

ROLE OF ANTIOXIDANT TREATMENTS IN IMPROVING POTATO YIELD AND QUALITY

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ABSTRACT

This trial was conducted at Mallawy Agricultural Research Station, El-Minia, Egypt, during the summer seasons of 2003 and 2004 to investigate the role of some antioxidant treatments on potato yield and quality. Three antioxidants *i.e.* salicylic acid (SA), acetylsalicylic acid (Aspirin) (ASA) and *n*- propylgallate (PG) at three levels; 0.1, 0.5, and 1.0 mM, were used as tuber seed soaking and foliar application treatments on potato plants, *Solanum tuberosum* L. cv. Diamant at the tuberization time. The results revealed that these antioxidants enhanced the content of chlorophyll (Chl) a, b and carotenoids in the leaves. Propylgallate at 0.5 mM in both seasons and 1.0 mM only in the second season gave the highest content of Chl. a, b and carotenoids. Also, SA at 0.5 mM and ASA at all tested levels recorded a significant increase in carotenoids. However, 1.0 mM SA showed a decrease in this respect. PG at 1.0 mM increased the tested pigments except Chl. a in the first season. The results indicated the importance of PG against photodamage of potato plants.

Significant increase in the plant height (cm) was noticed with propylgallate (PG) treatment in both seasons. The increment of plant height was corresponding with raising the concentrations. The other antioxidant treatments recorded the lowest values. Moreover, the increasing of SA or ASA levels, led to reduce plant height with insignificant differences as compared with the control. These results suggest that the higher concentration of ASA may be used as growth inhibitors, and the lower one as potato tuber promotion. Improvement in the reduction of the % of potato feathering by using SA treatment at 1.0 mM represents 24.86 % and 27.48 % in both seasons. The low levels of antioxidant treatments at 0.1 mM showed the highest value of tuber grading (10.67 % with SA). The other levels of antioxidant treatments (0.5 and 1.0 mM) showed the lowest and decreased the unmarketable potato tubers. The highest percentage of potato tubers (over 340g) was obtained by using PG at 0.5 mM in the first season and at 1.0 mM in the second season (7.08 % and 7.14 %) followed by PG at 0.5 mM in the second season (5.99), whereas SA and ASA at 1.0 mM showed a reverse effect.

PG at 1.0 mM in the two seasons improved the increasing of the dry matter percentage, specific gravity, total yield (ton /fed.) which was (10.50% in the first and 9.54 % in the second season) and starch % followed by SA at low levels (0.1mM or 0.5 mM). Acetylsalicylic acid gave a highly effective reducing agent in improving the colour value. Also, low levels of SA, PG and ASA at 0.1 and 0.5mM showed improvement in the colour value. The obtained results could be summarized as follows: a- Propylgallate at 1.0 mM improved the pigment contents yield (ton /fed.), plant height (cm), dry matter, specific gravity, and starch. b- Low levels of these antioxidants improved the production of potato seed tubers. c- Improvement in the reduction of the potato feathering % was recorded by using SA at 1.0 mM. So, SA may play a role in the promotion of senescence (aging, effects of old age) at the highest level. d- Acetylsalicylic acid (Aspirin) was effective in improving the colour value of potato tubers.

Key words: *acetylsalicylic acid, propylgallate, salicylic acid, Solanum tuberosum* L.

1. INTRODUCTION

Antioxidants a class of nutrients in human health that protect the body from damage caused by different factors (Karadeniz *et al.*, 2005), has prompted research in the fields of food science and horticulture to assess fruit and vegetable antioxidants (Kalt *et al.*, 1999). The majority of the antioxidant capacity of fruits or vegetables

may be from some compounds such as flavonoids, isoflavonoids, flavones, isoflavones, anthocyanins, catechins, vitamin C, E or β carotene (Kähkönen *et al.*, 1999). Many of these phytochemicals may help to protect cells against oxidative damage caused by free radicals (Wada and Ou, 2002). Antioxidants intercept free radicals and protect cells from the oxidative damage that leads to aging

and disease (Karadeniz *et al.*, 2005). Active oxygen scavengers (antioxidants) should be beneficial in the protection of the structure and function of the photosystems against excess light. (Rajagopal *et al.*, 2005). Also, Antioxidants play role in the reduction or prevention of enzymatic browning by inhibiting polyphenol oxidase (Maurice *et al.*, 2000).

