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Effects Of Ethrel And Packaging On De-Greening And Quality Of Sweet Orange

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ABSTRACT:
Sweet orange (*Citrus sinensis* L.) is one of the highly demanded commercially sub-tropical fruit in the world and it is also an important fruit in Eritrea. Post-harvest handling of sweet oranges in Eritrea is very poor and this has resulted in great losses. Sweet orange of Eritrean lowlands (particularly Zoba Anseba) reach ripe stage while fruits are still green in color. The lack of colored fruits is due to the relatively high temperature in this region during harvesting period, which results to low demand and low prices in the market. The objective of this research was to find out effects of ethrel concentrations and packaging on de-greening (color development) and quality of sweet orange fruits. The experiment was conducted at Horticultural Science laboratory (Dark room) with cooling system (fan) during the period from 14th - 29th of November 2020. Light green sweet orange fruits were treated with ethrel at two concentrations (2ml/l and 3ml/l) and some of them left untreated. On the other hand, fruits were packaged individually in sealed-intact polyethylene (transparent one) and some of them left unpackaged plus a control (untreated and unpackaged). Six treatments were arranged in a Complete Randomized Design (CRD) with three replicates and four fruits/treatment/replicate. Results showed treated sweet orange fruits with ethrel at both concentrations significantly accelerate de-greening of fruit rind and developed uniform orange color compared to control fruits, which remained yellowish green. Packaged fruits recorded minimum weight loss (2.08 %) compared to the highest weight loss of unpackaged (13.13%). No change in TSS (%) and TA during storage of fruits. It is recommended to treat sweet orange fruits with ethrel at (2ml/l) and package them in sealed-intact polymeric polyethylene bag to obtain attractive appearance and good quality.
Keywords: Ethrel, Color development, Genetic variation, TA and TSS(%).

Introduction:

Sweet orange (*Citrus sinensis* L.) is one of the most widely grown fruits, almost in all tropical and sub-tropical regions expanding from 40º north to 40º south of equator. It is a non-climacteric fruit which belongs to Rutaceae family. It is an important fruit crop worldwide. It is second to grapes in the amount of total annual production, second to bananas for freshly consumed fruits and second to apples in the world fruit trade (FAO, 2012).

In Eritrea citrus is second major fruit, ranks next to banana. It occupies an area equal to 2409 hectares and sweet orange covers 2064 hectares (MoA, 2016). Those fruits are facing several constraints apart of these problems poorly colored, which remains green (uncolored), but physiologically ripened fruits particularly in the lowlands. This problem reduces marketability of sweet orange fruits. In lowland of tropics, the average temperature remains high during fruit maturity and chlorophyll level remains high and peel color remains green. Chlorophyll is degraded and chloroplast converted to chromoplast containing yellow, oranges or red pigments when air and soil temperature fall below 15ºC (Davies and Albirgo, 1994).

The practice of postharvest de-greening of light green citrus fruits has developed in order to promote external color development which is destruction of green chlorophyll pigment and lead to accumulation of orange or yellow carotenoid pigment. The de-greening process is complicated since it depends on various indigenous and exogenous factors. Such as fruit maturity at harvest and sensitivity of fruit to ethylene, ethylene concentrations and duration of de-greening process, temperature and RH and efficiency of air circulation and ventilation (Li *et al*, 2019).

Sweet orange grown in lowland of Eritrea remain green even after they reach ripe stage and consumers think they are still unripe. Postharvest de-greening of sweet orange can be done by application of ethrel. There was no negative effect of ethrel on total soluble solids, ascorbic acid, acidity or juice content (Yadava *et al.,* 2008).One of the most important factors which increase shelf life during storage is the proper packaging material and method of packaging. Polymeric film should be thin or perforated to permit adequate gas exchange, otherwise, fermentation may result from insufficient oxygen. Packaging produce is a dynamic system in which respiration and fermentation are occurring. Simultaneous selection of proper film type and thickness could reduce water loss and favorably modify the in-package atmosphere, there by extending shelf life (Wilis *et al*.,1998).

Elkashif *et al*. (2015), recommended to de-greening sweet orange fruits using ethrel at 2ml/l and packaging them in intact polymeric film. Earlier they were using calcium carbide but it has health hazards.

Therefore, this research aims to investigate effects of ethrel concentrations and packaging on sweet orange fruit de-greening and quality in lowlands of Eritrea.

