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Improving Fruit Quality and Storability of 'Anna" Apple Cultivar by Using some Substances

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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 color, quality and enhancing storability through spraying with ethylene (2cm/L) as ethphone, 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). Ethylene and different sources of nutrients were sprayed 2 weeks before harvest and picked 14 and 19 June in both seasons, respectively. 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 results revealed that all substances increased red skin color of "Anna" apple fruits compared to control. Furthermore, ethylene, landamine and saccon gave the highest values before and after cold storage. All substances increased the resedual of ethylene compared to control. Ethylene and landamine recorded the highest values. While saccon was the lowest value. All substances increased fruit weight loss and decay percentages compared to control. Furthermore, the ethylene and keap recorded the highest values followed by landamine and potassium nitrate. While, saccon recorded the lowest value compared to the other substances. All substances reduced firmness and acidity compared to control. However, saccon gave the highest firmness compared to other substances. Moreover, there are positive correlation and regression between residual ethylene and fruit decay in the second season. Thus, it recommended to spray Saccon substance at 3cm/L 2 weeks before harvest for improving skin color and storability of "Anna" apple fruits as well as maintaining fruit quality.

Key words: Apple, *Malus domestica,* ethylene releasing, fruit color, quality, enhancing storability

Introduction

In Egypt, orchards of "Anna" apple suffer from poor fruit colour due to the little differences between day and night temperatures. Ethylene is used to improve fruit colour of many fruit trees (Makarem *et al.*, 1995). The presence of ethylene is not always beneficial, especially in terms of postharvest shelf life (Optimal Fresh, 2001). It seems that because it is a colourless gas that is not often measured in commercial situations its presence is over looked. Loss of quality and quantity occurs along the postharvest chain of horticultural crops. However, the loss of shelf life will be most frustrating for the final consumer as the loss of quality will not be obvious during marketing and retail sale. The major reason for the loss of shelf life is that ethylene exposure increases the rate of the product aging. The responses of harvested fruits, vegetables, and ornamental crops to endogenous produced and exogenously applied ethylene are numerous and varied, and they can be beneficial or detrimental depending on each case (Saltveit, 1999). In general, ethylene can influence the postharvest life of both climacteric and non climacteric fruits by affecting their quality attributes and the development of physiological disorders and postharvest diseases (Kader, 1985). Effects of ethylene on fruit external appearance, texture, flavor and nutritive value has been extensively reviewed by different authors. Frequently, the action of ethylene results in promotion of fruit softening, acceleration of deterioration, and consequent abbreviation of postharvest life. Thus it is clear that in some commercial horticultural crops, ethylene has detrimental effects; it accelerates senescence and ultimate death of the plant / plant parts. As an evil leads/ guides human being in the wrong direction and facilitates weakness and loss of strength, so doing ethylene in some horticultural crops (Hussein, 2014). Many investigators studied the effect of Ethylene spraying on apple fruit trees before harvest and during storage period, and found that all maturity parameters accelerated, bitter pit was decreased and enhanced red colour and senescence breakdown were enhanced (Gil *et al.*, 1980, Samra *et al.*, 1987, Makarem *et al.*, 1990, Makarem *et al.*, 1995 and Taha *et al.*, 2009). The known physiological and biochemical effects of ethephon (C_2H_4) on harvested horticultural crops include increase respiratory rate and enzymes activity (Kader

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1985). The increase in anthocyanin in apple skin before harvest coincided with decreasing temperatures and increasing ethylene production by the fruit (Faragher1983).

The main function of potassium (K) in biochemistry is the activation of various enzymatic systems (Evans and Sorger, 1966). Yagodin (1984) who found that potassium is important for structure and promotes formation of ATP (plant energy) oxidative polyphosphorelation synthesis of amino acid proteins. Potassium nitrate has been specifically developed for foliar feeding of large variety of crops. It is sprayed at concentration up to 10% for intensive foliar nutrition and for a prolonged effect without any phytotoxic effect (Achilea *et al.*, 2001). The physiological effect of KNO_3 sprays was in its important role in balancing membrane potential and turgor, activating enzymes and regulating osmotic pressure according to Cherel (2004) and Yanhai *et al.*, (2008). Mohamed *et al.*, (2014) indicated that, preharvest application with KNo3 (starting at two weeks after fruit set and repeated after one month from the first spraying date) improved fruit quality at harvest time which means early fruit maturation but decreased fruit storability.

Mode of action for micro – elements was explained by Larue and Johnson (1989) who found that Iron (Fe) complexes with proteins to form important enzymes in the plant and is associated with chloroplasts where it has some roles in the synthesizing chlorophyll. In addition Mn is a minor constituent of plant chlorophyll which is responsible for photosynthesis (Mengel and kirkby, 1987). Manganese (Mn) participates important in several processes including photosynthesis and metabolism of both nitrogen and carbohydrate (Larue and Johnson 1989). Spraying B may be due to the fact that B is known to increase transportation of sugars and increase of carbohydrate movement from leaves into fruit tissue (Dugger, 1983). Boron might have a direct effect on activities of some relevant enzymes responsible for anthocyanin biosynthesis (Awad and de Jager, 2002). Zinc (Zn) plays a role in treptophan synthesis which is the precursor of endogenous natural hormone (IAA) which is necessary for all plants metabolic processes (Price, 1970). Moreover, Jyung *et al.*, (1975) stated that Zn has a possible role in plant metabolism involved in starch formation. Zinc (Zn) has been identified as a 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 (Larue and Jhnson, 1989). Also, Shahin *et al.*, (2010) studied the effect of Fertifol Misr (N-P –K – Mg –Zn –Cu – Mo and B) on the quality of "Anna" apple trees. Results cleared that; quality was positively affected by Fertifol Misr compared with control. Zinc (Zn) is an essential nutrient that has particular physiological functions in all living systems, such as maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression, enzymes structure energy production and krebs cycle, also has a positive impact on crops quantitative and qualitative yield. (Mousavi *et al.*, 2013). Moreover, Aly *et al.*, (2014) reported that, increasing rates of foliar application of all nutrient treatments 1% , 2% and 3% of (K_2SO_4, $ZnSO_4$, H_3BO_3 and Ca chelated) at full bloom and one month after fruit setting increased the TSS%. While it was noticed that, all foliar application of K and B decreased acidity content of "Anna" apple fruits.

