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# Influence of Different Maturity Stages on Fruit Yield and Essential Oil Content of Some Apiaceae Family Plants
## A: Anise (*Pimpinella anisum,* L.)

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## ABSTRACT

This study investigated the effects of harvesting at different plant maturation stages on the fruit and essential oil yield as well as its compositions of anise. It was carried out at El- Baramoon Research Farm, Mansoura Horticulture Research Station, HRI, ARC, Egypt, during the winter seasons of 2013/2014 and 2014/2015. The plants were harvested at eight different fruit development stages and determinations were made of the yields of fruit , germination percentage the thousand fruit weight (seed index), the essential oil percentage and its constituents. The obtained results indicated that high yield and quality of anise fruits were obtained when fruits harvested at stage 4 (the primary umbel was matured completely).The highest essential oil percentage was higher in stage 1 (the primary umbel was at the beginning of waxy stage.). However, this high percentage of essential oil did not produce the maximum oil yield per plant in stage1 was associated with low fruit yield. Essential oil yield per plant with high Trans-Anethole content reached their maximum when fruits harvested at stage 4. Generally, it could be recommended that to obtain the maximum fruit yield and quality as well as high essential oil yield with high Trans-Anethole content, anise fruits should be harvested at stage 4 (The primary umbel was matured completely).

**Keywords:** Anise, fruit yield, germination, essential oil, harvest stage, maturity

## INTRODUCTION

Anise(*Pimpinella anisum* L.) is an annual important spice and medicinal plant belonging to the family of Apiaceae and originating from the Mediterranean region. Anise plant is an important natural raw material and widely cultivated for fruit and essential oil, which mostly used in medicine, pharmaceutics, perfumery and cosmetic industries. It is also used as functional food; it is added to confectionary products (honey cookies, candies). Recent research found that this spice plant has drawn more consideration of consumers due to the antimicrobial, antifungal, insecticidal, and antioxidtaive effect of this herb on human health (Gulcin *et al.,* 2003 and Kosalec *et al.,* 2005). The drug as well as the essential oil is characterized by carminative, mild expectorant, diuretic, antiseptic as well as antispasmodic effects .Its fruits known as aniseed were used as traditional medicine. Anise fruits contain 2–3% of essential oil. Essential oil contains mainly anethol (80–90%), which gives to anise oil its characteristic aroma. Anise oil also contains p-methoxyphenylacetone, anisic alcohol and anisaldehyde (Lawrence, 1983 and Saibi *et al.,* 2012). Other components can be found at levels less than 1%. The fruit contain 10–30% of fat oil (Melchior and Kastner, 1974 and Tabanca *et al.,* 2006).

The quality of anise is determined mainly on the basis of the essential oil content and its composition. Both of these parameters are significantly affected by environmental factors, i.e. soil type and weather conditions during the year (temperature, precipitation, etc.) especially during the development of anise fruit (stages of plant maturity) and by the applied agronomic practices (Zehtab-Salmasi *et al*.,(2001); Omidbaigi et al., (2003); Tuncturk and Yildirim, 2006; Özel, 2009 a; Jevdjovic *et al*., 2012). Harvesting stage is an important factor influencing fruit yield and essential oil production in anise because of the changes during maturation period. Late harvest allowing fully maturity can result in fruits on the primary umbel shattering. Early harvesting also causes yield loses because of the premature fruits. However, there are no satisfactory literature on the relationship between plant maturation and yield fruits as well as essential oil and its contents of aniseed. It is known that fruits have differing levels of maturity at harvesting (Nassar *et al.,* 2001). In addition, Omidbaigi *et al.,* (2003) revealed that the loss of yield at early and late harvesting times and the levels of maturation of the fruits in the harvested plants may cause changes in the yield and its contents of anise. Also, Zehtab-salmasi *et al.,* (2001) found that fruits of anise harvested in waxy stage had higher essential oil percentage than those harvested at later stages. Moreover, Özel, (2009a) harvested anise plants at 10 different growth stages and showed that the fourth harvesting stage gave the highest yields of fruit, essential oil and (E)-anethole. Furthermore, Majid *et al.* (2014) reported that harvesting time had significant effect on some of traits including fruit thousand weight, fruit yield, fruit essence content and essence yield. By delaying in harvesting time, fruit yield, fruit essence content and essence yield significantly decreased. Thus, this research was conducted to determine the effect of stages of fruits maturity on the quality of anise fruit principal traits (thousand fruit weight and total germination), on its essential oil content, as well as on the content of *trans*-anethole, the main constituent of the essential oil in order to minimize the harvesting loses and to maximize the essential oil quality.

