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Enhancing Fruit Quality and Storability of "Anna" Apple Cultivar by Using Amino Acids, Ethylene and some Nutrients

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ABSTRACT

This investigation was conducted during 2011 and 2012 seasons in an orchard located at El-Nubaria Horticulture station, Behera governorate on "Anna" apple trees (*Malus domestica* L.) budded on Malus rootstock to study the possibility of improving fruit colour and enhancing storability through spraying with ethylene (2cm/L) as ethephone, amino acids (2gm/L), Landamine (32% P_2O_5 + 35%K_2O + 1.6%B + 0.4% Mo) (3cm/L), Keap (11.5% B + 13.0% Mo) (3cm/L), Saccon (9 % N + 25 % P + 0.3 % Fe + 0.3 % Mn + 0.3 % Zn + 0.1% Cu + 0.005 % Mo) (3cm/L) and KNO_3 (3gm/L). All these substances were sprayed in combined with amino acids 14 days pre-harvest. The chosen trees were four years old and grown on sandy loam soil, spaced at 5 X 5 meters apart, irrigated by drip irrigation system. The present results cleared that, spraying amino acids alone or combined with these substances resulted enhancing in the skin colour peel specially ethylene (E) + amino acids (A). Amino acids alone improved storability of "Anna" apple fruits decreased decay in both seasons. Moreover, adding amino acids to ethylene, Landamine, Keap, KNO_3 and Saccon decreased decay %. Furthermore, it resulted in decreasing firmness loss of fruits which were treated with KNO_3 in both seasons. In addition, decreased the weight loss % of fruits which were treated with Landamine or Keap in both seasons. Moreover, KNO_3 + amino acids was enhanced colour, decreased decay % and decreased firmness loss compared to control. On the other hand, Keap + amino acids was enhanced colour, decrease decay %, weight loss % and acidity %. Thus, it is recommended to spray "Anna" apple trees at 14 days before harvest with 2 gm/L amino acids + 3 gm/l KNO_3 or 3 cm/l of Keap to enhance colour and storability of fruits.

Key words: *Malus domestica* L., rootstock, fruit quality and storability, amino Acids, ethylene, nutrients

Introduction

Consumer expectations of quality, defined as all those characteristics of the product leading to their satisfaction, have been steadily increased over the last couple of decades. One of the main quality attributes affecting apple fruit acceptance and price is colour (Abbott, 1999, Kays, 1999).

In recent years, a new group of substances called polyamines (PAs) have been added to the list of growth regulating substances. Essential for life and are naturally found in all living organisms. PAS are multifunctional compounds containing one or more amino groups. Due to the fact that (PAs) demonstrate polycationic characteristics in their cellular PH values they can be easily bound to cellular polyanions DNA, RNA, phospholipids, acidic proteins and cell wall compounds (Unsal, 1990 and Thomas and Thomas, 2001). Amino acids act as buffers which help to maintain favorable PH within the plant cell, since they contain both acid and basic groups they remove the ammonia from the cell this function is associated with amide formation protect the plants against pathogens (Davies,1982).

Amino acids have a chelating effect on micro nutrients when applied together where the absorption and transportation of micro nutrients inside the plant is easier, this effect is due to the chelating action, the effect of cell membrane permeability and low molecular weight (Westwood, 1993).

Also, amino acids as organic nitrogenous compounds are well known to stimulate cell growth and acting as buffers maintaining favorable pH value within the plant cell as well as synthesizing other organic compounds Opike and Rolfe (2005). In addition, Abd El-Baree *et al.*, (2013) found that all treatment "single or combined" (GA_3, Milagrow, Petpon and Folgers) caused obvious increment in fruit quality parameters to the control. The most effectively treatment was spraying "Costata" persimmon trees three times (at full bloom, fruit set and June fruit drop) with a combined treatment of peptone at 1000 ppm + GA_3 at 20 ppm or Milagrow at 50000 ppm + peptone at 1000 ppm + GA_3 at 20 ppm also, El –Shemmar and Yusif, (2014) on tomato found the same results. Many investigators studied the effect of Ethylene spraying on apple fruit trees before harvest and during storage period, and found that all maturity parameters were enhanced, bitter pit was decreased and enhanced red colour

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and senescence breakdown was enhanced (Gil *et al*., 1980, Samra *et al*., 1987, Makarem *et al*., 1990, Makarem *et al*., 1995 and Taha *et al*., 2009).

Hussen, (2014) noticed that there is an increase rate of respiration mainly due to a very high synthesis of the ripening hormone (ethylene, C_2H_4), which has both beneficial and deterimentals "evil" effects depending on the type of commodity.

Removal of ethylene from the atmosphere surrounding apple fruits or limiting their ability to synthesis ethylene and response to it slowed their ripening (Graell and Recasens, 1992; Klee and Clark, 2002). A number of studies have discovered the relationship between the ethylene hormone and polyamines in plants however, the association of these compounds with auxins and cytokinins could not be explained completely (Bouchereau, *et al*., 1999 and Legocka and Zamowaka, 1999 & 2000). Foliar spraying of Aminoethoxy vinylglycine (AVG) on apple trees preharvest suppressed ethylene production during ripening, maintained firmness during storage decreased acidity % and had no effect on TSS (Fallahi, 2007 and Valeria and Douglas, 2009) also, Hegazi, *et al.,* (2014) on grapes.

Potassium is a major nutrient that needs to be supplied in relatively large amount to fruit trees. It is the most abundant cation in the cytoplasm has an important role in PH stabilization, osmoregulation, enzyme activation, protein synthesis and photosynthesis and cell extension (Faust, 1989).

Mode of action for micro – elements was explained by Larue and Johnson, (1989) that Iron (Fe) complexes with proteins to form important enzymes in the plant and associated with chloroplasts where it has some roles in the synthesizing chlorophyll. Zinc (Zn) has been identified as component of almost 60 enzymes therefore it has a role in many plant functions and it has a role as an enzyme in producing the growth hormone IAA. Manganese (Mn) participates in several important processes including photosynthesis and metabolism of both nitrogen and carbohydrate. On the other hand foliar fertilizer as chelate should be rapidly transported and should be easily release their ions to affect the plant.