Therefore, the main objective of this study was to improve fruit colour and enhance storability and keeping quality through spraying with ethylene, and nutrients on "Anna" apple.

Materials and Methods

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, 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, irrigated by a drip irrigation system. Eighteen trees as uniform as possible were selected for achieving this study. 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. Ethylene (E) at 2cm/L as (ethephone).
3. Landamine (Lm) (32%P_2O_5 + 35%K_2O + 1.6%B + 0.4%Mo) at 3cm/L.
4. Keap (Kp) (11.5% B + 13.0%Mo) at 3cm/L.
5. Saccon (S) (9%N + 25%P + 0.3%Fe + 0.3%Mn + 0.3%Zn + 0.1%Cu + 0.005%Mo) at 3cm/L.
6. Potassium nitrate (KNO_3) at 3.0gm/L.

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

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

1. 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).

2. Residual ethylene in fruits:
Residual ethylene in fruits was determined by LC–MS/MS Analysis of Highly Polar Pesticides (2009).

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 to be 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:

1. Physical characteristics of fruits:

- Fruit colour: Intensity of color 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.

2. 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 and Discussion

I-At harvest assessments:
Fruit color:

The present results (Table 1) reveal that ethylene (81.43 and 99.89) followed by Landamine (104.20 and 101.29) and Saccon (108.71 and 105.13) treatments recorded the lowest Hue angle (the highest red colour) throughout the two studied seasons respectively compared with control and other treatments. However, all sprayed substances decreased Hue angle (increased red colour) than control (114.67 and 110.32) in 2011 and 2012 seasons respectively.

With respect to ethylene, the results are harmony with Kishore and Dhuria (1977) who mentioned that applying ethephon at 1000 – 4000 ppm on "Red Delicious" apples, 12 weeks after full bloom enhanced fruit colour greatly especially at the highest concentration of ethylene. Also, Ahmed and Shaladan (1980) reported that, spraying ethylene at 0, 250, 500 and 1000 ppm 2 weeks before harvest on "Jami" apple trees, significantly promoted the development of red colour. Jons (1981) applying ethylene at 500, 1000 and 2000 ppm on 1 or 8 March on "Golden Delicious" apple gave best results with regared to fruit colouring. Moreover, Makarem *et al.*, (1995) found that fruit treated with ethylene at (1000 or 500ppm) + NAA at 10ppm had a large red colour, than the control. However, Li *et al.*, (2002) stated that, ethephon treatments (applied four weeks before commercial harvest) caused an enhancement in red peel colour and an increase in concentration of flavonoid compounds, anthocyanin and internal ethylene in "Fuji" apple fruits. Also, Abd el-Fatah *et al.*, (2008) on "Costata" persimmon.

Regarding effect of macro and micro nutrients on fruit color, these results are in line with Kim and Kim (1983). Found that at high boron levels apple tress produced fruits with intensive red coloration. Murphey and Dilley (1988) mentioned that the change in apple fruit color might be due to the destruction of chlorophyll revelation of pigments previously masked and synthesis of new pigments.

Faust (1989) clarified the role played by boron in controlling fruit respiration and the synthesis of phenolic compounds. He reported that low boron levels promote the flow of sugars through the pentose phosphate cycle, the main pathway for the synthesis of phenolic compounds. Therefore, the formation of brown areas within the core or near the surface of apple fruits would be highly expected. On the contrary, high boron levels promote the flow of sugars through glycolysis and hence increase fruit respiration, and activity closely associated with faster fruit ripening. Furthermore, Peryea and Drake (1991) found that increasing fruit boron concentration caused minor changes in apple fruits external colour. Morover, Kilany and Kilany (1991) found obviously that, high level of potassium foliar application as well as boron treatments, maximized red coloration of "Anna" apple fruit. However, fruits of other potassium treatments had the deep pink colour similar to control fruits. On the other hand, Vitrac *et al.*, (2000) suggested that, effects of N on apple coloration remains unclear but it may act adversely and interfere with synthesis of sugar and anthocyanin. Li *et al.*, (2002) indicated that, a study is necessary to understand the function of ethylene, calcium, nitrogen and phosphorus on red coloration of apple skin related to enzyme activity. Also, Mitchan *et al.*, (2003) found that K improved orange fruit pigments by increasing fruit sugars and carbohydrates and in the same tendency Awad *et al.*, (2004) reported that both rate and onset of red color accumulation were clearly stimulated and advanced (about one week) by boron application at both 50 and 100ppm without hastening fruit ripening compared with the control.

Regarding the effect of KNO_3, data cleared that KNO_3 treatment increased skin color, some authors reported that the application of K fertilization improved fruit quality on apple (Kilany and Kilany 1991; Aly *et al.*, 2014; Mohamed *et al.*, 2014).

Residual ethylene:

The present results (Table 1) showed that all the studied treatments increased apple residual ethylene in fruits than control (0.21mg/kg). However, ethylene spray more effectively increased residual ethylene in fruits (0.66 mg/kg) than other treatments. Saccon treatment increased ethylene residual compared to control but it gave the lowest value compared to other treatments.

The results are harmony with Wills *et al.*, (2000) and Hussien (2014) found that the effect of ethylene is accumulative so continuous exposure to a low concentration of ethylene throughout marketing can cause significant harm.