## MATERIALS AND METHODS

Two field experiments were carried out during two successive winter seasons of 2013/2014 and 2014/2015, at El- Baramoon Research Farm, Mansoura Horticulture Research Station, HRI, ARC, Egypt. Soil

was silt clay loam in texture with pH 8.13 and organic matter 1.7%. Anise seeds were obtained from the Department of Medicinal and Aromatic Plants, HRI, ARC, Egypt. The experimental filed was prepared and shaped to ridges of 65 cm apart. Seeds were sown on mid October in both seasons in hills at 30 cm apart then thinned for one plant/hill after 30 days from sowing. Agricultural practices were done as recommended by Egyptian Ministry of Agriculture. The experimental design used was a randomized complete block design with four replications. Each harvesting stage formed a different plot as follows:-

1. **Stage 1:** The primary umbel was at the beginning of waxy stage (fully green).
2. **Stage 2:** The primary umbel colour was changed (green).
3. **Stage 3:** The secondary umbels colour was changed (green-yellow).
4. **Stage 4:** The primary umbel was matured completely (green-yellow).
5. **Stage 5:** The primary umbel became brown (yellow-brown).
6. **Stage 6:** The secondary umbels were brown (brown).
7. **Stage 7:** The primary umbel was easily dropped off (fully brown).
8. **Stage 8:** The primary umbel was falling (fully brown).

The plots were harvested at 8 different fruits maturation stages using a sample size of 5 plants per replicate. Harvesting was carried out when the fruits in the primary umbel reached the waxy stage and a total of 8 harvests. Harvesting started at 7 am and comprised cutting the stems at ground level and storing the cut material in jute bags to prevent fruits loss. The plants harvested were dried at ambient temperature in shade. After hand rubbing of the dried plants, the fruits were separated from stalks by sieving and weighed. The following data were recorded:

1- **Fruit yield and seed index**: The dried fruits were weighed to determine yield and the thousand fruit weight (seed index).

2- **Germination percentage**: was determined (ISTA, 2011).

3- **Volatile oil percentage**: was determined using a modified Clevenger apparatus (Guenther, 1961).

4- **Essential Oil Constituents**: The GC analysis of the second season volatile oil samples were carried out using Gas chromatography instrument , Dept. of Medicinal and Aromatic Plants Laboratory, HRI., with the following specifications: DsChrom 6200 Gas Chromatograph equipped with a flame ionization detector, Column: BPX-5, 5% phenyl (equiv.) polysillphenylene-siloxane 30m x 0.25mm ID x 0.25µm film., Sample size: 1µl, Temperature program ramp increase with a rate of 10º C / min from 70º to 200º C, Detector temperature (FID): 280 °C, Carrier gas: nitrogen, Flow rate: N2 30 ml/min; H2 30 ml/min; air 300 ml/min. Main compounds of the volatile oils were identified by matching their retention times with those of the authentic samples injected under the same conditions. The relative percentage of each compound was calculated from the area of the peak corresponding to each compound.

5-**Total carbohydrate**: was determined (Gul and Safdar, 2009).

6-**Crude protein**: was determined (AOAC, 2000).

7-**Crude fat** was extracted from ten grams of each powdered sample using a continuous extraction apparatus (Soxhlet) with a solvent of petroleum ether (b.p.60-80$^{O}$C) for sixteen hours. Each extract was dried over anhydrous $Na_2SO_4$ and evaporated to dryness. The residue was dried at 80$^{O}$C for ten minutes, cooled, weighed and expressed as percent lipid (AOAC, 2000).