Salicylic acid (SA, 2-hydroxy benzoic acid) is a natural cellular component (Raskin *et al.*, 1990), a natural phenolic compound (Klessige and Malamy, 1994), a natural growth regulator (Zhou *et al.*, 1999), a signal transduction or messenger (Klessig and Malamy, 1994). It has the ability to induce systemic acquired resistance (SAR) to pathogens (Raskin, 1992; Galal *et al.*, 2001 and Kawano *et al.*, 2004), and may enhance chilling and drought resistance in plants (Senaratna *et al.*, 2000). It gave heat tolerance (Pan *et al.*, 2006). It is present in many plant species at various levels. The concentration of endogenous SA varied significantly from tissue to tissue and from species to species (Raskin *et al.*, 1989). SA uptake was pH- dependent (Chen and Kuc', 1999). The function of SA excretion is unclear (Chen *et al.*, 2001). However, accumulation of SA in cells may affect some physiological functions and cause cytotoxicity (Kapulnik *et al.*, 1992). Exogenous application of SA induced pathogenesis-related gene expression and SAR (Bi *et al.*, 1995). Senaratna *et al.*, (2000) showed that the concentrations over 1.0 mM of acetylsalicylic acid or salicylic acid appeared to have adverse effects and therefore lower concentrations were used in most experiments. Studies by Munne-Bosch and Penuelas, 2003) concluded that moderate doses of SA enhance the antioxidant status and induce stress resistance; higher concentrations activate a hypersensitive cell death pathway and increase stress sensitivity. Also, Lopez-Delgado and Scott (1997) noted growth retardant effects of ASA on potato microplants *in vitro* at $10^{(-4)}$ - $10^{(-3)}$ mol/l. The followed work indicating that ASA was more effective than salicylic acid in potato tissue culture (Lopez-Delgado *et al.*, 1998). Koda *et al.* (1992) excluded the possibility of the involvement of SA in natural tuberization of potato plants.

Acetylsalicylic acid (aspirin;2-acetoxybenzoic acid) has been used for >100 years for pain (Paterson *et al.*, 2006) It is one of the basic preparation used in the therapy of cardiovascular diseases, leads to irreversible reduction of platelet aggregation (Stejskal *et al.*, 2001). Salicylic acid is widely present in plants and functions as a hormonal mediator of the systemic acquired resistance response to pathogen attack and environmental stress. Thus, it is present in a large

range of fruits, vegetables, herbs and spices of dietary relevance. The recognized effect of consuming fruits and vegetables on lowering risk of colon cancer may be partly attributable to salicylates in plant-based foods (Paterson *et al.*, 2006). The results by Godoy-Hernandez and Loyola-Vargas(1997)suggested that acetylsalicylic acid (Aspirin) (ASA) could act as a new biotic elicitor of metabolite production in *Catharanthus roseus* cell suspension cultures.

Propylgallate, (Three hydroxyl groups) is alkyl ester of gallic acid. It has strong antioxidant effect in foods, and blocks activity of lipoxygenase (Stejskal *et al.*, 2001) which make it very reactive, lower solubility, tend to chelate trace minerals such as iron and form colored complexes. It can inhibit ethylene production in fruit slices, flowers and vegetative tissues (Elad 1992). Plants contain a number of different pigments - including the carotenes and the xanthophylls - that are thought to protect from light stress. These pigments also play a role in capturing light and in maintaining the structure of the membrane (Johnson *et al.* 1993). The protective role of reactive oxygen scavengers against photodamage was significantly protected in the presence of histidine or n-propylgallate, chlorophyll photobleaching resulting in a decrease and retarded the damages to the antenna proteins, as reported by Zolla and Rinalducci (2002) and Rajagopal *et al.*, (2005). Also, it removes the hydroxyl radicals (Sonoike, 1996), and provided complete protection against light induced protein aggregation in isolated thylakoids Roberts *et al.*, (1991). Shelf life of peeled and cut potatoes is strongly limited by enzymatic browning that leads to a decrease in food quality (Limbo and Piergiovanni, 2006). It can be retarded by eliminating oxygen from the cut surface. However, this is not always feasible. The common way of inhibiting the enzymatic browning of peeled and sliced potatoes is to dip, or immerse, them in anti-browning agents. Among, such as ascorbic acid or citric acid through its ability to reduce quinines to phenolic compounds or its inhibitory effect on polyphenol oxidase (PPO) (Iyengar and McEvel, 1992). Dry matter is generally used as an index of starch content by breeders and growers (Gould and Plimpton, 1985) Tubers with high dry matter content require less energy and absorb less oil during frying, and have a drier texture after cooking (Storey and Davis, 1992). Lopez-Delgado *et al.*, (2004) reported that external application of salicylate could enhance tuber industrial quality by increasing dry matter and starch content. The objectives of this study were

to assess responses of potato plants to some antioxidants to improve the quality and productivity, find the best treatment to prevent the browning development of potato tuber slices for potato processing, as well as reducing the risks of potato consumption.