Table 1: Effect of different treatments on color (Hue angle) and residual ethylene (mg/kg) of Anna apple

	Fruit color		Residual ethylene
Treatments	First Season	Second Season	Second Season
Control	114.67	110.32	0.21
Ethylene	81.43	99.89	0.66
Landamine	104.20	101.29	0.51
Keap	108.17	107.41	0.54
Saccon	108.71	105.13	0.37
Potassium nitrate	109.77	106.73	0.43
LSD at (0.05)=	4.53	2.08	0.09

II-Storability

Fruit color

Data presented in Table (2) and figure (1) revealed that ethylene treatment gave the highest significant degree of fruit red color (the lowest Hue angle) (67.39 and 91.02) during cold storage period in both seasons respectively.

Table 2 : Effect of treatments and cold storage at 0°C and 95%RH on fruit peel colour (Hue angle) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days.

Treat. Day	First season								
	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
Ethylene	81.43	88.32	63.54	64.38	55.53	76.97	67.85	41.09	67.39
Landamine	104.20	112.72	110.59	106.36	104.00	101.56	100.58	107.24	105.91
Keap	108.17	104.96	106.46	107.75	106.67	107.72	103.99	106.97	106.59
Saccon	108.71	106.97	106.61	103.08	104.80	101.12	103.72	106.42	105.18
Potassium nitrate	109.77	107.82	107.94	108.55	108.35	104.72	108.32	110.29	108.22
Ave. (B)	104.49	103.63	98.81	100.48	98.54	99.92	99.36	97.07	
Second season									
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	110.32	107.65	106.24	101.08	109.20	106.86	109.84	112.17	107.92
Ethylene	99.89	94.55	98.47	83.47	85.48	87.97	86.44	91.88	91.02
Landamine	101.29	107.01	104.63	109.67	107.40	103.26	104.57	104.91	105.34
Keap	107.41	106.71	104.32	105.13	103.86	106.70	104.50	107.35	105.75
Saccon	105.13	109.33	105.92	103.50	105.19	107.36	105.11	100.87	105.30
Potassium nitrate	106.73	107.21	105.30	105.08	106.66	106.10	106.49	106.00	106.20
Ave. (B)	105.13	105.41	104.15	101.32	102.97	103.04	102.83	103.86	
LSD at 5% for:			1st season			2nd season			
Factor A (Treatments) =			3.08			3.19			
Factor B (Date of cold storage)=			3.56			3.68			
Interaction AXB =			8.71			9.02			

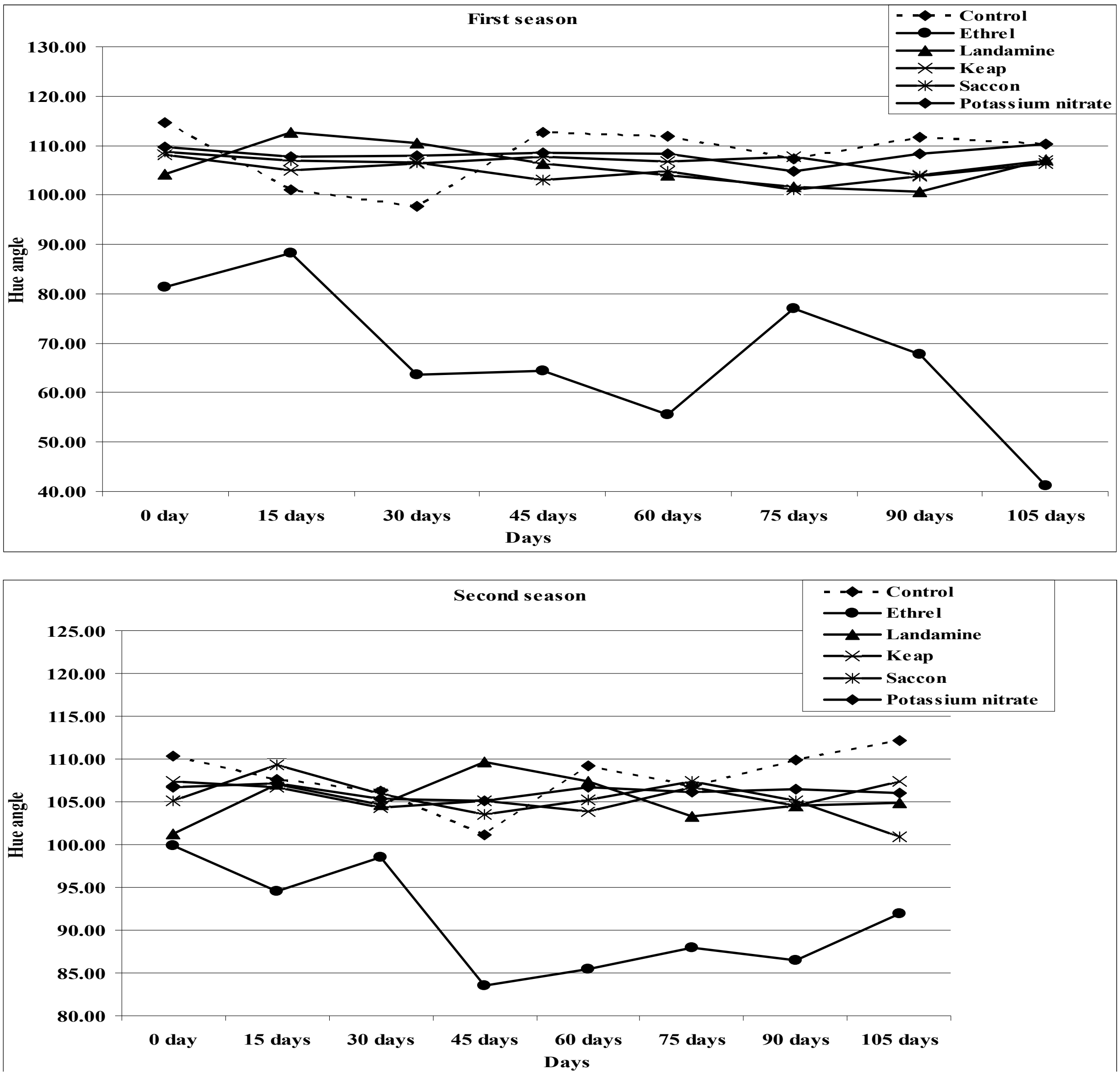

Fig. 1: Effect of treatments and cold storage on fruit peel colour in both seasons.