8-**Total ash** content was determined as follows: Two grams of sample were added into previously weighed porcelain crucible, place in muffle furnace at 600$^{O}$C for 2 hours, and then placed in desiccators, cool and weigh. The weight of the residue was calculated and expressed as percent ash (AOAC, 2000).

9-**Mineral content**: Nitrogen, phosphorus, and potassium in seeds were determined (Cottenie *et al.*, 1982).

**Statistical analysis**:

The obtained data were subjected to analysis of variances, and the significant differences among treatment means were compared using the LSD test according to Gomez and Gomez 1984.

## RESULTS AND DISCUSSION

**Fruit yield and its quality**

The data presented in Table (1) showed that there are significant differences between different harvesting stages on anise fruit yield and its quality. The highest fruit yield was obtained when the primary umbel was matured completely with values of 34.8 and 36.42 g/ plant for the first and second seasons, respectively, followed by stage 3 (the secondary umbels colour was changed) and stage 5 (the primary umbel became brown). Harvesting anise fruits early at stage 1 (the primary umbel was at the beginning of waxy stage) or late at stage 7 (the primary umbels were easily dropped off) or stage 8 (the primary umbels were falling) resulted in a considerable reduction in fruit yield reached to 43.26, 35.64 and 49.25 % for stage 1 (the primary umbel was at the beginning of waxy), stage 7 and stage 8 ,respectively when compared with stage 4 as an average of the two seasons. This may be because in early harvesting a large amount of the fruit was immature and in late harvesting fruit yield declining mainly due to fruit shattering.

Thousand fruit weight (Seed index) is an important yield parameter which has direct impact on the crop's final yield and quality of the fruit. By observing the average seed index value for 8 harvesting stages, its varied between 2.69 and 4.89 g in the first season and 2.75 and 4.97 g in the second season. It can be concluded that there were significant differences between different maturity stages. The highest values were obtained in at the fourth harvesting stage in both growing season. The lowest values were noted at the first harvesting stage (the primary umbel was at the

beginning of waxy stage) in both growing seasons. This may be due to dominance of immature and small fruits which light in weight.

From table (1) the germination percentage started with 44 and 45 % for the first and second season ,respectively from fruits harvested at the first maturity stage when the primary umbel was at the beginning of waxy stage and increased gradually to reach its maximum at the fourth maturity stage when the primary umbel was matured completely and recorded 68 and 70 % for the first and second season respectively. The remaining 32 and 30 % of seeds did not germinate after that. There were no significant changes in germination of seeds after the fourth stage in the first season while the differences were slight in the second season

In this concern, Harrington, (1972) reported that harvesting seeds before physiological maturity as defined the point when fruit reaches maximum dry weight resulted in lighter fruit, reduced viability and low fruit yield. Moreover, Özel, (2009a) observed that there was a positive correlation between seed index and the fruit yield for anise. Our results are in harmony with Majid et *al.,* (2014) they reported that delaying anise harvesting time, fruit yield and seed index significantly decreased.

**Table 1. Effect of maturity stages on anise fruit yield , seed index and germination percentage during 2013/2014 and 2014/2015 seasons**

| Treatments | fruit Yield g/plant | | Seed Index g | | Germination Percentage | |
|---|---|---|---|---|---|---|
| | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Stage 1 | 19.56 | 20.85 | 2.69 | 2.75 | 44 | 45 |
| Stage 2 | 24.84 | 26.21 | 3.15 | 3.34 | 52 | 54 |
| Stage 3 | 29.89 | 31.34 | 4.24 | 4.31 | 60 | 60 |
| Stage 4 | 34.80 | 36.42 | 4.89 | 4.97 | 68 | 70 |
| Stage 5 | 29.57 | 31.01 | 4.15 | 4.19 | 68 | 69 |
| Stage 6 | 27.28 | 28.69 | 3.99 | 4.06 | 67 | 68 |
| Stage 7 | 22.25 | 23.59 | 3.84 | 3.89 | 68 | 68 |
| Stage 8 | 17.36 | 18.63 | 3.71 | 3.76 | 67 | 67 |
| LSD 5% | 1.96 | 1.67 | 0.20 | 0.63 | 1.5 | 1.6 |

