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# SENSITIVITY OF DATES TO ACETIC ACID AND ETHREL IN RELATION TO SOLUBLE TANNINS CONTENT IN THE ASTRINGENT FRUITS OF AUM EL-FERAKH AT THE KHALAL STAGE

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## ABSTRACT

**In spite of the numerous-available clones and cultivars of date palm, few of them produce non-astringent dates at the khalal stage. The astringent fruit must convert to the rutab stage to be edible as fresh dates which means the conversion of soluble tannins to the insoluble form. Applications of the ethylene- releasing compound, namely, Ethrel, even at very high concentrations failed to induce rutab development in astringent fruit at the khalal stage. This research was conducted to investigate the involvement of soluble tannins in the sensitivity of tissue to ripening (rutab) enhancers such as Ethrel and acetic acid. This study was carried out during the two successive seasons 2004 and 2005 using Aum El-Ferakh cultivar as a model system that is very rich in soluble tannins at the khalal stage. After surface sterilizing the harvested fruits from the same trees, fruit at the full khalal were treated by dipping for 20 mins in one of the treatment solutions. The treatments included: acetic acid at three concentrations, 1, 3, and 5% (v/v) and Ethrel at 1000, 2000, and 3000 ppm, in addition to the control (dipping in water). Fruits were left on bench for 6 days at 22±2°C then assessed for rutab development, soluble tannins and other quality parameters. The data revealed that acetic acid at all used concentrations were able to induce rutab development while Ethrel concentrations failed to achieve that as was the case with the control fruits.**

**Meanwhile, the concentration of soluble tannins significantly decreased in both seasons especially with acetic acid at 3 and 5% while Ethrel-treated fruits at all concentrations had similar amount of soluble tannins to that found in the control. As a result of the conversion to the rutab stage by acetic acid treatments, there was a decline in fruit weight by the end of the experiment while fruit weight of Ethrel-treated fruits did not vary from that of the control. Other fruit quality parameters were also assessed such as weight loss, flesh weight, rag weight, TSS, acidity and vitamin C. This study provided experimental evidences that Ethrel treatment was sensitive to the presence of soluble tannins in fruit tissue while acetic acid was not. Acetic acid was also able to reduce soluble tannins and induce rutab development.**

## INTRODUCTION

There are hundreds of date palm clones and cultivars in the growing areas around the world. However, few cultivars are less or almost not astringent at the end of the khalal stage as in Zaghloul fruits in Egypt and Barhe in the Gulf region. The rate at which soluble tannins are converted to insoluble tannins varies within cultivars, making some of them edible as fresh juicy dates (Dowson and Aten, 1962). Tannins are mainly found in the tanniferous layer of the mesocarp which are responsible for the astringent taste of unripe fruit (Reuveni, 1986). Thus, fruits of astringent cultivars must convert from the Khalal to rutab stage to be edible. Definition of ripening is very specific for date fruits. The initiation of rutab development means the initiation of ripening while full rutab formation means the completion of ripening. It was found that soluble procyanidin tannins were the predominant polyphenolic constituents of immature dates, and the increase in soluble tannins, close to or at maturation time was believed to be the result of a conversion of soluble to insoluble tannins (Rygg, 1975; Vandercook *et al*., 1979).

Date producers have been attempting to induce rutab development in astringent cultivars by using ripening enhancers such as Ethrel to get ride of their taste. In spite of increasing the used Ethrel concentration to more than recommended, Ethrel application, either before or after harvest, failed to induce ripening in astringent fruits. However, Zaghloul date fruits, a non astringent fruit at the khalal stage, positively responded to the application of ethephon (Farag and Kassem, 1998). Hence, the presence of soluble tannins in fruit tissue might alter their sensitivity to an ethylene – releasing compound such as Ethrel. Soluble tannins have a strong protein binding capacity and have been widely used as deproteinizing agents. Polymerized tannins do not show astringency, primarily, because they are insoluble in water (Taylor, 1993).

On the other hand, acetic acid was found to induce earlier maturation when sprayed before harvest (Samish, 1957) and was successful in artificial ripening of detached fruits (Reuveni, 1986). Date fruits naturally produce acetic acid at the initiation of ripening which leads to the formation of the major volatile, namely acetaldehyde, produced as fruit starts to mature (Norman and Fouse, 1977). Aforementioned, suggested the importance of soluble tannins as natural compounds in date fruits affecting their sensitivity to ripening enhancers.