Throughout the storage period, red color of apple fruits was better after 105 days in 1st season as well as after 45 days in 2nd season. However, the interaction data showed that ethylene after 105 days in 1st season and after 45 days in 2nd season resulted least Hue angle (the most bright red color) along cold storage period.

The results are in line with Ibrahim (1994) and Makarem *et al.*, (1995) on "Anna" apple who reported that, treated fruits with ethylene at (500 or 1000ppm) + NAA at 10ppm had a large colour area than control before and during storage period.

Concerning macro and micro nutrients effect, the results are harmony with Granelli and Ughini (1989) they found that, the application of urea-boron fertilizer (20%N and 7%B2O3) improved skin colour of apple at harvest and after storage. Also, Awad *et al.*, (2004) on "Anna" apple found that both the rate and the onset of red colour accumulation were clearly stimulated and advanced (about one week) by boron application at both 50 and 100ppm without hastening fruit ripening compared with the control. Moreover, Mohamed *et al.*, (2014) reported that KNO_3 increased anthocyanin fruit apple content after 2 months of cold storage.

Fruit weight loss

Data presented in table (3) and figure (2) cleared that ethylene recorded the highest percentages (23.02 and 22.84%) of fruit weight loss in both seasons, while control treatment attained the lowest value (11.41 and 13.56%), so it effectively kept the fruit quality through storage, followed by Saccon treatment (12 and 16.29%) in both seasons, respectively.

Prolonging cold storage period resulted in increased fruit weight loss in both seasons, weight loss of apple fruits was highest after 105 days in both seasons.

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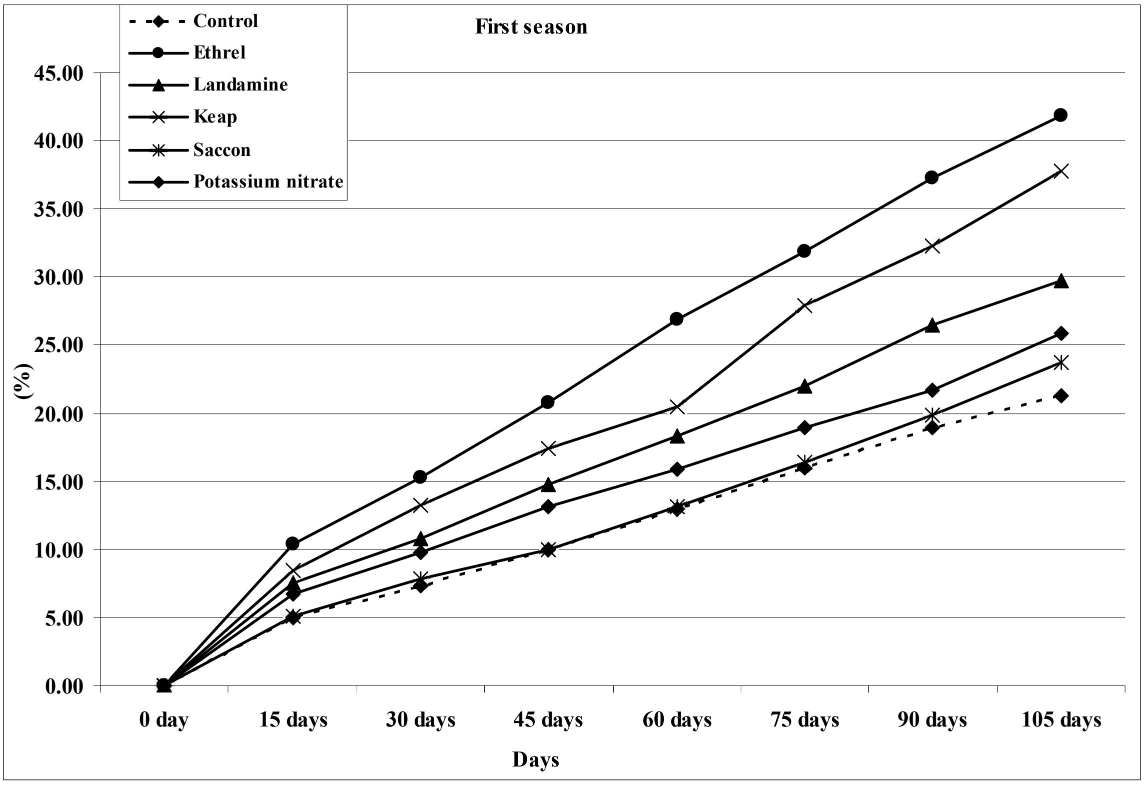
Concerning the interaction between treatments and storage period, data indicated that Saccon and control gave the lowest value along storage in both seasons. On the other hand, ethylene (41.82 and 43.02%) gave the highest value after 105 days storage in both seasons, respectively.

Table 3 : Effect of treatments and cold storage at 0°C and 95%RH on fruit weight loss (%) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days.