2. MATERIALS AND METHODS

Two field experiments were carried out in the two successive summer seasons of 2003 and 2004 at the Experimental Farm of Malloway Agricultural Research Station, El-Minia, Egypt on potato cv. Diamant. Imported potato seed

tubers were purchased and held in a semi dark room at room temperature (20°C±2) for two weeks to green sprouting (1.0cm length) before cuttings. Seed tuber was sized by diameter, cut into 50-60g pieces 2-3 days before planting. Each piece had not less than two active eyes. Then different antioxidant treatments were used as follows: These treatments were prepared and the pH value and the reduction in the pH solution at different concentration were recorded in Table (1).

Treatments	Concentrations (mM)	Form
Salicylic acid (SA)	0.1, 0.5, 1.0	C ₇ H ₆ O ₃ Molecular Weight (MW)= 138.12 g/mol
Propylgallate (PG)	0.1, 0.5, 1.0	C ₁₀ H ₁₂ O ₅ MW. 212.2
Acetylsalicylic acid (ASA)	0.1, 0.5, 1.0	C ₉ H ₈ O ₄ MW. 180.16
Control (tap water)		H ₂ O MW. 18.02

Table (1): pH values and the % of pH reduction of water solution treated individually with SA, PG and ASA at 0.1, 0.5 and 1.0 mM .

Treatment	Concen. (mM)	pH value	Reduction % in pH solution
Salicylic acid (SA)	0.1	3.50	52.70
	0.5	3.10	58.10
	1.0	2.80	62.11
Propylgallate (PG)	0.1	5.90	20.27
	0.5	5.80	21.62
	1.0	5.70	22.97
Acetylsalicylic acid (ASA)	0.1	4.10	44.59
	0.5	3.30	55.40
	1.0	3.00	59.45
Control (tap water)		7.40	-

Table (2): Some physical and chemical properties of the soil at depth of 0-30 cm (average of the two seasons).

Texture grade	Sand	Silt	Clay	pH	E.C	CEC	CaCO ₃	O. M	Available nutrient (ppm)		
									N	P	K
Clay loam	7.63 %	61.87%	30.50 %	7.9	1.12	36.45 %	2.08 %	1.09 %	45.13	11.25	82.30

CEC = Cation exchange capacity.

E.C = Electric conductivity.

O.M.= Organic matter

Table (3): Tubers yield (ton/fed.) of potato cv. Diamant as affected by some antioxidant treatments (SA, PG and ASA) at 0.1, 0.5 and 1.0 mM in the first and the second summer seasons.

Antioxidant treatments (mM)	Yield (ton/fed.)	
	First season (2003)	Second season (2004)
SA	0.1	11.724 B
	0.5	12.302 AB
	1.0	11.847 B
PG	0.1	11.703 B
	0.5	11.945 B
	1.0	12.880 A
ASA	0.1	11.737 B
	0.5	11.885 B
	1.0	11.995 B
Control (tap water)	11.656 B	

These treatments were applied by soaking the potato seed tuber pieces for 24h in one of the above solutions then, rinsed and left at room temperature for 1-2 days before plantings. The planting dates were January 20th and 23rd in the first and the second summer seasons respectively. Hills were 25 cm apart within row spacing. Each experimental plot consisted of 3 rows, 3 m length and 75 cm apart. At the time of the tuberization after 45, 60 and 75 days from planting an additional dose of the same treatments were applied as foliar application on potato plants. The experiment treatments were arranged in a randomized complete block design with three replicates. Other agricultural practices for potato production were followed as recommended by the Ministry of Agriculture, and potato requirements for fertilization was in accordance to the available nutrients illustrated in Table(2).

2.1. Pigment analysis:

After 3 days from the third foliar treatments (78 days after planting) pigments were determined. Fresh leaves (1g) were taken from these treatments, homogenized in a mortar with 5 ml of 80 % (v/v) acetone containing CaCO₃ as described by Gilmore and Yamamoto (1991). The extract was centrifuged at 10,000 g for 15 min at 4°C. The supernatant was stored in the dark at 5°C, while 3 ml of the solvent were added to the pellet and recentrifuged, this procedure repeated twice. The total supernatant was brought to a final volume of 10 ml. the concentration of chlorophyll a, b and carotenoids was determined by reading the absorbance of the extract at 663 nm for chlorophyll a, 644 nm for chlorophyll b and 440.50 nm for carotenoids. Calculations for pigments (Chl. a, Chl. b and carotenoids) were derived from the equations of Arnon (1949). All spectrophotometric assays were performed using a Milton Roy Spectrophotometer (Milton Roy Spectronic 1201).