The objectives of this research were to investigate the relationship between the presence of soluble tannins and the sensitivity of mature fruits to Ethrel and acetic acid by using Aum El-Ferakh cultivar as a suitable model system since it contains remarkable amount of soluble tannins at the khalal stage.

## MATERIALS AND METHODS

This study was conducted during the two successive seasons 2004 and 2005 using mature fruits of Aum El-Ferakh cultivar. Fruits were harvested at the khalal stage (fully colored) from date palm trees grown in private orchard in Rashid, Behera governorate. Trees were ten years old, vegetatively reproduced by offshoots, healthy, free of defects and under standard cultural practices. Fruits at the full khalal were sorted out through their specific gravity since they sink in water while those at early khalal float on water. Treatments were done on Oct 4 and 16 during the two seasons 2004 and 2005, respectively. Fruits were washed with tap water, surface sterilized for 3 mins in sodium hypochlorite solution (0.5% v/v prepared from stock solution of 5%) then washed again with tap water to remove the remains of NaOCl, followed by air drying.

Ten fruits were used with each replication. The treatments included: acetic acid in three concentrations 1, 3, and 5% (v/v) and Ethrel at 1000, 2000, and 3000 ppm in addition to the control (water treatment). Fruits of each treatment were dipped for 20 mins, then left at 22±2°C for 6 days. At the harvest date, four replications of fruits each containing 10 fruits at the full Khalal were randomly selected for the determination of the initial values of various parameters reported in this research. After the 6 days, the following measurements were taken: rutab score (no rutab = 1; <25% rutab = 2; from >25 to <50% rutab = 3; from >50 to <75% rutab = 4; from 75> to <100% rutab = 5 and finally 100% rutab = 6), fruit weight (g), flesh weight (g), Rag (seed + cap) weight (g), total soluble solids (TSS) by using a hand refractometer, titratable acidity and vitamin C content in the fruit according to A. O. A. C. (1984). Soluble tannins in the fruit was determined according to the method of Johnson and Schall (1957). The experimental design was completely randomized with 4 replications per each treatment. Analysis of variance (ANOVA) was obtained by using SAS computer software (SAS 2000) while the means comparison was performed according to the least significant difference (LSD) using the same indicated software.

## RESULTS AND DISCUSSION

Data of rutab induction and some fruit characteristics after 6 days on the shelf as influenced by postharvest treatments with acetic acid or Ethrel were shown in Tables 1 and 2. The data revealed that all acetic acid concentrations were able to induce rutab formation while the control fruits remained at the khalal stage. The rutab score value of the control in both seasons indicated to zero rutab development. Furthermore, there was a significant difference between rutab score obtained with various acetic acid concentrations. As the used acetic acid concentration increased, rutab development also increased. In other words, the highest rutab development was obtained with dipping in acetic acid at 5% (v/v). However, Ethrel treatment at all concentrations did not cause a significant increase in rutab development as compared with that obtained with the control. Even when Ethrel concentration was increased to 3000 ppm, it did not lead to a significant change in rutab development when compared with that found with Ethrel at 1000 or 2000 ppm. Trends of rutab score were consistent in both seasons (Tables 1 and 2). Furthermore, acetic acid treatment at the lowest used concentration (1%, v/v) resulted in significantly higher rutab score than that found with all Ethrel concentrations. This also indicated that all acetic acid treatments had considerably higher efficacy than that obtained with Ethrel treatments in terms of rutab development in both seasons.

With regard to the changes in fruit weight after 6 days on the shelf as influenced by various treatments, it as found that there was, generally, a reduction in such weight with acetic acid treatments as compared with the control. The highest drop in fruit weight was obtained with acetic acid at 5% that also caused the highest rutab score. As the rutab formation progressed, tissue breakdown increased which reflected on lower fruit weight. In support of this conclusion, most Ethrel treatments, that were not effective on rutab development, resulted in similar fruit weight to that found with the control (Tables 1 and 2).