				First season					
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	0.00	5.00	7.30	9.98	12.88	16.00	18.91	21.24	11.41
Ethylene	0.00	10.34	15.27	20.74	26.85	31.89	37.24	41.82	23.02
Landamine	0.00	7.49	10.84	14.79	18.32	21.96	26.47	29.73	16.20
Keap	0.00	8.50	13.27	17.40	20.48	27.89	32.24	37.76	19.69
Saccon	0.00	5.10	7.84	9.95	13.10	16.39	19.90	23.69	12.00
Potassium nitrate	0.00	6.70	9.75	13.16	15.85	18.90	21.65	25.88	13.99
Ave. (B)	0.00	7.19	10.71	14.34	17.91	22.17	26.07	30.02	
				Second season					
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	0.00	6.10	9.74	12.07	15.33	18.55	21.99	24.69	13.56
Ethylene	0.00	9.47	14.48	19.51	26.13	31.81	38.31	43.02	22.84
Landamine	0.00	8.62	13.75	17.86	22.55	27.12	32.26	38.23	20.05
Keap	0.00	9.24	14.10	18.63	25.17	28.77	34.54	40.79	21.41
Saccon	0.00	6.99	11.47	13.43	18.41	22.35	26.56	31.13	16.29
Potassium nitrate	0.00	7.75	12.48	15.51	20.13	25.80	28.31	33.02	17.88
Ave. (B)	0.00	8.03	12.67	16.17	21.29	25.73	30.33	35.15	
LSD at 5% for:				1st season		2nd season			
Factor A (Treatments) =				4.27		4.51			
Factor B (Date of cold storage)=				4.93		5.21			
Interaction AXB =				12.08		12.76			



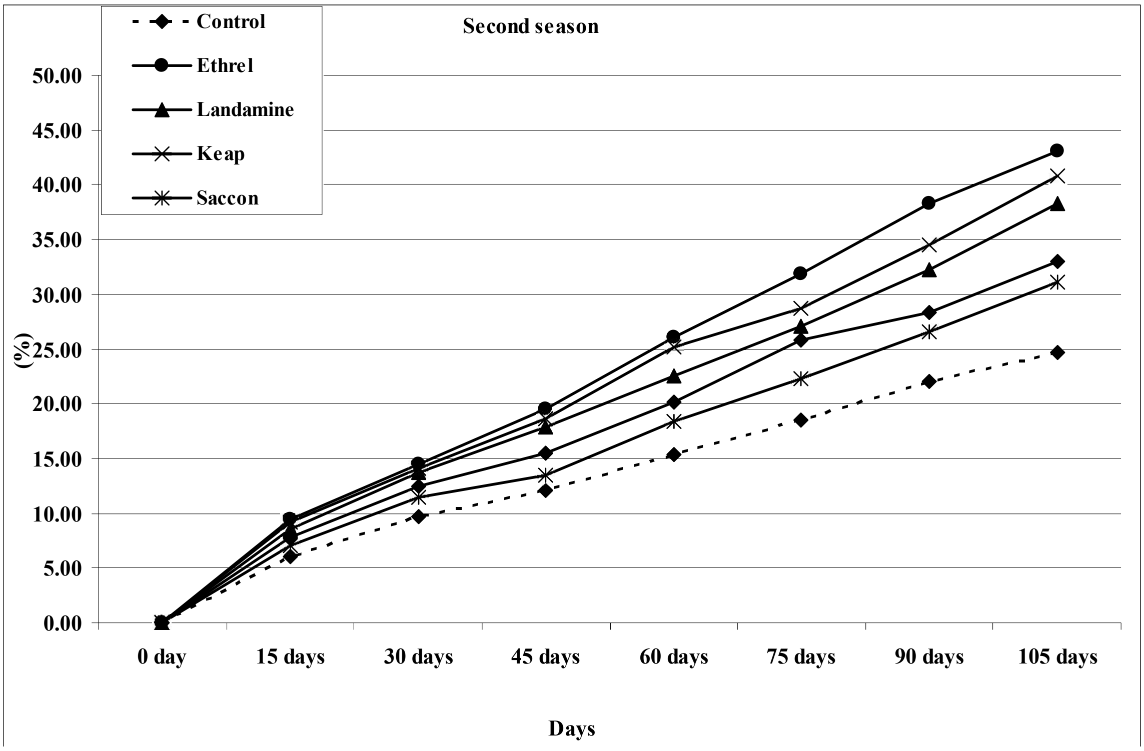


Fig. 2: Effect of treatments and cold storage on fruit weight loss (%) in both seasons

These results are in line with Ibrahim (1994) on "Anna" apple, he noticed that fruits treated with ethephon at 200ppm show the highest percentage of weight loss compared to control. Moreover, fruit weight loss% increased as the storage period advanced. Furthermore, applied ethylene accelerates the chemical changes associated with ripening and caused a shift in the time axis of the onset of the climacteric rise. In climacteric fruits, exogenous C2H4 caused the peel and flesh to ripen out of phase, with the flesh ripening faster than the peel (Hussien, 2014).

Regarding macro and micro nutrients, the results are in line with Xuan *et al.*, (2001) who noticed that pre-harvest boron application on pear reduced membrane permeability at harvest and during storage. Also, Mohamed *et al.*, (2014) recorded that spraying "Anna" apple with potassium nitrate at two concentrations at 1.5% (Starting at 2 weeks after fruit set and after one month from the first spraying) recorded the highest percentage of weight loss.

Decay%

Data presented in table (4) and figure (3) show that ethylene treatment induced the highest percentage of decay after cold storage period followed by Keap and Landamine treatments, while Saccon treatment recorded the lowest percentage of decay followed by KNO_3 in both seasons.

With respect to the prolonging cold storage period, decay percentage started after 30 days then increased and continued during the storage period until the end of cold storage period in both seasons.

Concerning the interaction between treatments and storage period, ethylene treatment induced the highest percentage of decay, while control and Saccon treatments recorded the lowest percentage of decay after 105 days in both seasons.