2.2. Plant height (cm): Plant height was recorded at harvest time, after 110 days from planting.

2.3. Percentage of feathering: was recorded in accordance to Muriel *et al.*, (1976)

2.4. Yield and its components: Percentage of potato tubers was taken in this study according to Zvomuya and Rosen (2001), under three categories:

2.4.1. Marketable potato seed tubers (85-340g):

2.4.2. Unmarketable potato tubers less than 85g:

2.4.3. Tubers over 340g:

2.4.4. Tuber yield (ton/fed.)

2.5. Tuber quality:

2.5.1. Dry matter, was evaluated according to A.O.A.C (1990)

2.5.2. Specific gravity, was measured as described by Sinha, *et al.*, (1992).

2.5.3. Starch %, was calculated as described by Yildirim and Tokusoglu (2005) using the following equation. Starch % = 17.546+199.07 x (specific gravity-1.098)

2.6. Color characteristics

Color measurements of potato tubers were detected as described by Matus-Cadiz *et al.*, (2003) and Kaur and Singh (2005). Flour samples (slicing, dried at 70°C for 48h and ground) were carried out using a Hunter Colorimeter (Color Tec PCM Associates, Inc. N. J. USA) on the basis of L, a and b values. L- value designates the lightness of the sample (100= white and zero = black), a - values designates redness when positive or greenness when negative, and b- values designate yellowness when positive or blueness when negative. Individual samples were placed in a sample container that had a glass bottom, and opaque sides. The container was placed over the aperture of the colorimeter. Four readings from each treatment were obtained by rotating the container at 90 angles.

The instrument was calibrated against a standard red-coloured reference tile

$$L_s = 25.54, a_s = 28.89, b_s = 12.03$$

Total colour differences (TCD) were calculated by applying the equation

$$TCD = [(L_s - L)^2 + (a_s - a)^2 + (b_s - b)^2]^{1/2} \quad (\text{Kaur and Singh, 2005 and Limpo and Piergiovani, 2006})$$

2.7. Statistical analysis: All recorded data were subjected to the analysis of variance procedures and treatment means were compared using the Duncan. as described by Duncan (1955).

3. RESULTS AND DISCUSSION

3.1. Pigment analysis

SA, PG and ASA treatment enhanced the content of the Chl. a, b and carotenoids in the leaves (Fig. 1). Propylgallate at 0.5 mM in both seasons and 1.0 mM only in the second season showed the highest content of Chl. a. Also, SA at 0.5 mM and ASA at all tested levels recorded a significant increase with insignificant differences between them. On the other hand, PG at 1.0 mM increased these pigments, except Chl a in the first season. These results revealed the importance of PG against potato plants photodamage. Also, these results agree with Rajagopal *et al.*, 2005 who reported that photooxidation was significantly protected in the presence of n-propylgallate and the chlorophyll photobleaching resulting in a decrease. The specific action of PG indicates that singlet

oxygen (1O_2) was the main form of reactive oxygen species (ROS) responsible for strong light-induced damage. Acetylsalicylic acid and PG at 1.0 mM scored the highest values of carotenoids in both seasons; carotenoids are the scavenger of 1O_2 and are known to protect chlorophyll and the photosynthetic membrane from photo-oxidation damage (Siefermann-Harms, 1987). Similarly, ASA at 0.1, 0.5 and 1.0 mM increased carotenoids in the first season with insignificant differences among them. However, 1.0 mM SA in both seasons decreased the levels of all major pigments. The results of SA treatment are in agreement with those reported by Rao *et al.*, (1997) who implied that leaves treated with 1.0 mM SA did not enhance the content of chl. a or Chl. b. However, 0.5 mM SA decreased all major pigments. Also, Chen *et al.*, (2001) showed that SA could induce AOS generation, and enhanced H_2O_2 production (Kauss and Jeblick, 1994 and Rao *et al.*, 1997) and 0.5 mM SA caused super oxide generation (Kawano *et al.*, 1998). H_2O_2 regulation which may play a critical role in the onset and dynamics of senescence and leaf senescence in particular may involve degradation of chlorophyll (Hodges and Forney, 2000)

3.2. Plant height

The data showed significant increase in the plant height (cm) by using probylgallate (PG) at the three levels in both seasons (Fig. 2). This effect was more noticed by raising the concentrations of PG to 1.0 mM (66.27cm and 70.45 cm in the first and the second season, respectively). The antioxidant treatment with ASA at 1.0 mM in the two seasons recorded the lowest values. So, increasing the SA or ASA levels decreased plant height causing insignificant differences with the control treatment. Lopez-Delgado and Scott, (1996) noted the growth retardant effects of ASA on potato microplants *in vitro* at 10^{-4} - 10^{-3} mol/l. The mechanism of the effects of salicylates on plant growth rate is poorly understood, and the physiological importance of these effects is not clear (Pierpoint, 1994 and Lopez-Delgado and Scott, 1996).