Materials And Methods:

Experimental site:

The experiment was conducted at dark room-laboratory of Horticultural Science, Hamelmalo Agricultural College (HAC). The maximum and minimum temperature and relative humidity percentage during experiment was recorded using Thermohygrometer at 8:00 am and 2:00 pm daily. During experiment period, maximum and minimum

temperature of the storage room was from 26.6^{0}C to 24.2ºC and relative humidity ranges from 47% to 77%.

Methodology:

Sweet orange fruits were harvested on 12th November 2020, from a private orchard near Hamelmalo college at (Anseba river). The selected fruits were at light green rind, medium size and visually free of blemish. Fruits randomly distributed to perform various treatments. A Complete Randomized Design with three replicates was used. Four fruits/treatment/replicate.

A thermohygrometer was placed at the center of the shelf among the fruits. A fan for ventilating was placed at the center opposite to the fruits. Fruits were treated using ethrel, which scientific name is: 2-chloroethane phosphonic acid. Fruits divided into three groups. The first and the second groups were dipped in ethrel solutions at a concentration of 2ml/ L and 3ml/L for five minutes, respectively. The third group was dipped in distilled water for five minutes. Four fruits (approximately 1 kilogram) were dipped in one liter of etherl prepared solution (the whole fruit was covered with the solution). Fruits were air dried to remove surface water and then subjected to packaging and some of them left unpackaged this plus a control (untreated and unpackaged).

The experiment with packaging:

The fruits were covered with polyethylene plastics individually (each fruit in separate sealed-polyethylene bag).

Recorded parameters:

The quality of fruits TSS % and TA were recorded at the beginning and at the end of the experiment. Rind color and fruit weight loss (%) were recorded every three days frequently, for fifteen days.

Total soluble solids:

Total soluble solids (TSS %) were determined using refractometer (model HRN-64).

Total Titrable Acidity:

Total titrable acidity was determined using a 5ml juice, sample completed to 200 ml with distilled water and titrated against 0.1N NaOH to a phenolphthalein end point (light pink color) and calculated as a citric acid (g/100ml of juice) using the following formula:

$$\text{Titrable acidity} = \frac{\text{ml of NaOH used} * \text{Normality of NaOH} * 0.064 * 100}{\text{5ml of juice}}$$

Determination of rind color:

Fruit rind color was rated visually according to a scale of 1 to 5 as follows:

1: light green, 2: greenish yellow, 3: yellowish green, 4: yellow and 5: orange.

Determination of fruit weight loss (WL %):

Initial weight of fruits were determined and then fruits were weighed every three days frequently till 15 days. Weight loss was determined as follows:

$$\text{Weight loss (\%)} = \frac{(W_0 - Wt) * 100}{W_0}$$

Whereas:

W_0 = initial weight

Wt = weight at designed time

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Data analysis:

GENSTAT software (Sixth Edition) was used for statistical analysis; the collected data of different variables were subjected to analysis of variance at 5% level of significance and L.S.D used for differences between treatments.

Results And Disscussion:

Total Soluble Solids (TSS)

The effect of ethrel concentrations and packaging on TSS (%) of sweet orange fruits during the storage are shown in table 1. Ethrel treatment had no effect on TSS content. Similar findings were reported by Elkashif *et al*. (2015) and Yadava *et al*. (2008) who found that, ethrel treatment did not significantly affect to TSS% of sweet orange fruits. Also these findings has a harmony with the findings of Elkashif *et al.*(2003) who worked on different mango cultivars and found no significant differences between ethrel treated and untreated fruits with respect to TSS. An inverse of this result, TSS% increased due to post-harvest application of ethephon, that reported by Singh *et al*. (1979) in guava and Meitei *et al*. (1983) in peaches.

The effects of packaging on TSS content of sweet orange fruits during storage showed no significant differences between packaged and unpackaged fruits (table 1). May be the reason of that, because all sweet orange fruits of the experiment were harvested at fully ripe stage. This result is disagree with the findings of Elkashif *et al*.(2015) and Fernandez *et al*.(2006), who interpret the increasing rate of TSS might be due to rapid loss of water from the fruits and the conversion of the starch into sugar at a faster rate. Also the table 1 showed no significant differences of interaction of ethrel and packaging on TSS (%) during fruits storage.