**Essential oil percentage, oil yield and GC mass of essential oil**

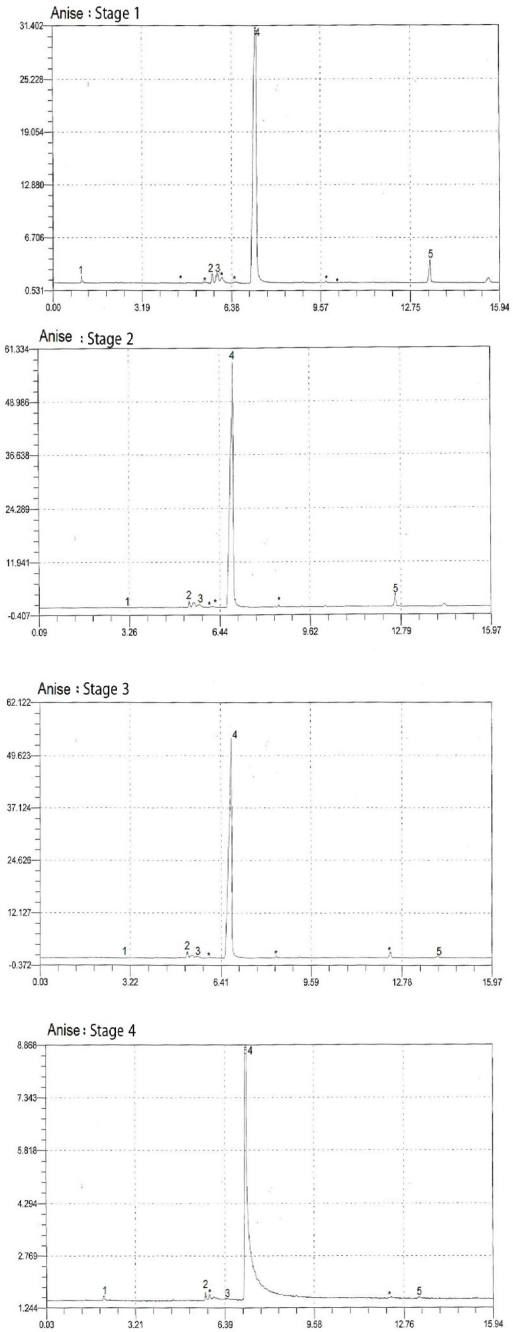
It is clear from data in Table (2) that the essential oil yield per plant trend had similarities variations as those of fruit yield per plant in Table (1). On the other hand, essential oil percentage had a regular trend with reduction from the first harvest stage to the last one. The different fruit development stages had a significant effect on both essential oil percentage and yield in both seasons. A significantly higher concentration of essential oil (4.82% and 4.95%) was synthesized from the first harvesting stage (the primary umbel was at the beginning of waxy stage) in both growing seasons, while the highest essential oil yield per plant (1.57 and 1.68 ml /plant) was of the fourth harvesting stage (the primary umbel was matured completely) in both seasons, respectively.

**Table 2. Effect of maturity stages on anise essential oil percentage , essential oil yield and GC during 2013/2014 and 2014/2015 seasons**