3.3. Percentage of feathering

The results presented in Fig.(3) indicate that potato seed tuber soaking and foliar treatments 3 times at the time of tuberization with ASA at 1.0 mM had positive and significant effects on increasing potato feathering after harvest in both seasons giving 25.27 and 38.71 % (in the first and second seasons, respectively) compared

to the control (19.79 % and 32.85 %). Also, PG at 1.0 mM scored 40.00 % but only in the second season. On the other hand, SA treatments significantly decreased the potato feathering in the two seasons. The lowest values were obtained by SA at 1.0 mM which gave 14.87 % in the first season and 23.82 % in the second season. The reduction in the potato feathering with using SA treatment at 1.0 mM represent ranged from 24.86 % to 27.48 % in the first and second seasons, respectively. These results suggested that SA may play a role accelerating potato maturing and promote senescence. In this regard Munne-Bosch and Penuelas (2003) and Bordersen *et al.*, (2005) reported that the high concentrations of SA activated hypersensitive cell death (HR).

3.3.1 Percentage of marketable potato seed tubers (85-340g)

The data presented in Fig. 4a and 4b showed that low levels of antioxidant treatments (SA, PG and ASA) at 0.1 mM, improved the culturable potato seed tubers without significant differences among them. Thereby, PG at the same level gave the highest value (58.23 %), whereas it was 56.72 % for ASA and 56.07 % for SA compared with the control in the first season. The improving percentage represents 14.94 % with PG, 11.96 with ASA and 10.67 % with SA. Also, in the second season SA only at 0.1 mM gave the highest value (58.30 %) which represents 14.13 %. The other levels of antioxidant treatments (0.5 and 1.0 mM) showed the lowest values without significant differences between them in both seasons. Decreased stem height by ASA at high levels (Lopez-Delgado *et al.* 1998) may be due to increased the tuberization. Also, Lopez-Delgado *et al.*,(2004) found useful effects of medium supplemented with salicylate in the promotion of tuberization.

3.3.2. Percentage of unmarketable potato tubers (less than 85g)

At 0.1 mM, the three antioxidant treatments slightly decreased the unmarketable potato seed tuber by 35.86 % for PG and 36.76 % for ASA in the first season. No significant differences were detected between them as shown in Figs. 4a and 4b. The reduction was 23.94 % for PG, 22.03 % for ASA and 16.56 % for SA. The highest concentrations of SA (0.5 and 1.0 mM) and ASA at 1.0 mM induced an increase of the unmarketable potato tubers but these increases were insignificant. PG at 0.5 or 1.0 mM had slightly positive effect. From the previous studies by Lopez- Delgado *et al.*, (1998 and 2004) and the data presented in this study ASA

can be used as growth inhibitor and promoter for potato tuberization and its effect is concentration dependent.

3.3.3 Percentage of tubers over 340g

Among the three antioxidant treatments tested, the best result was obtained with PG at 0.5 mM in the first season and at 1.0 mM in the second season which gave 7.08 % and 7.14 %, respectively followed by PG at 0.5 mM in the second season (5.99 %). However, the control gave 2.09 % and 3.91 % in the first and the second seasons, respectively. On the contrary, the highest levels of SA and ASA (at 1.0 mM) decreased the percentage of tubers more than 40g with insignificant difference with the control.

3.3.4. Total yield (ton/fed.)

The obtained data in Fig. 8 and Table(3), revealed that potato yield as ton/fed. increased insignificantly with the most antioxidant treatments in both seasons, except with PG at 1.0 mM, in the first and PG at three levels in the second season, as compared with the control. This increase was significant with PG at 1.0 mM in both seasons and represented 10.50 and 9.54 % in the first and second season. On the other hand, SA at 1.0 mM caused a significant decrease in the total yield (ton/fed.) in the second season compared with the control. This decrease represents 7.74 % over the control. The reason may be due to cytotoxicity of SA. This explanation was reported by Kapulnik *et al.*, (1992) who mentioned that the accumulation of SA in the cells may affect their physiological functions and cause cytotoxicity. Also, the low level of the pigments, play a role in capturing light and in maintaining the structure of the membrane (Johnson *et al.*, 1993) as well as inhibiting the mineral uptake by changing the plasma membrane permeability (Einhellig, 1986) Also, Rao *et al.*, (1997) showed that leaves treated with SA exhibited greater damage to cellular pigments and organelles. Also, the pH reduction which represents 62.11 % SA at 1.0 mM may play a role in mineral uptake compared to 22.97 % with PG Table (1). The reasons for yield improvement by PG treatments may be due to the stimulation of photosynthesis, percentage of photooxidation and chlorophyll photobleaching resulting in a decrease in Chl. a, b and carotenoids. Also, n-propylgallate retarded the damages of the antennas proteins indicating mainly that singlet oxygen (1O_2) was involved in the degradation of PsaB gene product into two fragments, these fragments were absent with added n-propylgallate, which remove hydroxyl radical (OH) (Rajagopal *et al.*, 2005).