Titrable Acidity (TA)

The effect of ethrel treatments on TA of sweet orange fruits during storage are shown in table 1 and ethrel had no significant effects on TA. Similar results were reported by Elkashif *et al*. (2015) who found that, ethrel treatment had no consistent effects on TA of sweet orange fruits. Also a similar findings were reported by Elkashif *et al*., (2003) who found that ethylene treatments did not significantly affect TA of mango fruits. Also, these results are in agreement with findings of (Abu-Goukh and Elsheikh, 2008 and Elkheir and Abu-Goukh, 2010).

The effect of packaging treatments on TA of sweet orange fruits also showed no significant differences during the storage (table 1). These findings disagree with Elkashif *et al.* (2015) who found that TA of sweet orange increased in packaged sweet orange fruits towards the end of the experiment after three weeks. Also these findings disagree with Ribereau-Gayon (1968) suggested that transformation of organic acids into sugars was one of the reasons for decreasing organic acids during fruit ripening. Therefore, another possibility seemed that ethephon might enhance the conversion of organic acids to sugars since present findings revealed that sugar content was increased and acidity was decreased following ethephon application. Sweet orange fruits packed in intact film or waxed had the highest titrable acidity. Polyethylene film liners and waxing usually result in a modified atmosphere with low oxygen and high carbon dioxide concentrations. These conditions mostly reduced respiration rate, decreased the degradation of organic acids and hence, resulted in higher titrable acidity content. Modified atmosphere had been shown to decrease respiration rate in banana (Osman and Abu-Goukh, 2008). Also no

significant effect of interaction of ethrel and packaging treatments on TA during fruits storage (Table 1).

Table (1): Effect of ethrel concentrations and packaging on TSS and TA of sweet orange.

Treatments	**TSS (%)**	TA
T0	9.2	0.97
T1	8.6	0.67
T2	9.4	0.71
T3	9.6	0.71
T4	9.4	0.66
T5	10.1	0.67
T6	9.6	0.70
CV%	6.1	19.3
Sig. Level	NS	NS
SE±	0.33	0.08

*T0: analysis of fruits at the beginning of experiment.
* T1: untreated and unpackaged as a control.
* T2: only packaged fruits.
* T3: only treated with ethrel (2ml/l).
* T4: treated with ethrel (2ml/l) and packaged.
* T5: only treated with ethrel (3ml/l).
* T6: treated with ethrel (3ml/l) and packaged.

Weight loss (WL%)

Effect of packaging on weight loss of sweet orange fruits during storage are shown in figure 1. The difference between packaged and unpackaged fruits on weight loss (%) was highly significant. Weight loss progressively increased during storage of sweet orange fruits. Packaged sweet orange fruits resulted the lowest (wl %), 2.08% while the highest (wl%) was recorded by unpackaged fruits (13.13%) at the end of the experiment. Packaged fruits in intact polyethylene film were of a good quality up to the end experiment, whereas unpackaged or control fruits lost their quality after 6 days of storage. These findings agreed with (Elkashif *et al*.2015 and Osman and Abu-Goukh, 2008) who found packaging of sweet orange fruits in intact or perforated film reduced (wl %). Polymeric film packaging has been extensively used to reduce weight loss and to enhance fruit quality (Bhullar and Farmahan, 1980 and Elamin and Abu-Goukh, 2009). Packaging of okra pods in intact polyethylene film resulted in a high relative humidity inside the package and hence reduced weight loss compared with perforated and control treatments (Elkashif *et al.,* 2013). Elkashif *et al.* (2003-2005) and Elamin and Abu-Goukh (2009) reported similar finding with mangos and bananas. Therefore, sweet orange fruits intended for export or local market should be packaged in intact thin polymeric film.