| Treatments | Essential Oil % | | Oil Yield ml /plant | | Essential Oil Constitutes | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1st Season | 2nd Season | 1st Season | 2nd Season | ρ-Cymene | Linalool | Methyl chavicol | Trans-Anethole | Anise aldehyde |
| Stage 1 | 4.82 | 4.95 | 0.94 | 1.03 | 0.77 | 1.25 | 2.19 | 88.38 | 4.20 |
| Stage 2 | 4.73 | 4.85 | 1.17 | 1.27 | 0.57 | 1.42 | 1.35 | 90.65 | 2.98 |
| Stage 3 | 4.62 | 4.71 | 1.38 | 1.48 | 0.13 | 3.15 | 0.58 | 93.09 | 1.60 |
| Stage 4 | 4.51 | 4.6 | 1.57 | 1.68 | 0.12 | 3.39 | 0.34 | 94.20 | 1.53 |
| Stage 5 | 3.81 | 3.9 | 1.13 | 1.21 | 0.20 | 2.68 | 2.23 | 92.07 | 1.34 |
| Stage 6 | 3.51 | 3.61 | 0.96 | 1.04 | 0.26 | 0.93 | 2.27 | 90.83 | 0.84 |
| Stage 7 | 3.27 | 3.31 | 0.73 | 0.78 | 0.25 | 0.91 | 3.29 | 90.37 | 2.17 |
| Stage 8 | 3.09 | 3.2 | 0.54 | 0.60 | 0.28 | 0.81 | 3.45 | 88.99 | 3.20 |
| LSD 5% | 0.54 | 0.35 | 0.17 | 0.13 | -- | -- | -- | -- | -- |

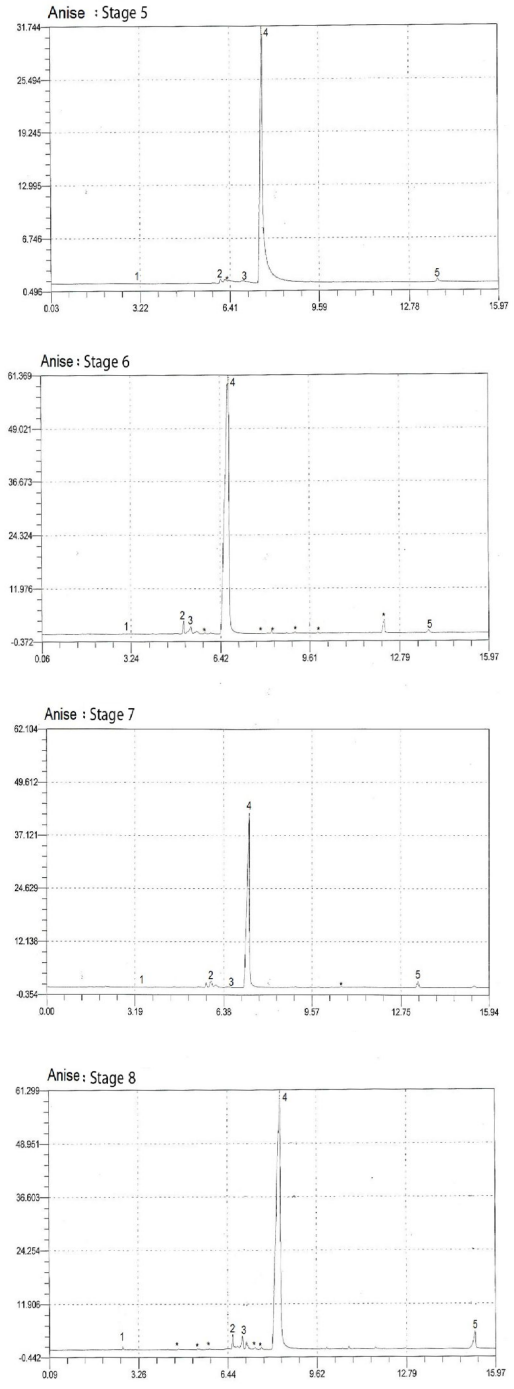
Essential oil composition was determined using GC analysis technique and a total of five components were identified of second season anise essential oil in the same table and figures (1 and 2). It was found that the major component was *trans*-Anethole with the range of 88.38% to 94.20%. The second most abundant component was Anise aldehyde with ranged from 0.84% to 4.20%. The other components were present, Methyl chavicol (Estragol) ranged from 0.34% to 3.45% and Linalool ranged from 0.81% to 3.39%. Anise essential oil percentage showed is higher than 2% with a limit Methyl chavicol of 0.5% to 0.6% as the accordance of European Pharmacopoeia (European Pharmacopoeia, 2000). The high essential oil percentage in early fruit development could be attributed to higher number of fruits per weight unit. Also the high Anethole percentage at the third and fourth stages could be connected to the increase of amount of waxy fruits in newly matured umbels (the same harvest stage had fruits with different maturity levels (Özel, 2009b). Based on the previous results the stage 4 (the primary umbel was matured completely) had highest oil yield (1.63ml/plant) with 4.56% essential oil (an average of two seasons) and composition of 94.20% Trans-Anethole and 0.34% Methyl chavicol, followed by stage 3 (the secondary umbels colour was changed) which had 1.43 ml/plant oil yield with 4.67% essential oil (an average of two seasons) and composition of 93.09% *trans*-Anethole and 0.58% Methyl chavicol had a high chance for European Pharmacopoeia demand. In