Moreover, Zewail, (2014) on bean indicated that, foliar sprayed of seaweed (Fe, Zn, Cu, Mn, Mo, Vitamins, enzymes, amino acids, sugars and plant hormones) and amino acids three times on bean increase of photosynthetic pigments and total chlorophyll SPDS. In addition, the most effective treatments was that seaweed at 2 ml/l combined with the amino acids at 4 ml/l.

Therefore, this study was under taken to evaluate abdicative effects of using compounds as amino acids alone or with ethylene and some nutrients as a pre harvest treatment to improve peel colour control postharvest decay and keeping quality of "Anna" apple during cold storage.

Material and Methods

This investigation was conducted during 2011 and 2012 seasons in an experimental orchard located at El-Nubaria Horticulture station, Behera governorate on "Anna" apple trees (*Malus domestica* L.) budded on Malus rootstock to study the possibility of improving fruit colour, enhancing storability and keeping quality through spraying with ethylene and some nutrients 2 weeks before harvest time. The chosen trees were four years old and grown on sandy loam soil, spaced at 5 X 5 meters apart, and irrigated by a drip irrigation system. Twenty one trees as uniform as much as possible were selected for achieving this study for each season. Each treatment was replicated three times with one tree acting as a replicate. Trees were of normal growth, uniform in vigour and received normal fertilization and cultural practices as scheduled in the farm. The experiment involved the following treatments:

1. Control trees sprayed with water.
2. Amino acids (A) consist of (80% total amino acids + 20% free amino acids) at 2gm/L.
3. Ethylene (E) at 2cm/L as (ethephone) + Amino acids (A).
4. Landamine (Lm) (32%P_2O_5 + 35%K_2O + 1.6%B + 0.4%Mo) at 3cm/L + Amino acids (A).
5. Keap (Kp) (11.5% B + 13.0%Mo) at 3cm/L + Amino acids (A).
6. Saccon (S) (9%N + 25%P + 0.3%Fe + 0.3%Mn + 0.3%Zn + 0.1%Cu + 0.005%Mo) at 3cm/L + Amino acids (A).
7. Potassium nitrate (KNO_3) at 3.0gm/L + Amino acids (A).

* Notice: The above compounds were references to the Company Plant Impact.

The following parameters were adopted to evaluate the tested treatments at maturity:-

Fruit colour:

Colour (Hue angle) of fruits was estimated by Konick Minolta, Chroma Meter CR-400/410 for the estimation of Hue angle as described by Mcgire, (1992).

Storability

Samples of thirty fruits were collected at maturity as previously identified date (June 14 and June 19) for the first and second seasons, respectively and stored tow cartoon boxes were taken from each considered tree (replicate) and placed in cold storage (0^oC and 90-95% relative humidity R.H.) one box was used to assess both the percentage of weight loss and decay every 15 days while the other was used to assess changes in physical and chemical properties every 15 days up till 105 days (Makarem *et al*., 1995) at (0ºC - 95%RH) in the two seasons of the experiment to determine physical and chemical properties:

The changes occurring in physical and chemical properties of the stored fruits were estimated after 0, 15, 30, 45, 60, 75, 90 and 105 days as follows:

Physical characteristics of fruits:

- Fruit colour: Intensity of colour was measured by Konick Minolta, Chroma Meter CR-400/410 for the estimation of Hue angle as described by Mcgire, (1992).
- Fruit weight loss (%) per box was determined periodically according to the equation percentage of weight loss = (initial weight – weight at that date)/ Initial fruit x 100).
- Decay (%) per box was calculated periodically according to the equation (weight of decayed X 100 / the initial weight of box).
- Fruit firmness (g/cm^2) was estimated on three apple fruits per treatment through the use of texture analyzer instrument using a penetrating cylinder of 3mm in diameter to a constant distance 2 mm inside the fruit skin by a constant speed 2mm per sec. and the peak of resistance force of the skin was recorded periodically.

Chemical characteristics of fruits:

- Percentage of total soluble solids in fruit juice (TSS %) was recorded periodically using a hand refractometer.
- Total titratable acidity as malic acid (%) was also determined periodically as (A.O.A.C., 2000).

Statistical analysis:

The complete randomized block design was adopted for the experiment. The statistical analysis of the present data was carried out according to Snedecor and Cochran (1990). Averages among treatments were compared using L.S.D. values at 5% level. In addition, regression equations as well as correlation coefficient were assessed between residual ethylene in fruits and its effect on decay percentage throughout the storage period.

Results

I-At harvest assessments:

- *Color (Hue angle):-*

Data in Table (1) cleared that, amino acids enhanced red skin color as alone or combined with nutrients compared to control in both seasons. Ethylene + amino acid gave the highest red skin colour (95.81 and 104.35) followed by amino acids (A) and KNO_3 + A. While the lowest value was recorded by control (114.67 and 110.32) respectively in both seasons. These results are in line with, Vitrac *et al*., (2000) who suggested that, effects of N on apple coloration remain unclear but it may act adversely and interfere with synthesis of sugar and anthocyanin, but Hussein *et al*., (1992) who indicated that, amino acids treatment resulted insignificant increase in chlorophyll a and b in Datura leaves while, carotenoids significantly decreased. Moreover, Malik and Singh (2006) obtained fruit skin colour increase due to the use of aqueous solutions of Pas (Putrescine, Spermine and Spermidine) containing a surfactant "Tween 20" sprayed onto panicles of mango cv. "Kensington pride", at the final fruit set stage and at the rates of 0, 0.01, 0.1 and 1 mμ. the best treatment was Pas plus Tween 20 at 1 mμ. Sabry *et al*., (2009) found that the anthocyanin content in the berry skin of "Red Globe" grapes increased when treated with effective micro-organisms (EM) at 10 and 20 cm/vine, seaweed extract (Gifert) at 10 and 20 cm/vine, and amino acids (peptone) at 0.5 and 1 g/vine on three dates: after bud burst stage, after fruit stage, and at Veraison stage. The best treatment was the amino acids (Peptone) at 1 g/vine. Furthermore, Ibrahim *et al*., (2010) stated that, higher concentration of adenine and cytosine amino acids increased the photosynthetic pigments of plants, also, Abd El-Rahman (2011) on peach, showed that the positive effect on anthocyanin content was observed under amino acids + KNO_3 also Abd El-Baree *et al*., (2013) on "Costata" persimmon. Furthermore, Hegazi *et al*., (2014) on grape spray clusters with citric or acitic acid combined with ethylene as preharvest treatments presented a higher anthocyanin content in berry skins, and Al-Shemmar and Yusif (2014) on tomato indicated that arginine spray treatment increased beta-carotene percentage as compared to control and Zewail (2014) on Bean.