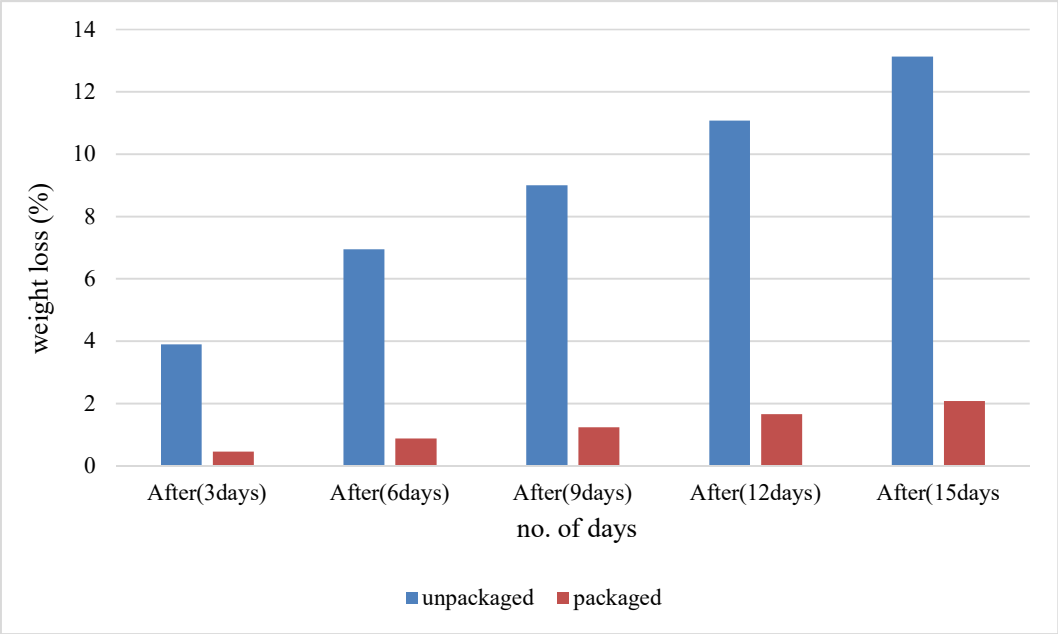

Figure (1): Effect of packaging on weight loss (%) of sweet orange fruit during storage.

Color Development:

The effect of ethrel concentrations on de-greening of sweet orange fruits during storage are shown in figure 2. Ethrel significantly enhanced color development in sweet orange fruits compare to the control. There is no significant difference between the two concentrations (2ml or 3ml) in color development. All fruits either treated with ethrel (2ml/l or 3ml/l) were colored with the orange color at the end of experiment while untreated fruits remain yellowish green. These findings agreed with Elkashif *et al*. (2015) who found Ethrel significantly enhanced color development in sweet oranges. Also they found, the higher concentration of ethrel (2ml/l) was more effective in color development than lower one (1ml/l). Also they found all fruits of sweet orange treated with 2ml/l their rind color changed to yellow color and not to orange color(as the findings of this experiment) and this may be according to differences between the sweet orange cultivars that used in the two experiments. Nour and Goukh (2010) observed that peel color score progressive increase during ripening of guava fruits. They observed that fruits treated with ethephon (250-1000 ppm) reached the full yellow stage, 6 days earlier than untreated fruits. They also reported ethephon treated fruits had reached the soft stage, 6 days earlier than the control. Color development was better due to rapid degradation of chlorophyll and higher synthesis of carotenoid pigmentation and alternation in pigment due to different applied ethephon treatment. Also, these findings are more or less similar to the finding of Gurjar *et al.* (2017) and Sukhjit (2017) in mango.

