the fruit flesh was firmer and the leaves were shaded morely. Compare with the previous case, we can see that the intensive damage occured from the epicentre of damage only from 10 mm and the depth of damaged tissue was in 25.0-30.0 mm distance nearly irrelevant.

Studied the deep of injury at petals, we have diagnosed that from the epicentre of the sunburned blotch within 10.0 mm distance was the significant tissue damage (1.6-1.7 mm). After this, within 15.0 mm distance and over the depth of injury staid under 0.5 mm by a strong tendency – brake.

Effect of sunburn on fruit flesh firmness

Sunburn's effect on fruit flesh firmness are show non Figure 4. According to the Figure, we can determine that from the effect of sunburn, the damaged fruit flesh firmness increase. This can be defined with the fact, that sunburned plant cells mainly perish, the tissue loose water and get harder.

Studying the flesh firmness along the cross-section's diameter, we can establish that it is decrease, but not linearly, far from the epicentre of damaged blotch. In the middle of the blotch, demonstrateingly higher the value of the fresh fruit firmness (8.50 kg/cm^2) and the spread of this indicator (± 0.3 kg/cm^2). Further from the epicentre of damaged blotch, the fresh fruit firmness is decreased (near to the healthy tissue) and the spread is getting increased.

From the epicentre of the „imaginary blotch" slight fruit flesh firmness reduction can also be demonstrated in healthy tissue (fruit). This can be explicable, with the fact that under the healthy fruit's surface which is covered greatly with red colour, the fruit flesh firmness is higher, but near to the less intensive colour, the fruit flesh is less also. In the healthy tissue the highest fruit flesh firmness was 6.98 kg/cm^2. We have experienced the different conditioned tissue's fruit flesh firmness compensation at 35.0 mm distance, with 6.82 kg/cm^2 therefore we could not show the effect of sunburn on fruit flesh firmness from this distance.

On the Figure 4 can be seen, that along the peduncle, the fruit firmness did not decrease as much as in the previous case. Tissues' fruit flesh firmness near the peduncle, even at health fruit, are higher than along the transversal diameter of fruit. At a healthy fruit, along the peduncle the fruit flesh firmness increases, the maximum value is at 25.0 mm distance and relapse. This is happend because the tissue under the fruit shoulder shows high fruit flesh firmness. The effect of damage stops at 40.0 mm distance from the epicentre.

The fruit flesh firmness decreased from the epicentre of damaged blotch to the withered petals. However, measure the same value from the transversal diameter, the fruit flesh firmness increased. The tendency of the decrease and increase is nearly the same, but with converse signals. The spread of the fruit flesh firmness is the lowest (± 0.3 kg/cm^2) from the epicentre within 5 mm, and the highest value is within 15 mm distance (± 0.6 kg/cm^2). In this case, the effect of sunburn is perceptible from the epicentre of damaged blotch, in the lowest distance (30 mm) and the fruit flesh firmness is 7.51 kg/cm^2.

Effect of sunburn on dry matter content of apple fruit

From the effect of sunburn, dry matter content changes in fruit flesh are shown at Figure 5. From the effect of sunburn the dry matter content was significantly increased. The reason is, that from the strong sunburn's (plus the low relative moisture with high temperature) effect the plant cells perish, the tissue

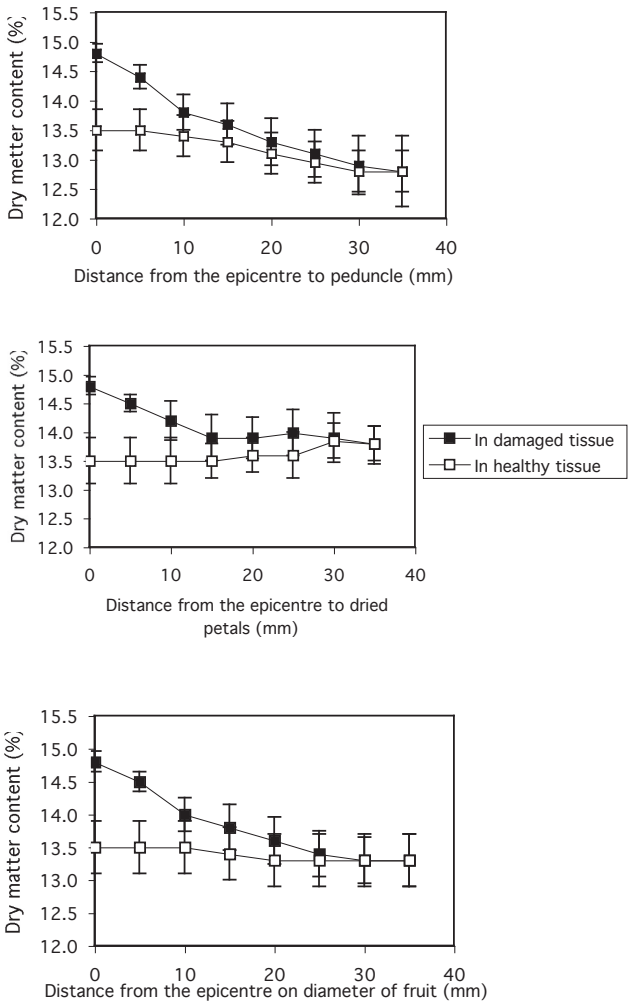

Figure 5. Effect of sunburn on dry matter content of apple fruit.

looses water and the outside of the water.

Dry matter content is relatively increased. Measure the fruit dry matter content from the epicentre of damaged blotch along the transversal diameter of fruit, decrease. In the middle of the blotch we have measured 14.84%, with very low spread (± 0.15%).

If we study a health's „imaginary blotch", we can establish, that in the middle of the blotch, the dry matter content is higher with 0.2% this is true, because on this area the colorizing of fruit surface is higher, which is always in pair with dry matter content. There is no significant change in dry matter content from the epicentre of damaged blotch along the transversal diameter of fruit.

Figure 5 shows the changes of fruit dry matter content from the epicentre of damaged blotch along the transversal diameter of fruit. The decreasing tendency is not linear. The study shows delicate damage and low dry matter content along the fruit peduncle (symptoms are not powerful) (12.82%). The value of the spread int he mostly damaged tissues, which were close to the epicentre. There were recurrance in dry matter content in healthy tissues as well, notably from 13.15% to 12.82%. Values show, that the dry matter content at not damaged fruit usually low (at the shoulder of the fruit). From the middle of the sunburned blotch, along the dried petals decrease is experienced, but the reduction is not unequivocal. At 15 mm from the epicentre is 13.91%, at 25 mm 13.99% is measured. From the middle of the sunburned blotch, along the dried petals until 15 mm, we found decrease. The value of the spread is the lowest (± 0.16%) at the very near to the damage.

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