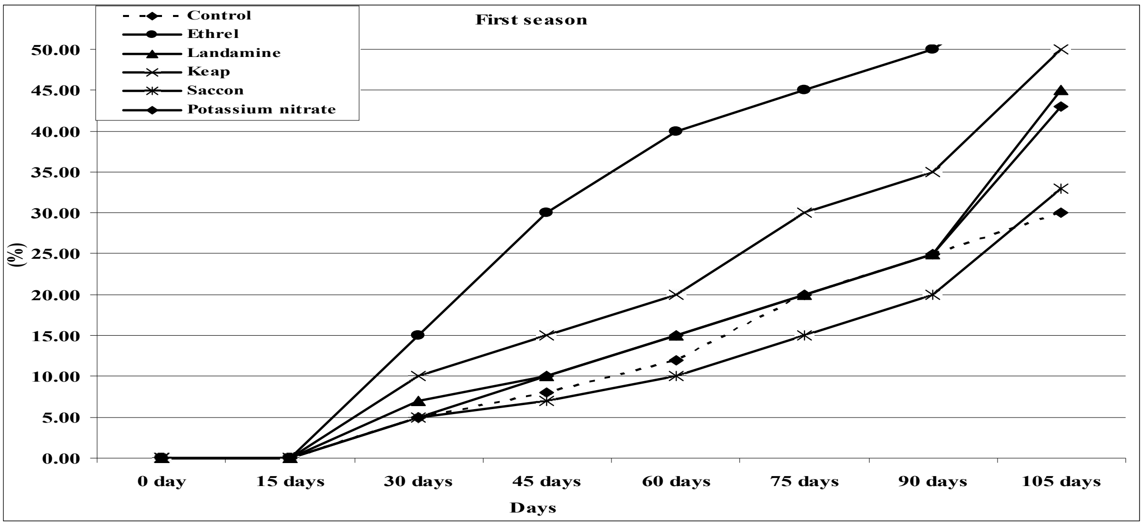
These results are harmony with Lyons and Pratt (1964) stated that high concentration of ethylene could cause reversible swelling of isolated mitochondria and postulated that this might explain the role of ethylene in enhanced respiration and other metabolic processes. Also, Ibrahim (1994) and Makarem *et al.*, (1995) they found that ethylene treatment increased decay % of "Anna" apple. Furthermore, Hussein (2014) noticed that ethylene has an "evil" effect makes such fruits more perishable and shortens the shelf life of these crops.

Regarding macro and micro elements, the results are in line with Ali *et al.*, (2006) mentioned that sprayed K markedly improved fruit quality at harvest and during cold storage and decreased fruit disorders while it increased fruit pigments of "Hermosa" peach.

Pre-harvest boron application eliminated the incidence of brown heart in "Conference" pears during four months of controlled atmosphere storage (Xuan *et al.*, 2001). Moreover, spraying KNO_3 at 1.5% on "Anna" apple trees recorded the highest percentage of decay during cold storage for two months Mohamed et al., (2014).

Table 4 : Effect of treatments and cold storage at 0ºC and 95% RH on decay (%) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days

	First season								
Treat. 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
Ethylene	0.00	0.00	15.00	30.00	40.00	45.00	50.00	60.00	30.00
Landamine	0.00	0.00	7.00	10.00	15.00	20.00	25.00	45.00	15.25
Keap	0.00	0.00	10.00	15.00	20.00	30.00	35.00	50.00	20.00
Saccon	0.00	0.00	5.00	7.00	10.00	15.00	20.00	33.00	11.25
Potassium nitrate	0.00	0.00	5.00	10.00	15.00	20.00	25.00	43.00	14.75
Ave. (B)	0.00	0.00	7.83	13.33	18.67	25.00	30.00	43.50	
	Second season								
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	0.00	0.00	5.00	9.00	12.00	20.00	22.00	35.00	12.88
Ethylene	0.00	0.00	15.00	20.00	25.00	40.00	50.00	65.00	26.88
Landamine	0.00	0.00	10.00	13.00	15.00	22.00	30.00	45.00	16.88
Keap	0.00	0.00	13.00	15.00	20.00	30.00	40.00	50.00	21.00
Saccon	0.00	0.00	5.00	8.00	12.00	20.00	30.00	37.00	14.00
Potassium nitrate	0.00	0.00	7.00	9.00	15.00	20.00	32.00	42.00	15.63
Ave. (B)	0.00	0.00	9.17	12.33	16.50	25.33	34.00	45.67	
LSD at 5% for:				1st season			2nd season		
Factor A (Treatments) =				4.17			3.83		
Factor B (Date of cold storage)=				4.82			4.42		
Interaction AXB =				11.79			10.83		