II-Storability

Fruit colour

The present data in Table (2) and Fig. (1) Indicated that amino acids treatment as alone decreased red skin coloration (high Hue angle value) in the first season while, it increased in the second season compared to control. On the other hand, ethylene (E) + amino acids (A) gave the highest red skin coloration after cold storage period (90.27 and 93.05 Hue angle) followed by Keap. (Kp) + amino acids (A) and KNO_3 + A in both seasons. Regarding the prolonged period the highest red skin coloration was after 75 days in both seasons. Concerning the interaction, (E + A) after 60 days resulted in the highest red skin color while (A) after 15 days and (Lm + A) and (Lm + A) after 45 days caused the lowest red skin color during the first season. While (E + A) after 15 days was the highest red skin color and control was the lowest red skin coloration after 105 days in the second season. These results are in harmony with, Refaat and Naguib (1998) as well as Abo-Sedra *et al*., (2010) and Ibrahim *et al*., (2010) they reported that amino acids spray may have important role on the biosynthesis of chlorophyll molecules and in turn affected carbohydrate content. Furthermore, Hegazi *et al*., (2014) on grape and Al-Shemmar and Yusif (2014) on tomato. Contrarily, Awad *et al*., (2004) indicated that red colour formation of apple fruit was inhibited by 250 or 500 ppm (s)-trans-2-amino-4- (2-aminocthoxy)-3- butenoic acid hydrochlgric (ABG-3168/Retain, Abbott), while low content had less negative impact fruit red colour formation.

Table 1: Effect of different treatments on skin colour of Anna apple in both seasons

Treatments	Fruit colour (Hue angle)	
	First season	Second season
Control	114.67	110.32
A	106.74	105.00
E + A	95.81	104.35
Lm + A	111.52	103.94
Kp + A	112.52	105.28
KNO3 + A	106.77	107.21
S + A	111.87	108.02
LSD at (0.05)=	3.790	3.065

A: Amino acids E: Ethylene Lm: Landamine Kp: Keap KNO3: Potassium nitrate S: Saccon

Table 2: Effect of treatments and cold storage at 0°C and 95%RH on fruit external colour (Hue angle) after storage period

Treat.	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	114.67	101.00	97.73	112.74	111.89	107.42	111.69	110.40	108.44
A	106.74	113.82	110.33	112.04	113.04	113.45	108.54	111.83	111.22
E + A	95.81	92.18	95.04	92.45	75.12	87.08	90.55	93.96	90.27
Lm + A	111.52	112.00	110.98	113.82	108.01	105.61	105.23	109.39	109.57
Kp + A	112.52	105.63	113.28	106.34	102.29	89.17	105.97	107.47	105.33
KNO_3 + A	106.77	105.65	108.01	107.77	108.57	107.07	106.84	105.38	107.01
S + A	111.87	107.93	110.04	111.34	109.03	106.66	105.86	108.38	108.89
Ave. (B)	108.56	105.46	106.49	108.07	103.99	102.35	104.95	106.69	
	Second season								
Control	110.32	107.65	106.24	101.08	109.20	106.86	109.84	112.17	107.92
A	105.00	100.00	105.90	104.34	100.05	101.84	105.85	107.46	103.80
E + A	104.35	73.59	97.36	91.34	94.48	91.99	96.28	94.99	93.05
Lm + A	103.94	109.40	104.12	104.19	104.41	101.75	103.84	103.35	104.37
Kp + A	105.28	105.86	105.89	107.04	106.03	104.07	107.76	102.70	105.58
KNO_3 + A	107.21	106.02	104.87	104.17	106.61	101.59	104.81	102.70	104.75
S + A	108.02	109.32	106.57	107.52	107.14	104.60	107.50	107.79	107.31
Ave. (B)	106.30	101.69	104.42	102.81	103.99	101.81	105.13	104.45	
LSD at 5% for:				First		Second			
Factor A (Treatments) =				1.468		1.511			
Factor B (Date of cold storage)=				1.373		1.414			
Interaction AXB =				2.883		3.999			

A: Amino acids E: Ethylene Lm: Landamine Kp: Keap KNO3: Potassium nitrate S: Saccon