addition, anise essential oil can cause gastric protection, muscle relaxation, reduce dependence of morphine, hypolipidemic and hypoglycemic effects, and so on (Shojaii and Fard 2012). This allows new usage of the active constituents in a new field of medicine industries. Moreover, Naher *et al.*,( 2012) concluded that a slight variation of essential oil content and composition of anise depends on several factors such as genotype and stage of maturity. Our results were in agreement with those of Omidbaigi *et al.,* 2003, Özel, 2009 b and Majid *et al.,* 2014 on anise.




**1= ρ- Cymene 2= Linalool 3= Methyl chavicol**
**4= Trans-Anethole 5= Anise aldehyde *= Unknown compounds**

**Figure 1. Effect of harvesting stages (1-4) on the essential oil components (%) of anise during 2014/ 2015 season.**




**1= ρ- Cymene 2= Linalo l 3= Methyl chavicol**
**4= Trans-Anethole 5= Anise aldehyde *= Unknown compounds**

**Figure 2. Effect of harvesting stages (5-8) on the essential oil components (%) of anise during 2014/ 2015 season.**

**Biochemical constituents**

The evaluation of different biochemical constituents content during the different maturity stages was reported in Table (3). The biochemical constituents were significantly affected by the fruits development stages. The accumulation of total carbohydrates began slowly and increased significantly during fruits maturation to reach the maximum value (43.5% and 42.81%) at stage8 (the primary umbels were falling) in both seasons, respectively. Accumulation of total fat

had the same trend and reached the maximum value (19.93% and 20.96%) in both seasons, respectively. On contrast the accumulation of crude protein started quick during the first development stages and decreased significantly during the late development stages to reach the minimum value (9.95% and 10.14%) at stage8 in the first and second seasons, respectively. Ash varied with the variation of fruits development during the different stages and had the highest value at stage 4 followed by stage 3. It was suggested that lignin-carbohydrate-protein complexes from anise fruits potency possessed ingredient functional food against the infectious diseases (Lee *et al.,* 2011). High content of total fat at the late fruits development stages had high content of petroselinic acid for many industrial purposes. However first stages had a high healthy nutritional value due to the presence of linoleic acid (has antioxidants activities) and DHGLA (C20:3n-6, dihomo--y-linolenic acid) which possess anti-viral and anti-cancer inhibitors (Msaada *et al.,* 2009b).

**Table 3. Biochemical constituents of anise fruits as affected by harvesting stages during 2013/2014 and 2014/2015 seasons.**

| Treatments | Total Carbohydrates | | Crude Protein | | Total Fat | | Ash | |
|---|---|---|---|---|---|---|---|---|
| | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Stage 1 | 19.17 | 18.27 | 21.91 | 22.79 | 9.19 | 9.92 | 4.81 | 4.95 |
| Stage 2 | 23.24 | 22.52 | 19.45 | 20.16 | 10.41 | 10.97 | 6.17 | 6.34 |
| Stage 3 | 24.65 | 23.95 | 17.32 | 18.63 | 12.98 | 12.99 | 9.19 | 9.4 |
| Stage 4 | 27.1 | 26.31 | 15.9 | 16.87 | 14.25 | 14.91 | 10.84 | 10.69 |
| Stage 5 | 32.91 | 31.85 | 13.58 | 14.73 | 15.97 | 16.27 | 8.78 | 8.96 |
| Stage 6 | 36.59 | 35.95 | 12.96 | 13.13 | 17.15 | 18.11 | 7.65 | 7.8 |
| Stage 7 | 40.28 | 38.78 | 11.96 | 12.99 | 18.89 | 19.95 | 7.01 | 7.16 |
| Stage 8 | 43.5 | 42.81 | 9.95 | 10.14 | 19.93 | 20.96 | 5.85 | 5.98 |
| LSD 5% | 2.25 | 1.70 | 1.60 | 1.50 | 1.42 | 1.79 | 0.63 | 0.66 |