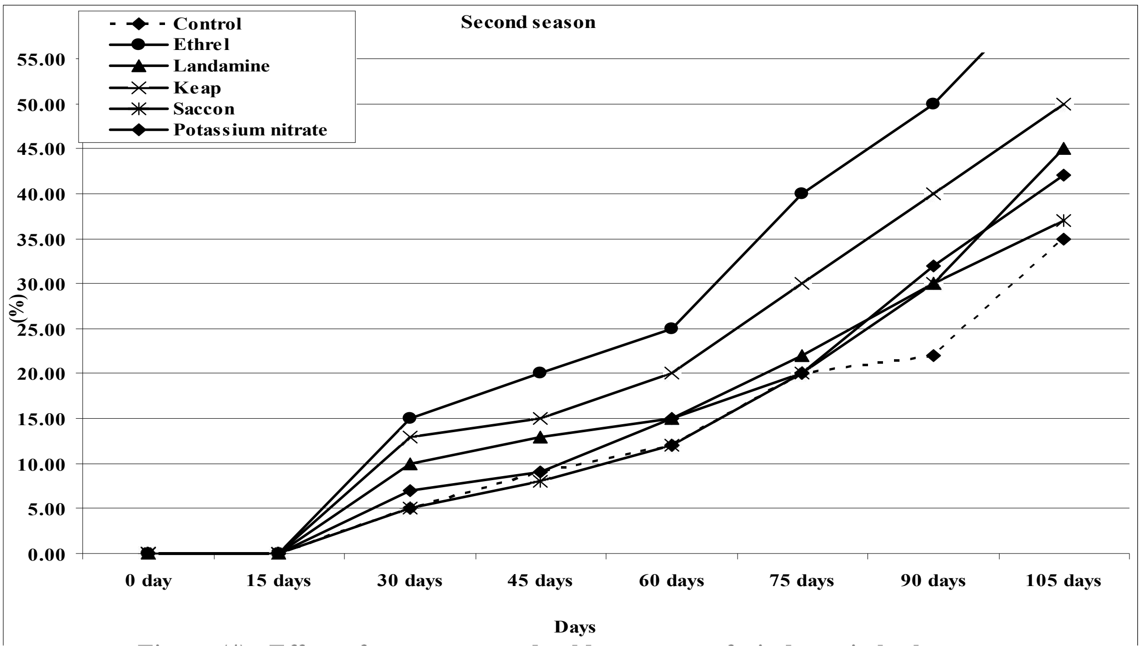


Fig. 3: Effect of treatments and cold storage on fruit decay in both seasons

Fruit firmness

Data presented in table (5) showed that cold storage resulted in fruit softening. The lowest value of firmness was recorded by ethylene treatment in both seasons (31.81 and 28.94g/cm^2) respectively, while control recorded the highest value in the both seasons.

With respect to the prolonging cold storage period, data clear that fruit firmness was swinging till 45 days then decreased after 45 days and continue until the end of cold storage period after 105 days during the first season, while in the second season, it decreased after 30 days and continued until the end period.

Concerning the interaction between treatments and storage period, control treatment gave the highest value of fruit firmness (76 and 48.5g/cm^2) followed by Saccon treatment (64 and 40.5 g/cm2) after 30 days in both seasons respectively. Also, control treatment gave the highest value (37.5 and 33.5g/cm^2) after 105 days (at the end of storage period) followed by Saccon treatment (33.5 and 28.8 g/cm^2) in both seasons respectively, while ethylene treatment gave the lowest value of fruit firmness (15.5 and 17.5g/cm^2) after 105 days in both seasons respectively.

These results are in line with Ibrahim (1994) and Makarem *et al.*, (1995) who stated that treated fruits of "Anna" apple with ethylene had less firmness than control before and during storage period.

Concerning macro and micro nutrients, Wojcik (2004) reported that boron used as foliar application had no effect on fruit texture firmness of apple fruit.

Mohamed *et al.*, (2014) found that the lowest significant firmness was induced by KNO_3 at 1.5% after two months of storage in both seasons.

Table 5 : Effect of treatments and cold storage at 0^{o}C and 95%RH on fruit firmness (g/cm^2) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days

	First season								
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	71.0	61.0	76.0	54.0	51.0	45.0	40.0	37.5	54.44
Ethylene	51.0	44.5	37.5	32.0	29.5	24.0	20.5	15.5	31.81
Landamine	61.0	46.0	44.5	41.2	38.5	33.5	29.5	24.4	39.83
Keap	57.0	44.5	41.0	35.2	32.5	29.5	25.5	20.5	35.71
Saccon	68.0	55.0	64.0	53.0	51.0	44.0	37.5	33.5	50.75
Potassium nitrate	67.0	52.5	50.0	48.2	46.0	40.5	34.5	29.8	46.06
Ave. (B)	62.50	50.58	52.17	43.93	41.42	36.08	31.25	26.87	
	Second season								
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	53.0	50.5	48.5	45.3	43.0	40.5	36.5	33.5	43.85
Ethylene	36.5	35.5	32.0	30.5	28.8	26.5	24.2	17.5	28.94
Landamine	40.0	38.0	36.0	34.1	32.5	30.0	28.5	25.9	33.13
Keap	39.0	36.5	34.5	32.0	30.0	29.5	27.7	24.5	31.71
Saccon	45.0	44.0	40.5	38.5	36.5	33.5	30.0	28.8	37.10
Potassium nitrate	42.0	40.5	38.0	36.0	33.7	31.0	29.5	27.0	34.71
Ave. (B)	42.58	40.83	38.25	36.07	34.08	31.83	29.40	26.20	
LSD at 5% for:				1st season			2nd season		
Factor A (Treatments) =				3.71			3.42		
Factor B (Date of cold storage)=				4.28			3.95		
Interaction AXB =				10.49			9.67		

TSS

Data presented in table (6) showed that control and ethylene treatments attained the highest percentage of TSS after cold storage period followed by Saccon and potassium nitrate treatments, while Landamine and Keap treatments recorded the lowest percentage of TSS in in both seasons.

With respect to the prolonging cold storage period, TSS percentage increased and continued during the storage period until at 45 days then it decreased until the end of cold storage period in the first season, while in the second season, it increased and continued until 30 days then decreased.

Concerning the interaction between treatments and storage period, potassium nitrate treatment induced the highest percentage of TSS after 30 days in the first season, while in the second season; Saccon treatment after 30 days attained the highest percentage of TSS. On the other hand, control and Landamine treatments gave the lowest percentage of TSS at the end of storage period (after 105 days) in both seasons.

These results are in line with Makarem *et al.*, (1995) on apple fruits and Hussein (2014) on banana, they noticed that there were no clear differences between treated and untreated fruits.

Regarding macro and micro-elements, the results are in line with Wojcik (2004) found that foliar application of boron and zinc has no effect on TSS of apple fruits. On the other hand, Dawood *et al.*, (2001) and Mitchan *et al.*, (2003) found that K improved orange fruit pigments by increasing fruit sugars and carbohydrate. Furthermore, Mohamed *et al.*, (2014) found that foliar application of KNO_3 at 1.5%((1) after 2 weeks of fruit set and (2) after one month from the first spray) increased TSS% significantly during 2 months storage.