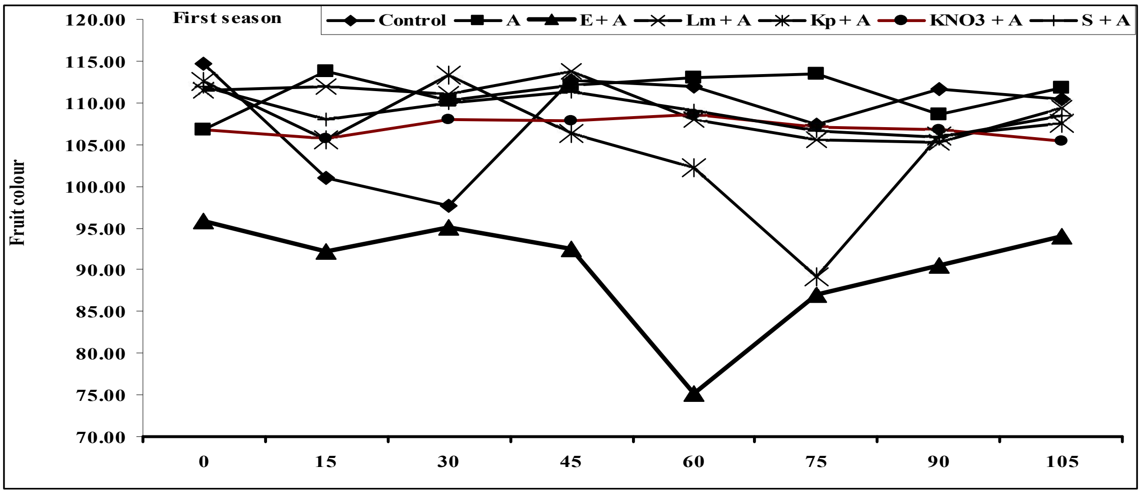

Fig. 1: Effect of treatments and cold storage at 0°C and 95%RH on fruit external colour (Hue angle) after storage period in the first season.

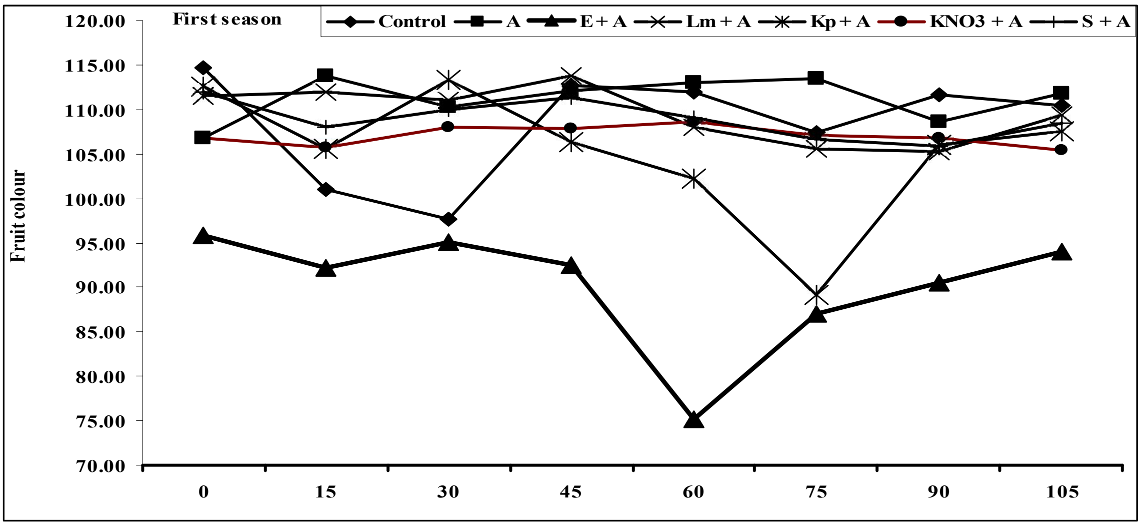

Fig. 2: Effect of treatments and cold storage at 0°C and 95%RH on fruit external colour (Hue angle) after storage period in the second season.

Fruit weight loss

Data in Table (3) show that, all treatments were significantly increased weight loss (%) compared to control except (Keap + A) and (Lm + A) in the first season. While (Keap + A), (Lm + A) and amino acid in the second season. On the other hand ethylene (E) + amino acid (A) was the highest percentage (22.90 and 22.59). while Keap (Kp) + A had the lowest in both seasons (7.42 and 9.12). Regarding the prolonged period weight loss (%) increased during the storage period and continued until the end of the period. The highest weight loss % was recorded at 105 days in both seasons. The interaction cleared that (E + A) recorded the highest weight loss % at 105days, while (Kp + A) showed the lowest % at 15 days in both seasons. These results are in line with Al-Shemmar and Yusif (2014) indicated that, arginin amino acids spray treatment significantly decrease weight loss % compared to control. Also, Hegazi *et al.*, (2014) on grapes found that, spray clusters with citric or acetic acid combined with ethylene as pre harvest treatments reduced the total loss of cluster weight due to their effect on reducing decayed berries and berry shatters.

Table 3: Effect of treatments and cold storage at 0°C and 95% RH on fruit weight loss (%) after storage period.

Treat.	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	0.00	5.16	7.30	9.98	12.88	16.00	18.91	21.24	11.43
A	0.00	4.77	8.30	11.06	14.07	16.38	19.46	21.85	11.99
E + A	0.00	9.46	15.04	20.46	26.23	31.58	37.88	42.54	22.90
Lm + A	0.00	5.50	5.50	8.62	11.25	14.43	18.13	20.36	10.47
Kp + A	0.00	2.90	4.37	5.24	7.71	10.57	13.45	15.10	7.42
KNO_3 + A	0.00	7.85	11.25	15.62	20.04	23.96	29.03	32.60	17.54
S + A	0.00	5.53	8.39	11.21	14.49	17.74	22.85	25.66	13.23
Ave. (B)	0.00	5.88	8.59	11.74	15.24	18.67	22.82	25.62	
	Second season								
Control	0.00	6.10	9.14	12.07	15.33	18.55	21.99	24.69	13.48
A	0.00	5.40	8.21	10.90	13.76	16.50	19.60	22.01	12.05
E + A	0.00	9.82	14.93	19.60	25.08	31.80	37.44	42.05	22.59
Lm + A	0.00	6.03	6.03	9.39	13.03	16.52	20.19	22.68	11.73
Kp + A	0.00	3.58	4.82	6.82	9.85	12.76	16.57	18.61	9.12
KNO_3 + A	0.00	7.87	12.10	16.44	20.48	24.90	29.61	33.25	18.08
S + A	0.00	6.53	11.63	14.79	18.71	23.79	28.47	31.97	16.99
Ave. (B)	0.00	6.48	9.55	12.86	16.61	20.69	24.84	27.89	
LSD at 5% for:				First		Second			
Factor A (Treatments) =				0.488		0.521			
Factor B (Date of cold storage)=				0.456		0.487			
Interaction AXB =				1.291		1.378			