To provide further support, weight loss was monitored in the second season (Table 2). Percentage of weight loss at the end of the 6 days on the shelf relative to fruit weight at the beginning of the incubation was calculated. It was found that weight loss in acetic acid-treated fruits was significantly higher that that in the control fruits. All acetic acid concentrations were equally effective in the magnitude of weight loss reduction after 6 days on the shelf. On the other hand, Ethrel-treated fruits at 1000 ppm did not vary in weight loss percentage when compared with the control. Similar trend of results was obtained with Ethrel-treated fruits at 2000 and 3000 ppm. The highest weight loss was obtained with Ethrel at 2000 ppm among used Ethrel concentrations. Thus, the magnitude of weight loss was relevant to the development of rutab in the fruit (Table 2).

Changes in flesh weight after 6 days on the shelf following the treatments were shown in Tables 1 and 2. The data revealed that flesh weight tended to be reduced by acetic acid treatments but this reduction was significant only in the second season relative to the control.

Moreover, flesh weight of Ethrel-treated fruits at all used concentrations was significantly greater than those treated with acetic acid in the first season. Similar trend of results was found in the second season except with Ethrel at 3000 ppm. Changes in rag weight as influenced by the treatments after 6 days on the shelf were not consistent when results of both seasons were compared. Since the rag included the seed plus the cap and physical changes were related to rutab development, no conclusion could be drawn between rag weight and the ability to convert to the rutab stage.

Total soluble solids data in the fruits after 6 days of the treatments were reported in Tables 1 and 2. No significant changes in TSS of acetic acid or Ethrel-treated fruits in the first season when compared with the control. However, TSS % in acetic acid-treated fruits at all concentrations was higher than that of the control in the second season. Meanwhile, acidity of fruits treated with acetic acid at 1% and 3% was significantly higher than that of the control in the first season only. However, fruit acidity of Ethrel-treated fruits was, in general, similar to that found in the control fruits in both seasons.

With regard to vitamin C content in the treated fruit after 6 days on the shelf, the data showed that acetic acid- treated fruits had significantly higher vitamin C content that the control in both seasons. Meanwhile, vitamin C content of Ethrel-treated fruits was similar to that obtained in the control fruits. Vitamin C of acetic acid-treated fruits was, generally, greater than that found in Ethrel-treated fruits. Soluble tannins content in the treated fruits after 6 days on the shelf were affected by various treatments (Tables 1 and 2). The data revealed that acetic acid at 3 and 5% caused a significant reduction in soluble tannins as compared with the control in both seasons.

Acetic acid treatment at 1% tended to reduce soluble tannins especially in the first season. Moreover, acetic acid-treated fruits at 5% had significantly lower soluble tannins than those treated with acetic acid at 1% in both seasons. On the other hand, Ethrel-treated fruits at all concentrations maintained their high content of soluble tannins that did not significantly vary from those found in the control in both seasons. The increase in Ethrel concentration from 1000, to 2000 or 3000 ppm did not lead to any appreciated change in soluble tannins and this trend of results was consistent in both seasons. Thus, at the initial higher concentration of soluble tannins, tissue sensitivity to the released ethylene seemed to be lost even if Ethrel concentration was doubled or tripled (Tables 1 and 2). There was an inverse relationship between the progress of rutab development and the concentration of soluble tannins in the fruits that had an astringent taste such as Aum El-Ferakh.

The present study provided evidence that the use of an ethylene-releasing compound such as Ethrel at high concentration was not effective in inducing rutab development. However, a natural compound such as acetic acid at low concentrations was able to achieve what Ethrel failed to do. These results explained the postulation that since soluble tannins have a strong protein binding capacity and have been widely used as deproteinizing agents (Taylor, 1993). These binding proteins in the fruit cells might be occupied with bound soluble tannins. The released ethylene from Ethrel needs to bind with its proteins to start the cascade of events leading to the initiation of the ripening (rutab) process. The ability of acetic acid to induce rutab development even in the highly astringent cultivar, such as Aum El-Ferakh, suggested the possibility of working through a different mechanism from that found with ethylene to induce ripening. That is logic to propose since acetic acid treatment has been effective, through pre or post harvest application, on inducing ripening of astringent or non-astringent dates. Furthermore, acetic acid is naturally produced at the initiation of date fruit ripening (Norman and Fouse, 1977). The significant reduction in soluble tannins caused by acetic acid treatment in this study demonstrated the possibility that soluble tannins could change the tissue sensitivity to ripening enhancers. Further support was concluded from the finding that Ethrel could not significantly reduce soluble tannins in the fruit even after 6 days on the shelf. Date producers must not increase Ethrel concentration to obtain the desired rutab induction in astringent cultivar since such increase adds to the production cost without any positive return. Although date fruits were reported to be climacteric (Abbas and Ibrahim, 1996) and must be sensitive to exogenous application of ethylene sources, but soluble tannins may hinder the initiation of the ripening process. It was also found that ethanol fumes, as polymerizing agents, were able to induce rutab development in an astringent cultivar such as Helali that did not positively respond to Ethrel treatment (Farag and Al-Konaissi, 2001). Ethrel was also found to remove astringency in persimmon and fruits contained 13 times more insoluble tannic substances (Manabe, 1982). The involvement of soluble tannins in the ability to induce ripening must be taken into consideration before deciding the suitable sprayed substance.