The changes in nitrogen, phosphorus and potassium percentages during the fruits maturation were shown in Table (4). Nitrogen decreased markedly from the first maturity stage (3.51% and 3.65%) to the last stage (1.59% and 1.62%) in the first and second season, respectively. Phosphorus and potassium were varied with the variation of fruits development stages. Stage4 (the primary umbel was matured completely) had the highest percentage of phosphorus (0.471% and 0.475%) and potassium (2.26%and 2.29%) followed by stage 3 (the secondary umbel colour was changed) in both seasons, respectively. From different constituents data, it is appeared that the maturity stage of the primary umbel was matured completely (stage4) was the most suitable one for nutrition and materials in food and pharmaceutical purposes. The obtained results were in the same line of the results of Gupta *et al.,* 1995 on fennel, Msaada *et al.,* 2009a and Nguyen *et al.,* 2015 on coriander.

**Table 4. Nitrogen, phosphorus and potassium percentages of anise fruits in response to harvesting stages during 2013/2014 and 2014/2015 seasons**

| Treatments | N% | | P% | | K% | |
|---|---|---|---|---|---|---|
| | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Stage 1 | 3.51 | 3.65 | 0.397 | 0.402 | 1.48 | 1.52 |
| Stage 2 | 3.11 | 3.23 | 0.422 | 0.426 | 1.74 | 1.77 |
| Stage 3 | 2.77 | 2.98 | 0.464 | 0.466 | 2.15 | 2.18 |
| Stage 4 | 2.54 | 2.70 | 0.471 | 0.475 | 2.26 | 2.29 |
| Stage 5 | 2.17 | 2.36 | 0.452 | 0.453 | 2.07 | 2.16 |
| Stage 6 | 2.07 | 2.10 | 0.441 | 0.443 | 2.01 | 2.11 |
| Stage 7 | 1.91 | 2.08 | 0.427 | 0.431 | 1.85 | 1.88 |
| Stage 8 | 1.59 | 1.62 | 0.411 | 0.415 | 1.61 | 1.63 |
| LSD 5% | 0.26 | 0.24 | 0.11 | 0.13 | 0.68 | 0.55 |

The correlation coefficient for the relationship between fruit yield per plant and seed index (R=0.788), essential oil yield per plant (R=0.887), phosphorus percentage (R=0.943) and potassium percentage (R=0.939) was high and positively correlated at the different maturation stages of fruits Table (5). The results of this work also showed positively correlation between essential oil yield per plant and essential oil percentage (R=0.732), crude protein (R=0.525), phosphorus percentage (R=0.758) and potassium percentage (R=0.701). Moreover, the correlation coefficient for the relationship between the germination percentage and seed index (R=0.813) was high and positively at the different fruits development stages. These results could lead to determine the suitable harvest stage which is favorable for the idea of functional fruits for better human health, medicine and food industry and seed viability.

**Table 5. Correlation coefficients for the relationships between the different characters (as average of the two seasons) of anise at different maturity stages.**