A: Amino acids E: Ethylene Lm: Landamine Kp: Keap KNO_3: Potassium nitrate S: Saccon

Decay

Data in Table (4) and Fig. (2) cleared that, amino acids as alone or combined with nutrients, decreased decay % in both seasons except (E + A) which had no effect in the first season. Moreover, Kp + A had the most positive effect (lowest decrease in decay %) followed by (Lm + A) and (KNO_3 + A) in both seasons. Concerning the prolonged period, decay % was increased started at 30 days then continued until the end of storage period in both seasons for control and some treatments, while Kp + A, KNO_3 + A and S + A treatments (in both seasons) as well as Lm + A treatment (at 1st season) started after 60 days of cold storage. Regarding the interaction, the highest decay % was recorded by (E + A) treatment at 105 days in both seasons (35.23 and 38.42 %), respectively during cold storage. While amino acid as alone resulted in lowest decay percent at 30 days in both seasons.

These results are harmony with, adding amino acids inhibition the activity enzymes which responsible of ethylene formation (El-Hammady *et al*.,1999, Awad *et al*., (2004) who found that, the occurrence of browning was greatly decreased during cold storage of "Anna" apple fruits by ABG application. Abd El-Baree *et al*., (2013) found that, Milagrow + Pepton and Pepton + GA_3 treatments clearly stretched the fruit self life to 90 days in the cold storage (at 5 °C) than control of "Costata" persimmon as well as Al-Shemmar and Yusif (2014) on tomato and Hegazi *et al*., (2014) on grape.

Table 4: Effect of treatments and cold storage at 0ºC and 95%RH on decay (%) after storage period

Treatments	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	0.00	0.00	5.00	8.00	12.00	20.00	25.00	30.00	12.50
A	0.00	0.00	0.00	0.00	5.41	8.27	15.41	20.49	6.20
E + A	0.00	0.00	2.08	5.16	12.45	20.29	25.37	35.23	12.57
Lm + A	0.00	0.00	0.00	0.00	5.12	10.35	15.41	25.16	7.01
Kp + A	0.00	0.00	0.00	0.00	8.27	15.07	20.26	25.31	8.61
KNO_3 + A	0.00	0.00	0.00	0.00	5.45	8.41	15.44	20.36	6.21
S + A	0.00	0.00	0.00	0.00	8.43	17.09	25.27	30.41	10.15
Ave. (B)	0.00	0.00	1.01	1.88	8.16	14.21	20.31	26.71	
	Second season								
Control	0.00	0.00	5.00	9.00	12.00	20.00	22.00	35.00	12.88
A	0.00	0.00	1.75	3.05	9.41	18.26	22.31	25.41	10.02
E + A	0.00	0.00	2.60	5.41	10.35	15.46	22.09	38.42	11.79
Lm + A	0.00	0.00	2.55	5.23	15.12	20.31	22.35	27.19	11.59
Kp + A	0.00	0.00	0.00	0.00	5.29	12.25	21.37	25.37	8.04
KNO_3 + A	0.00	0.00	0.00	0.00	10.16	20.42	22.26	25.13	9.75
S + A	0.00	0.00	0.00	0.00	8.47	11.39	15.39	22.49	7.22
Ave. (B)	0.00	0.00	1.70	3.24	10.11	16.87	21.11	28.43	
LSD at 5% for:		First		Second					
Factor A (Treatments) =		0.619		0.598					
Factor B (Date of cold storage)=		0.579		0.560					
Interaction AXB =		1.639		1.584					

A: Amino acids *E: Ethylene* *Lm: Landamine* *Kp: Keap* *KNO₃: Potassium nitrate* *S: Saccon*

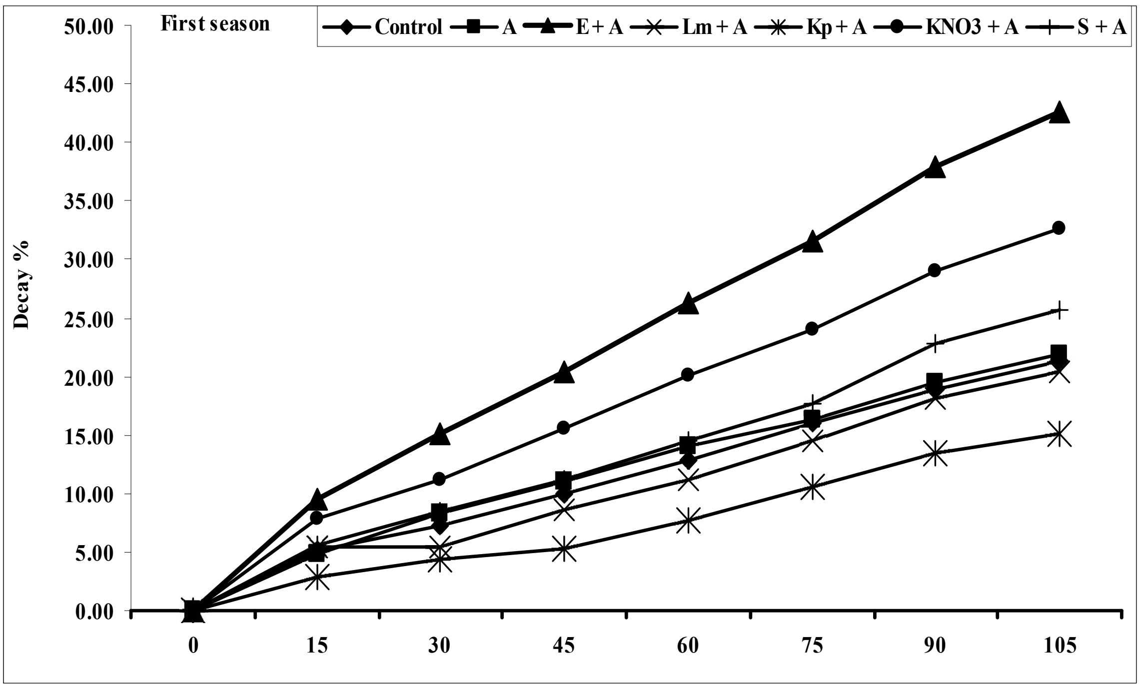

Fig. 3: Effect of treatments and cold storage at 0ºC and 95%RH on decay (%) after storage period in first season.