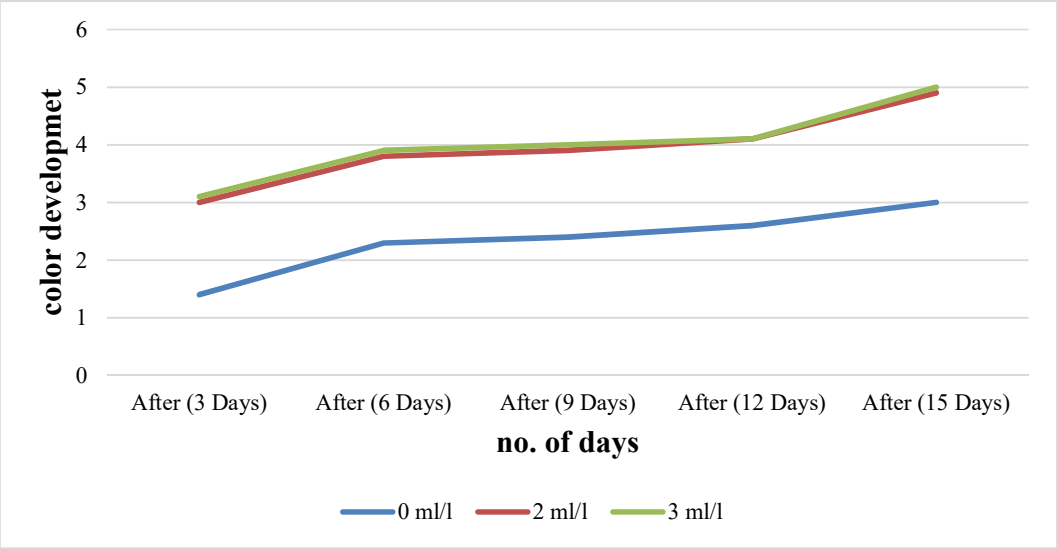

Figure (2): Effect of ethrel concentrations on sweet orange fruits color development

The effect of ethrel concentrations and packaging on sweet orange fruits color development during storage are shown in figure 3. Sweet orange fruits treated with ethrel and packed in intact polymeric film developed full orange color during storage. This was most probably due to the fact, intact film trapped ethylene hormone which is release from ethrel and hence resulted in the de-greening of fruits. This is in agreement with the finding of (Elkashif *et al*., 2015).

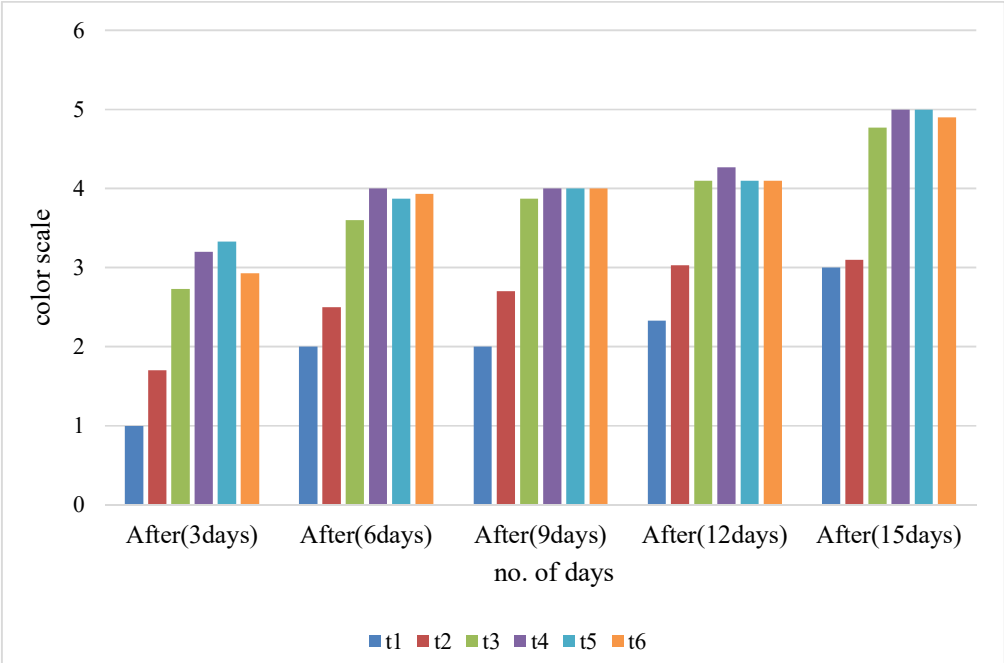

Figure (3): Effect of ethrel concentrations and packaging on color development of sweet orange fruits.

Conclusions And Recommendations;

Conclusion:

* Treatments of sweet orange fruits with ethrel accelerate color development compare to the control.

* No significant difference between the two concentrations of ethrel (2ml/l and 3ml/l) in color development. Since no significant differences between ethrel concentrations (2 ml/l and 3 ml/l) in color development, it is better to use ethrel (2 ml/l) in order to reduce the cost.

Packaging of sweet orange fruits, indicate:

*Covering of sweet orange fruits with transparent polyethylene reduced weight loss (%) compare to the control.

Combined effect of ethrel and packaging on sweet orange fruits de-greening and fruit quality:

* Sweet orange fruits treated with ethrel provide a good rind appearance and packaging decrease weight loss (%) and no change on TSS (%) or TA after two weeks of storage and fruits were ready for marketing.

* Fruit rind changes to uniform orange color, this is of genetic effect.

Recommendation:

* It is recommended to treat sweet orange fruits with ethrel (2 ml/l) and packaging them to obtain attractive appearance and good quality within two weeks.

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