3.4. Dry matter (%)

The data presented in Fig. 5 show substantial increase in the percentage of potato tuber dry matter with PG, SA and ASA compared with the control. These results agree with the results by Lopez-Delgado *et al.*, (2004) who reported that external application of salicylate could enhance industrial quality by increasing the dry matter and starch. Significant increases with increasing levels of PG were detected. This increase was more pronounced in PG at 1.0 mM in both seasons (20.35% and 20.18 %) followed by ASA at 0.1 mM in the first season (19.47 %) and 0.5 mM SA in the second season (19.00 %). Significant differences between the levels of antioxidant treatments were noticed. The increments with PG at 1.0 mM may be due to the stimulation of photosynthesis which has been indicated previously because of the positive effect of PG on increasing pigment content.

3.3. 5. Specific gravity

In spite of the increments of this quality character in the first seasons compared with the control, these increases were insignificant (Fig. 6). Significant increase in specific gravity in the second season was recorded by the application of PG at 1.0 mM which gave 1.082 followed by ASA at 1.0 mM (1.074), PG at 0.5mM (1.074), SA at 0.5mM (1.074) and SA at 0.1 mM as compared with the control, as well as the other of treatments. In the mean time, insignificant effects were detected among these positive treatments. On the other hand, the effects of all treatments were insignificant in the first season. These result may be due to a varietal character and the genotype effects

3.6. Percentage of starch

Application of SA at 0.1 and 0.5 mM, PG at 0.5 and 1.0 mM and ASA at 0.1 mM in the two seasons gave the highest values with insignificant differences among them (Fig. 7). The highest values were recorded with PG at 1.0 mM in both seasons (13.55 and 13.20 %) compared with the control (11.81 and 11.70%). In contrary, high levels of SA or ASA caused a slight increase in the percentage of starch. This increase by low levels of SA may be due to the enhancement of H_2O_2 production by salicylate treatments. In this respect, many authors showed a strong relation between SA and H_2O_2 . Lopez-Delgado *et al.* (2005) showed that H_2O_2 treatments significantly enhanced potato tuber starch accumulation ranged 6.7 % to 30.0 % as determined by the specific gravity. Also the increment by PG treatment may be due to the stimulation of the photosynthesis process.