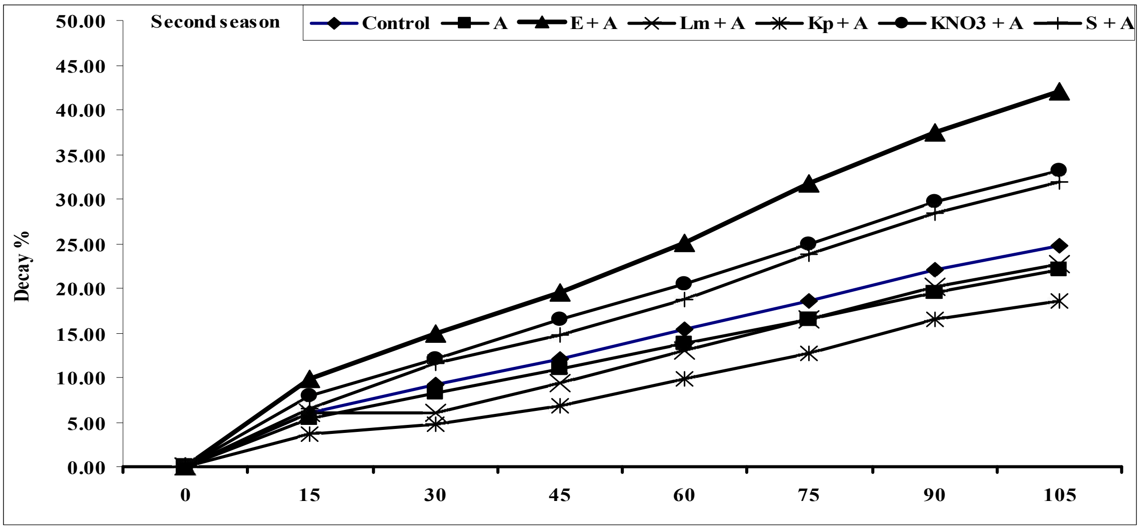

Fig. 4: Effect of treatments and cold storage at 0°C and 95%RH on decay (%) after storage period in second season.

Fruit firmness

The present data in Table (5) and Fig. (3) Indicated that amino acids alone or combined with substance decreased fruit firmness except (KNO_3 + A) and (S + A) in the first season. While, in the second season (KNO_3 + A) cleared significantly increased fruit firmness (decreased firmness loss).

Regarding the prolonged cold storage period, data cleared that, fruit firmness was decreased after 15 days from storage until the end of cold storage period in both seasons.

Concerning the interaction (KNO_3 + A) in both seasons, in addition (S + A) and (E + A) in the first season. Clearly the kept firmness after 30 days from cold storage period. While, (E+A) attained the lowest value at end of cold storage period in both seasons. In addition (Lm + A) in the second seasons. These results are harmony with Bregoli *et al*., (2006) who noticed that fruit firmness was sporadically affected by spraying ethylene and polyamines (PAS) on "Red Haven" peaches and "Stark Red Gold" nectarines at two different ripening stages in vitro; Valeria and Douglas, (2009) revealed that foliar spraying with AVG alone on apple tree maintained firmness than control and Al-Shemmar and Yusif, (2014) on tomato which treated with arginine decreased fruit pressure during cold storage.

Table 5: Effect of treatments and cold storage at 0°C and 95%RH on fruit firmness (g/cm2) after storage period

Treatments	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	71.00	61.00	76.00	54.00	51.00	35.00	29.00	27.50	50.56
A	60.00	55.00	61.50	56.00	52.50	46.50	45.00	38.00	51.81
E + A	70.50	64.00	64.50	64.00	59.50	51.00	43.50	35.50	56.56
Lm + A	60.00	56.00	58.50	55.50	46.50	37.50	30.00	31.00	46.88
Kp + A	58.50	43.50	58.50	52.00	49.00	33.00	31.50	31.50	44.69
KNO_3 + A	83.00	58.00	83.00	56.00	51.00	33.50	30.00	27.00	52.69
S + A	77.00	77.00	83.00	60.50	57.00	40.50	35.00	31.00	57.63
Ave. (B)	68.57	59.21	69.29	56.86	52.36	39.57	34.86	31.64	
	Second season								
Control	53.00	46.00	46.50	50.00	53.00	47.50	46.50	33.50	47.00
A	43.50	56.00	84.00	51.00	50.00	42.50	39.50	40.00	50.81
E + A	50.00	35.50	61.50	62.50	51.50	45.00	43.00	43.00	49.00
Lm + A	51.00	41.00	23.50	49.50	52.50	46.00	40.50	34.00	42.25
Kp + A	37.00	34.00	41.50	52.50	52.50	46.00	42.50	41.50	43.44
KNO_3 + A	45.00	36.00	49.00	60.00	57.50	45.00	48.00	41.00	47.69
S + A	47.00	51.00	44.50	46.50	49.50	44.00	41.00	38.50	45.25
Ave. (B)	46.64	42.79	50.07	53.14	52.36	45.14	43.00	38.79	
LSD at 5% for:				First	Second				
Factor A (Treatments) =				4.96	4.31				
Factor B (Date of cold storage)=				3.75	3.26				
Interaction AXB =				14.02	12.19				

A: Amino acids *E: Ethylene* *Lm: Landamine* *Kp: Keap* *KNO_3: Potassium nitrate* *S: Saccon*