Table 6 : Effect of treatments and cold storage at 0°C and 95%RH on fruit TSS (%) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days

	First season								
Treat. 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
Ethylene	11.80	12.15	12.25	12.35	12.40	10.45	10.45	10.15	11.50
Landamine	11.00	11.60	12.20	12.40	11.00	10.75	10.75	10.00	11.21
Keap	10.80	11.60	12.45	12.50	11.25	11.05	10.45	10.05	11.27
Saccon	11.70	12.20	12.15	12.20	11.15	10.60	10.50	10.15	11.33
Potassium nitrate	12.10	12.30	12.55	12.40	10.40	10.55	10.50	10.05	11.36
Ave. (B)	11.33	12.03	12.33	12.31	11.45	10.77	10.70	10.05	
	Second season								
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	12.10	12.25	11.45	11.40	11.40	10.45	10.35	10.25	11.21
Ethylene	11.90	12.05	12.25	11.80	11.55	10.55	10.35	10.25	11.34
Landamine	11.80	11.65	11.25	10.90	11.10	10.45	10.25	10.05	10.93
Keap	10.80	11.25	11.75	10.65	10.25	10.25	10.15	10.25	10.67
Saccon	11.80	11.45	12.40	11.50	10.40	10.25	10.35	10.25	11.05
Potassium nitrate	12.20	11.45	11.40	11.40	10.75	10.40	10.45	10.25	11.04
Ave. (B)	11.77	11.68	11.75	11.28	10.91	10.39	10.32	10.22	
LSD at 5% for:				1st season			2nd season		
Factor A (Treatments) =				0.19			0.13		
Factor B (Date of cold storage)=				0.22			0.15		
Interaction AXB =				0.54			0.37		

Acidity%

Data presented in table (7) indicated that treated fruits and cold stored for 105 days had decreased acidity without significant differences compared to control and Keap treatments found the highest significant percentage of acidity in both seasons, while ethylene and potassium nitrate treatments attained the lowest significant percentage of acidity in both seasons. On the other hand, the decrease in acidity continued during the cold storage period, that means better fruit quality.

Concerning the interaction between treatments and storage period, Keap was the best treatment, which gave the lowest percentage of acidity (0.31%) at 105 days in the first season. However, in the second season, ethylene, Landamine and potassium nitrate treatments induced the lowest percentage of acidity (0.35%) at 105 days from cold storage period.

The results are in line with Smith *et al.*, (1985) and Makarem *et al.*, (1995) on apple and Hussein (2014) on banana they noticed that treated fruits with ethylene had less acidity compared to control before and during storage period.

Regarding macro and micro-elements, the results are harmony with Abd – El Megeed *et al.*, (2013) on "Le conte " pear and Aly *et al.*, (2014) on "Anna" apple they noticed that B and K decreased acidity content.

Table 7 : Effect of treatments and cold storage at 0°C and 95%RH on fruit acidity (%) in both seasons after 0, 15, 30, 45, 60, 75, 90 and 105 days

	First season								
Treat. 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
Ethylene	1.07	1.17	1.24	1.03	1.04	0.89	0.40	0.35	0.90
Landamine	1.22	1.20	1.17	1.08	1.03	0.96	0.42	0.35	0.93
Keap	1.90	1.46	1.70	1.11	0.83	0.77	0.43	0.31	1.06
Saccon	1.29	1.34	1.38	1.11	0.97	0.95	0.42	0.37	0.98
Potassium nitrate	1.60	1.42	1.31	1.15	1.10	0.49	0.36	0.37	0.98
Ave. (B)	1.48	1.36	1.38	1.06	0.97	0.79	0.40	0.35	
	Second season								
Treat. Day	0	15	30	45	60	75	90	105	Ave. (A)
Control	1.68	1.64	1.53	1.20	0.95	0.74	0.45	0.43	1.08
Ethylene	1.17	1.11	1.01	0.90	0.86	0.46	0.41	0.35	0.78
Landamine	1.77	1.42	1.13	1.07	0.87	0.74	0.38	0.35	0.97
Keap	1.70	1.62	1.54	1.02	0.96	0.87	0.45	0.37	1.07
Saccon	1.75	1.58	1.55	1.08	0.76	0.42	0.41	0.37	0.99
Potassium nitrate	1.36	1.20	1.06	0.87	0.75	0.68	0.55	0.35	0.85
Ave. (B)	1.57	1.43	1.30	1.02	0.86	0.65	0.44	0.37	
LSD at 5% for:				1st season			2nd season		
Factor A (Treatments) =				0.07			0.04		
Factor B (Date of cold storage)=				0.08			0.05		
Interaction AXB =				0.20			0.11		

However, data illustrated in Figure, 4 indicate a medium positive correlation and regression between residual ethylene (Independent factor) and fruit decay (Dependent Factor) in the second season.

Generally, from the obtained results for all substances enhanced fruit colour compared to control. Furthermore, ethylene, Landamine and Saccon gave the highest skin colour. However, ethylene has evil effect which makes such fruits more perishable and shortness the shelf life of apple fruits. The present results also indicate that, ethylene treatment caused the highest residual ethylene in "Anna" apple fruits, the highest fruit weight loss as well as the highest percentage of decay with the lowest fruit firmness during cold storage. Hence, ethylene treatment improve fruit colour at harvest and during cold storage but with poor fruit quality. Thus there should be more investigation for further use of nutrients as Saccon 3cm/L before 14 days pre-harvesting for improving skin colour and storability of apple fruits for replacing ethylene.

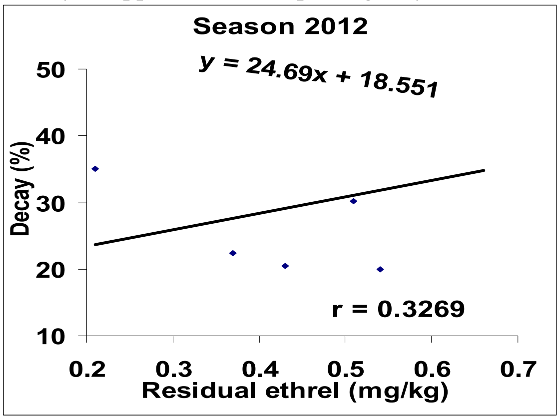


Fig 4: Relationship between residual ethylene (mg/kg) and decay (%)

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