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**Table 1. Effect of various concentrations of acetic acid and Ethrel on rutab induction and fruit characteristics of Aum El-Ferakh date palm cultivar during 2004 season.**

| Treatments** | Rutab Score | Fruit Weight (g) | Flesh Weight (g) | Rag Weight (g) | TSS (%) | Acidity (%) | Vitamin C (mg / 100 ml) | Soluble Tannins (absorbance) |
|---|---|---|---|---|---|---|---|---|
| Control | 1.00* d | 11.16 bc | 8.65 bc | 2.51 a | 21.60 abc | 0.24 b | 3.01 bc | 0.047 a |
| Acetic acid (1%) | 2.50 c | 10.38 d | 8.19 c | 2.18 c | 17.25 c | 0.38 a | 3.97 a | 0.027 b |
| Acetic acid (3%) | 4.05 b | 10.45 cd | 8.16 c | 2.28 bc | 19.20 bc | 0.36 a | 4.29 a | 0.0023 c |
| Acetic acid (5%) | 5.25 a | 10.24 d | 8.06 c | 2.18 c | 20.70 abc | 0.25 b | 4.61 a | 0.0020 c |
| Ethrel (1000 ppm) | 1.45 d | 11.71 ab | 9.26 ab | 2.46 a | 23.20 ab | 0.24 b | 2.58 c | 0.044 a |
| Ethrel (2000 ppm) | 1.03 d | 11.94 a | 9.43 a | 2.52 a | 23.50 ab | 0.22 b | 2.58 c | 0.045 a |
| Ethrel (3000 ppm) | 1.15 d | 11.55 ab | 9.13 ab | 2.42 ab | 23.85 a | 0.26 b | 3.30 b | 0.042 a |

* Values, within a column, of similar letters are not significantly different according to the use of least significant difference (LSD) at 0.05 level to compare the means.

** Initial values of rutab score, fruit weight, flesh weight, rag weight, TSS, acidity, vitamin C

and soluble tannins were 1.0, 14.95 (g), 11.64 (g), 3.31 (g), 22.65%, 0.41%. 4.32 (mg/100ml) and 0.052 (absorbance value), respectively.

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**Table 2. Effect of various concentrations of acetic acid and Ethrel on rutab induction and fruit characteristics of Aum El-Ferakh date palm cultivar during 2005 season.**

| Treatments** | Rutab Score | Fruit Weight (g) | Weight Loss (%) | Flesh Weight (g) | Rag Weight (g) | TSS (%) | Acidity (%) | Vitamin C (mg / 100 ml) | Soluble Tannins (absorbance.) |
|---|---|---|---|---|---|---|---|---|---|
| Control | 1.00* c | 22.27 a | 14.86 d | 19.08 a | 3.19 a | 16.45 d | 0.16 b | 0.55 c | 0.029 a |
| Acetic acid (1%) | 1.94 b | 20.95 cd | 17.55 ab | 17.74 b | 3.21 a | 22.95 b | 0.15 bc | 0.90 b | 0.027 ab |
| Acetic acid (3%) | 2.68 b | 20.71 cd | 18.89 a | 17.61 b | 3.10 a | 23.40 b | 0.10 cd | 0.90 b | 0.024 b |
| Acetic acid (5%) | 4.75 a | 20.50 d | 19.63 a | 17.45 b | 3.07 a | 25.50 a | 0.09 d | 1.16 a | 0.003 c |
| Ethrel (1000 ppm) | 1.00 c | 21.74 abc | 12.69 d | 19.35 a | 3.39 b | 19.35 c | 0.18 ab | 0.55 c | 0.027 ab |
| Ethrel (2000 ppm) | 1.00 c | 22.13 ab | 15.29 bc | 19.14 a | 2.99 ab | 18.60 c | 0.22 a | 0.55 c | 0.027 ab |
| Ethrel (3000 ppm) | 1.00 c | 21.08 bcd | 14.42 cd | 18.02 b | 3.06 a | 17.70 cd | 0.18 ab | 1.09 a | 0.028 a |

* Values, within a column, of similar letters are not significantly different according to the

use of least significant difference (LSD) at 0.05 level to compare the means.