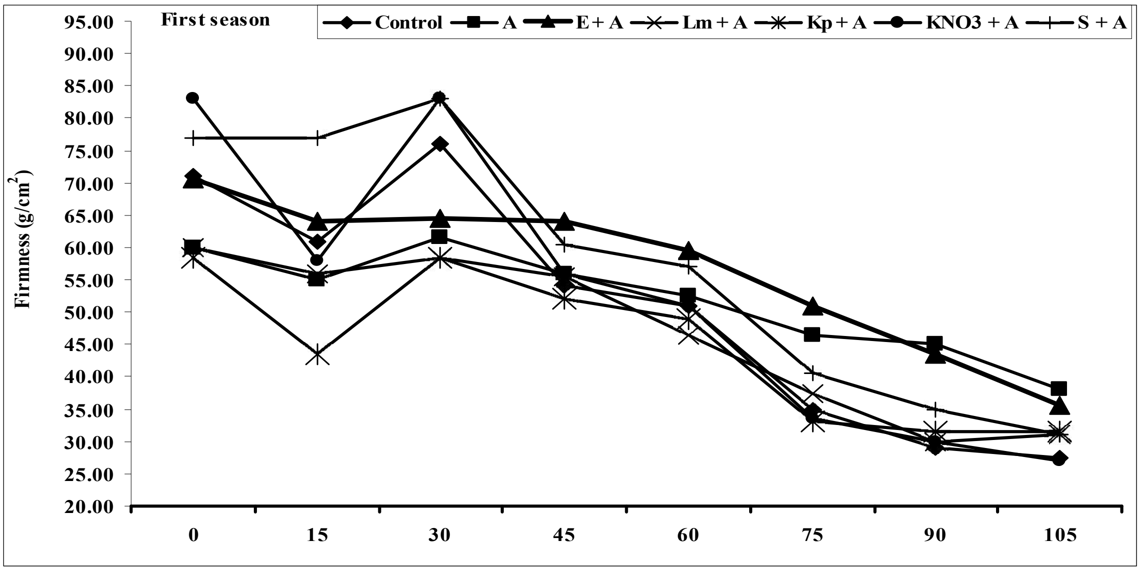

Fig. 5: Effect of treatments and cold storage at 0ºC and 95%RH on fruit firmness (g/cm^2) after storage period in the first season.

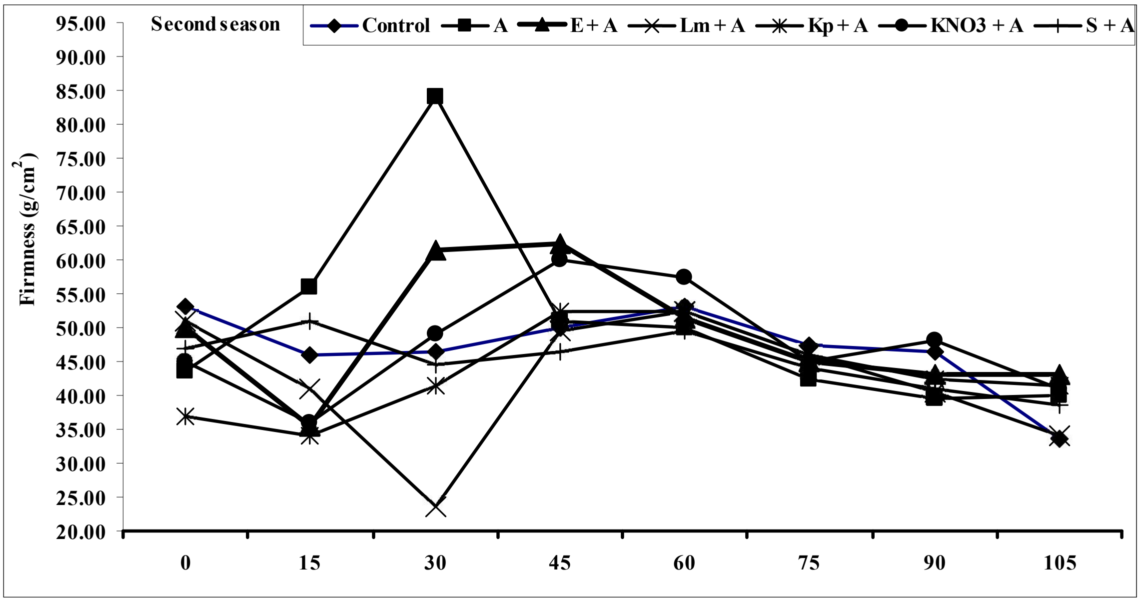

Fig. 6: Effect of treatments and cold storage at 0ºC and 95%RH on fruit firmness (g/cm^2) after storage period in the second season.

TSS

Data in Table (6) show that, amino acids (A) as alone and landamine (Lm) + A increased TSS (%) in the first season. While, in the second season all treatments decreased TSS % of "Anna" apple fruits during cold storage period. Regarding prolonged period, data indicated that, TSS % increased till 30 days then decreased at 45 days and continued until the end of cold storage period during the first season. While in the second season increased till 15 days then decreased at 30 days and continued until 105 days of cold storage period.

The interaction, Saccon (S) + A was the highest % of TSS at 60 days, while, Lm + A and Kp + A were the lowest % of TSS at 105 days of cold storage period in the first season. While control after 15 days gave the highest % of TSS but Lm + A and KP + A were the lowest % of TSS after 105 days of cold storage period during the second season. These results are in line with Refaat and Naguib (1998) as well as Valeria and Donglas (2009) on apple. Abo-Sedra *et al*., (2010) and Ibrahim *et al*., (2010) get an increase in fruit TSS as a result of peptone (amino acids) spray. Also, Hegazi *et al*., (2014) on grape.

On the other hand, Malik and Singh (2006) showed that fruit TSS was reduced by the aqueous solutions of amino acids in the form of Pas, Putrescine, Spermine and Spermidine, containing "Tween 20" surfactant at 0, 0.01, 0.1 and 1 mµ concentrations when sprayed onto panicles of mango, cv. "Kensington pride", at the final fruit set stage.