3.7. Color characteristics

The data illustrated in Figs. 9. and 2B. showed

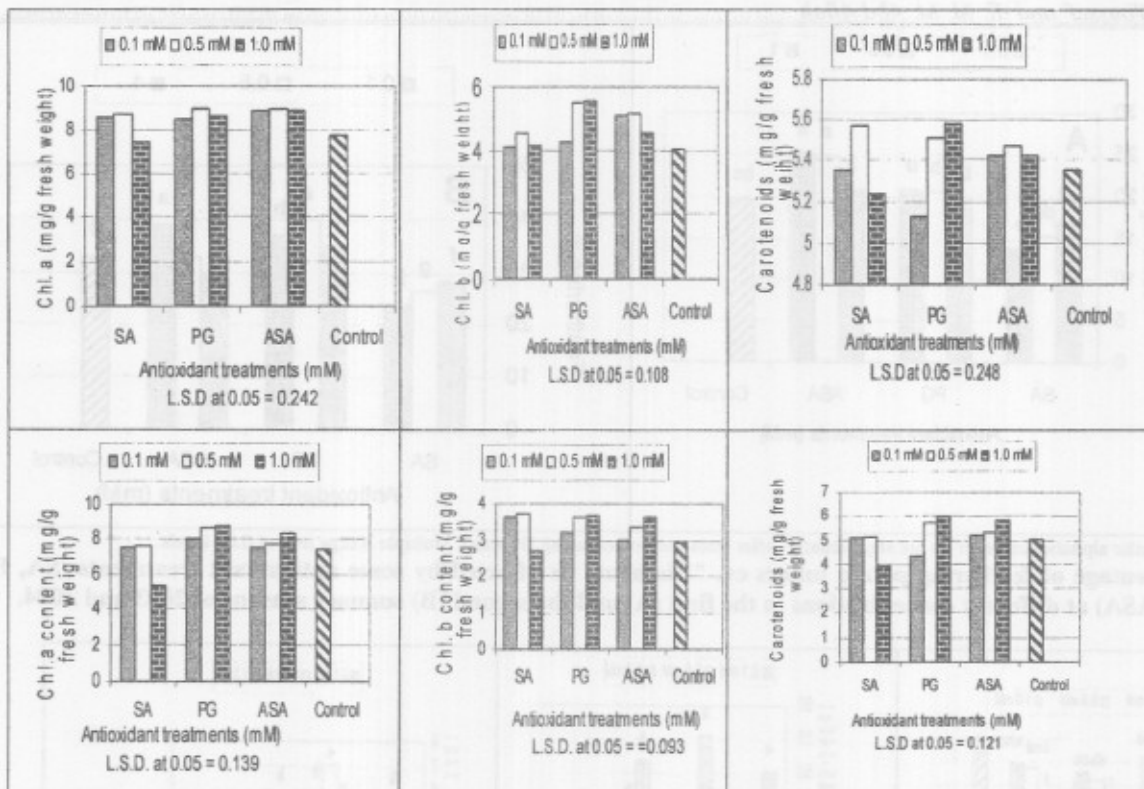
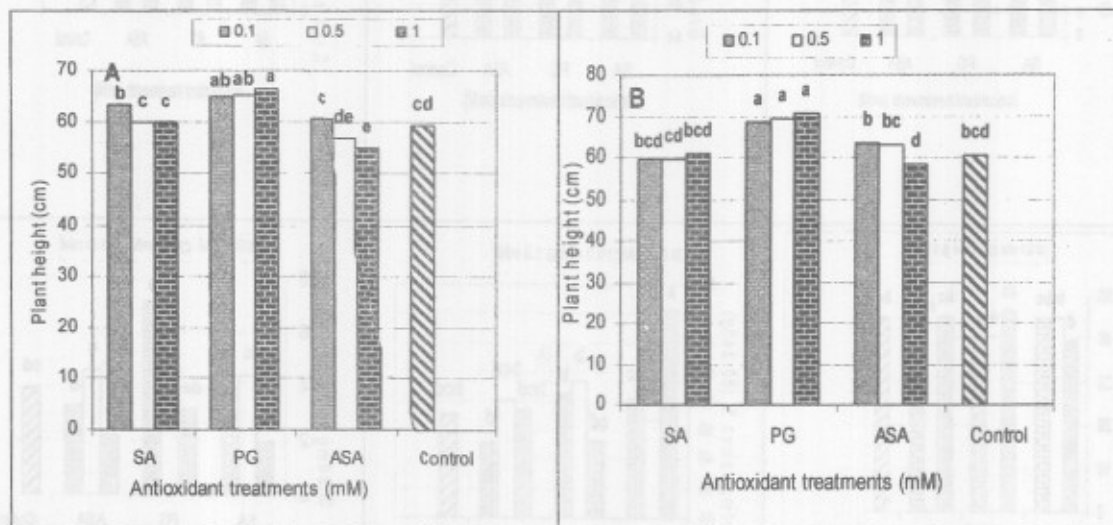
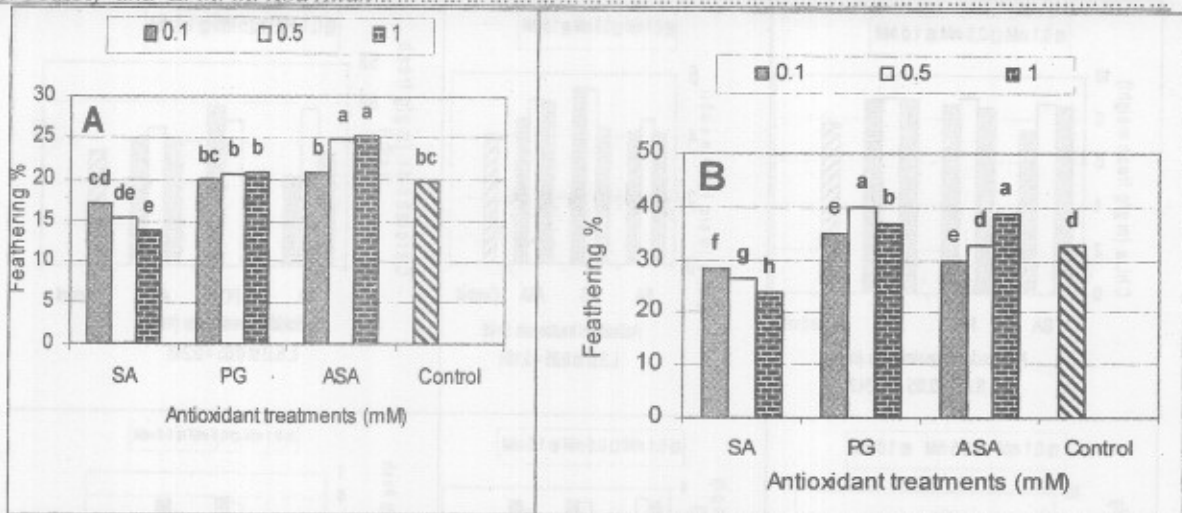


Fig. (1): Chlorophyll, a, b and Carotenoid content (mg/g fresh weight) of the leaves of potato plants cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different concentrations in the first (top) and the second summer seasons (bottom).