** Initial values of rutab score, fruit weight, flesh weight, rag weight, TSS,

acidity, vitamin C and soluble tannins were 1.0, 25.69 (g), 22.56 (g), 3.31 (g), 21.45%, 0.41%. 1.17 (mg/100ml) and 0.033 (absorbance value), respectively.

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## الملخص العربى

# العلاقة بين حساسية الثمار للمعاملة بحمض الخليك والإيثريل ومحتوى التانينات الذائبة فى صنف البلح أم الفراخ القابض الطعم فى مرحلة الخلال

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بالرغم من توافر العديد من سلالات وأصناف نخيل البلح، إلا أن القليل منها تكون خالية من الطعم القابض فى مرحلة الخلال، فالثمار القابضة الطعم يجب أن تتحول لمرحلة الرطب حتى يمكن استهلاكها طازجة وهذا يعنى أنه يجب أن تتحول التانينات الذائبة إلى تانينات غير ذائبة. ورغم استخدام منظم النمو الإيثريل الذى يطلق هرمون النضج الإيثيلين داخل الأنسجة إلا أنه فشل فى إرطاب الثمار القابضة الطعم فى مرحلة الخلال. أجرى هذا البحث لمعرفة مدى تدخل التانينات الذائبة فى حساسية الأنسجة لحدوث الإرطاب (الإنضاج) عند المعاملة بالإيثريل وحمض الخليك. أجرى هذا البحث خلال الموسمين المتتاليين 2004 ، 2005 باستخدام صنف أم الفراخ والذى اختير كنموذج مناسب للدراسة نظراً لاحتوائه على نسبة عالية من التانينات الذائبة فى مرحلة الخلال. تم جمع الثمار من نفس الشجرة، وبعد تعقيمها سطحياً تم غمس الثمار التى كانت فى مرحلة الخلال الكامل فى أحد محاليل المعاملات لمدة 20 دقيقة، وقد اشتملت المعاملات على استخدام حمض الخليك بثلاث تركيزات هى 1 ، 3 ، 5٪ (حجم / حجم)، واستخدام الإيثريل بتركيزات 1000 ، 2000 ، 3000 جزء فى المليون، بالإضافة للكنترول (نقع فى الماء)، ثم حفظت الثمار على درجة حرارة الغرفة (22±2°م)، تم تقييم الثمار من ناحية درجة الإرطاب ومحتوى التانينات الذائبة بالإضافة لبعض خصائص الجودة الأخرى. أثبتت التجربة أن كل تركيزات حمض الخليك المستخدمة كانت قادرة على إرطاب الثمار بينما فشلت كل تركيزات الإيثريل فى إرطابها بطريقة مشابهة لما كانت عليه ثمار الكنترول. وفى نفس الوقت فقد انخفض محتوى التانينات الذائبة فى الثمار بطريقة معنوية فى كلا الموسمين خاصة مع تركيزات 3 ، 5٪ من حمض الخليك بينما احتوت الثمار المعاملة بالإيثريل عند كل التركيزات المستخدمة على نفس الكمية من التانينات الذائبة التى احتوتها ثمار الكنترول. كما انخفض وزن الثمار معنوياً فى نهاية التجربة مع معاملات حمض الخليك نتيجة التحول لمرحلة الرطب بينما كان وزنها مشابهاً للكنترول فى حالة الثمار المعاملة بالإيثريل وقد تم قياس بعض خصائص الثمار الأخرى مثل انخفاض الوزن، ووزن اللحم والنفايات ونسبة المواد الصلبة الذائبة والحموضة ومحتواها من فيتامين ج. أثبتت الدراسة أن معاملات الإيثريل كانت حساسة لوجود التانينات الذائبة فى الأنسجة بينما لم يكن حمض الخليك حساساً لذلك، كما كان حمض الخليك قادراً على خفض نسبة التانينات الذائبة بالثمار.

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