Table 6: Effect of treatments and cold storage at 0°C and 95%RH on fruit TSS (%) after storage period

Treatments	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	10.60	12.35	12.40	12.00	12.50	11.20	11.55	9.90	11.56
A	11.20	12.25	12.35	12.35	12.35	11.40	11.35	10.00	11.66
E + A	11.40	11.75	12.35	12.45	10.50	10.35	10.55	10.00	11.17
Lm + A	11.50	12.15	12.35	12.40	12.45	11.25	11.20	9.85	11.64
Kp + A	11.30	12.20	12.15	12.15	12.25	10.40	10.15	9.85	11.31
KNO_3 + A	11.50	12.30	12.50	12.35	10.60	10.55	10.40	10.10	11.29
S + A	11.70	12.30	12.35	12.65	12.75	10.40	10.50	9.90	11.57
Ave. (B)	11.31	12.19	12.35	12.34	11.91	10.79	10.81	9.94	
	Second season								
Control	12.10	12.25	11.45	11.40	11.40	10.45	10.35	10.25	11.21
A	11.10	11.45	11.40	11.10	10.60	10.40	10.25	10.35	10.83
E + A	11.50	11.55	11.45	11.25	11.30	10.50	10.45	10.25	11.03
Lm + A	11.20	11.40	10.70	11.35	11.20	10.55	10.15	10.05	10.83
Kp + A	11.40	11.25	11.45	11.30	11.10	10.35	10.15	10.05	10.88
KNO_3 + A	11.60	11.50	11.20	10.90	10.35	10.20	10.15	10.15	10.76
S + A	10.90	10.75	11.60	10.75	10.55	10.40	10.35	10.20	10.69
Ave. (B)	11.40	11.45	11.32	11.15	10.93	10.41	10.26	10.19	
LSD at 5% for:									
Factor A (Treatments) =				0.26		0.21			
Factor B (Date of cold storage)=				0.20		0.16			
Interaction AXB =				0.75		0.59			

A: Amino acids E: Ethylene Lm: Landamine Kp: Keap KNO_3: Potassium nitrate S: Saccon

Acidity

Data in Table (7) cleared that, Amino acids (A) as alone has increased acidity % in both seasons followed by Ethylene (E) + A in the first season while, in the second season it was followed by KNO_3 + A. Regarding the prolonged storage period, acidity % decreased gradually till 105 days (the end of cold storage period) in both seasons. Concerning the interaction, amino acids (A) as alone resulted in the highest significant % on acidity after 15 days in both seasons followed by (E + A) in the first season while, by (KNO_3 + A) in the second. Moreover, lendamin (Lm + A, Keap (Kp) + A and KNO_3 + A recorded the lowest % of acidity in the first season. While, in the second KNO_3 + A had the lowest % of acidity. These results are in line with, Awad *et al*., (2004) who noticed that, foliar spray with ABG on "Anna" apple trees at the pre harvest stage increased acidity % compared to control during cold storage. Also, Valeria and Douglas, (2009) found that AVG plus heat had lower total acidity than control after cold storage on apple and Al-Shemmar and Yusif (2014) on tomato, they found that all treatments (arginin or $CaNO_3$) were superior to control fruit acidity during storage.

Table 7: Effect of treatments and cold storage at 0 °C and 95%RH on fruit acidity (%) after storage period

Treatments	First season								
Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	1.77	1.57	1.50	0.85	0.84	0.70	0.38	0.36	1.00
A	1.97	1.86	1.75	1.18	1.10	1.07	0.43	0.36	1.21
E + A	1.90	1.58	1.51	1.14	1.18	1.04	0.43	0.35	1.14
Lm + A	1.45	1.34	1.26	1.10	1.11	0.97	0.42	0.42	1.01
Kp + A	1.47	1.50	1.38	0.92	0.78	0.68	0.42	0.35	0.94
KNO_3 + A	1.22	1.12	1.13	0.85	0.69	0.68	0.37	0.35	0.80
S + A	1.09	1.32	0.96	1.15	1.10	1.04	0.35	0.36	0.92
Ave. (B)	1.55	1.47	1.36	1.03	0.97	0.88	0.40	0.36	
	Second season								
Control	1.68	1.64	1.53	1.20	0.95	0.74	0.45	0.43	1.08
A	2.01	1.88	1.76	1.44	1.61	1.16	0.41	0.41	1.33
E + A	1.45	1.41	1.37	1.21	0.95	0.68	0.36	0.42	0.98
Lm + A	1.20	1.17	1.11	1.07	0.94	0.67	0.75	0.37	0.91
Kp + A	1.45	1.42	1.38	0.71	0.66	0.67	0.45	0.41	0.89
KNO_3 + A	1.90	1.76	1.69	1.15	1.08	0.67	0.45	0.34	1.13
S + A	1.43	1.34	1.26	1.15	0.87	0.67	0.42	0.35	0.93
Ave. (B)	1.59	1.52	1.44	1.13	1.01	0.75	0.47	0.39	
LSD at 5% for:									
Factor A (Treatments) =				0.12	0.09				
Factor B (Date of cold storage)=				0.09	0.07				
Interaction AXB =				0.34	0.27				

A: Amino acids E: Ethylene Lm: Landamine Kp: Keap KNO_3: Potassium nitrate S: Saccon

Conclusion

The present results cleared that, spraying amino acids alone or combined with these substances resulted enhancing in the skin colour peel specially E + A. Amino acids alone improved storability of "Anna" apple fruits decreased decay

% in both seasons. Moreover, adding amino acids to ethylene, Landamine, Keap, KNO_3 and Saccon decreased decay %. Furthermore, it resulted in decreasing firmness loss of fruits which were treated with KNO_3. In addition, decreased the weight loss % of fruit which were treated with Landamine or Keap in both seasons. Moreover, KNO_3+ amino acids was enhanced colour, decreased decay % and decreased firmness loss compared to control. On the other hand, Keap + amino acids was enhanced colour, decrease decay %, weight loss % and acidity %. Thus, it is recommended to spray "Anna" apple trees at 14 days before harvest with 2 gm/L amino acids + 3 gm/l KNO_3. or 3 cm/l of Keap to enhance colour and storability of apple fruits.

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