| | FY | S. index | G% | E. Oil% | OY/p | TC | CP | TF | Ash | N% | P% | K% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FY | 1 | .788* | .385 | .346 | .887** | -.287- | .116 | -.169- | .936** | .116 | .943** | .939** |
| S. index | .788* | 1 | .813* | -.194- | .505 | .282 | -.450- | .415 | .942** | -.450- | .916** | .909** |
| G% | .385 | .813* | 1 | -.712-* | -.050- | .767* | -.865-** | .839** | .612 | -.865-** | .575 | .627 |
| E. Oil% | .346 | -.194- | -.712-* | 1 | .732* | -.988-** | .951** | -.967** | .101 | .951** | .132 | .046 |
| OY/p | .887** | .505 | -.050- | .732* | 1 | -.671- | .525 | -.572- | .741* | .525 | .758* | .701 |
| TC | -.287- | .282 | .767* | -.988-** | -.671- | 1 | -.980-** | .986** | -.026- | -.980-** | -.056- | .013 |
| CP | .116 | -.450- | -.865-** | .951** | .525 | -.980-** | 1 | -.989-** | -.154- | 1.000** | -.123- | -.184- |
| TF | -.169- | .415 | .839** | -.967-** | -.572- | .986** | -.989-** | 1 | .114 | -.989-** | .075 | .139 |
| Ash | .936** | .942** | .612 | .101 | .741* | -.026- | -.154- | .114 | 1 | -.154- | .988** | .972** |
| N% | .116 | -.450- | -.865-** | .951** | .525 | -.980-** | 1.000** | -.989-** | -.154- | 1 | -.123- | -.184- |
| P% | .943** | .916** | .575 | .132 | .758* | -.056- | -.123- | .075 | .988** | -.123- | 1 | .985** |
| K% | .939** | .909** | .627 | .046 | .701 | .013 | -.184- | .139 | .972** | -.184- | .985** | 1 |

**FY=fruit yield/plant, S. index=seed index, G%=germination percentage, E. Oil%=essential oil percentage, OY/p=essential oil/plant, TC=total carbohydrates, CP=crude protein, TF=total fat**
***. Correlation is significant at the 0.05 level (2-tailed).**
****. Correlation is significant at the 0.01 level (2-tailed).**

## CONCLUSION

Since, the highest yields of fruits, essential oil and Trans-Anethole were obtained from the fourth harvesting stage when the primary umbel was matured completely, this harvesting stage was considered to be the most appropriate harvesting stage for anise fruits.

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## تأثير مراحل النضج المختلفة على المحصول الثمرى و محتوى الزيت الطيار فى بعض نباتات العائلة الخيمية
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تم دراسة تأثير حصاد ثمار اليانسون فى مراحل نضج مختلفة على الإنتاج الثمرى ومحتوى الزيت الطيار و مكوناته فى اليانسون وذلك بإجراء تجربتين حقليتين فى المزرعة البحثية بالبرامون- محطة بحوث البساتين بالمنصورة- معهد بحوث البساتين – مركز البحوث الزراعية- مصر خلال موسمي الزراعة ٢٠١٣/ ٢٠١٤ و ٢٠١٤/ ٢٠١٥ . وكان من أهم النتائج المتحصل عليها أن أعلى محصول ثمرى و جودته تم الحصول عليهما عندما حصدت ثمار اليانسون فى المرحلة الرابعة من مراحل نضج الثمار . أما النسبة المئوية للزيت الطيار فى ثمار اليانسون فقد وصلت قمتها عندما حصدت الثمار مبكرا في المرحلة الأولى من مراحل نضج الثمار إلا أن هذه الزيادة فى النسبة المئوية للزيت الطيار لم تعطى أعلى محصول من الزيت الطيار للنبات وذلك لأن حصاد الثمار مبكرا فى المرحلة الأولى من مراحل نضج الثمار أعطى أقل محصول ثمرى للنبات. بينما حقق حصاد الثمار فى المرحلة الرابعة من مراحل نضج الثمار أعلى محصول ثمري للنبات بأعلي محصول من الزيت الطيار للنبات و كذلك أعلى محتوى من المركب الرئيسى و هو الترانس أنيثول . وبصفة عامة فإنه للحصول على أعلى محصول ثمرى ذو جودة عالية من حيث أعلى محصول للزيت الطيار بأعلي محتوى من الترانس أنيثول و كذلك نسبة الانبات ووزن الالف بذرة يمكن التوصية بحصاد ثمار اليانسون فى المرحلة الرابعة من مراحل نضج الثمار.

**الكلمات الرئيسية** : اليانسون ، المحصول الثمرى ، الإنبات ، الزيت الطيار ، مرحلة الحصاد ، النضج .