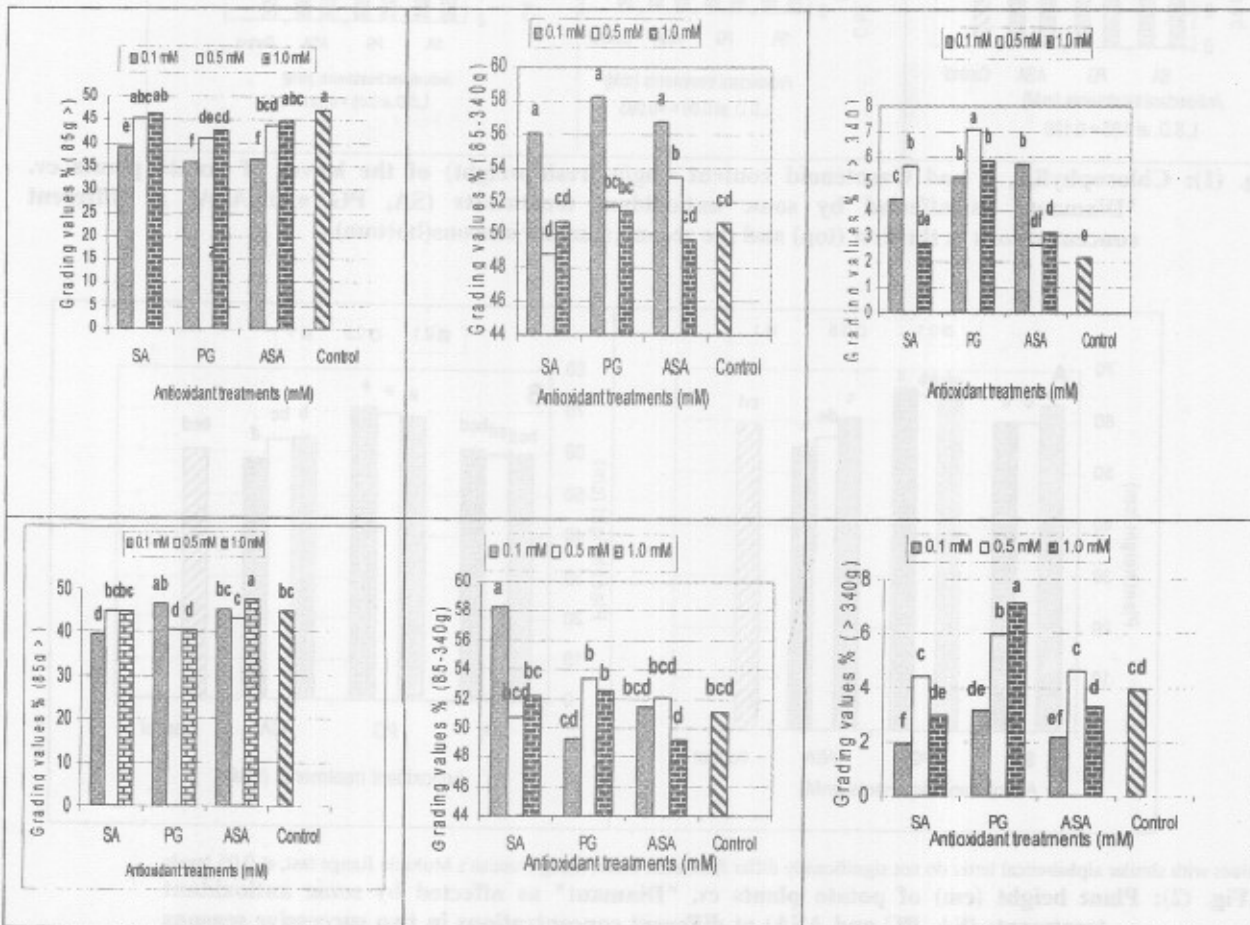
Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels

Fig. (2): Plant height (cm) of potato plants cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different concentrations in two successive seasons (2003 & 2004).



Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Fig. (3): Percentage of feathering potato tubers cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different concentrations in the first (A) and the second (B) summer seasons of 2003 and 2004.



Values with similar alphabetical letter not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Fig. (4a): Tuber grading % (< 85 g, 85-340g and 340g<) as affected by antioxidant treatments (mM) (SA, PG and ASA) in the first (top) and the second season (bottom).

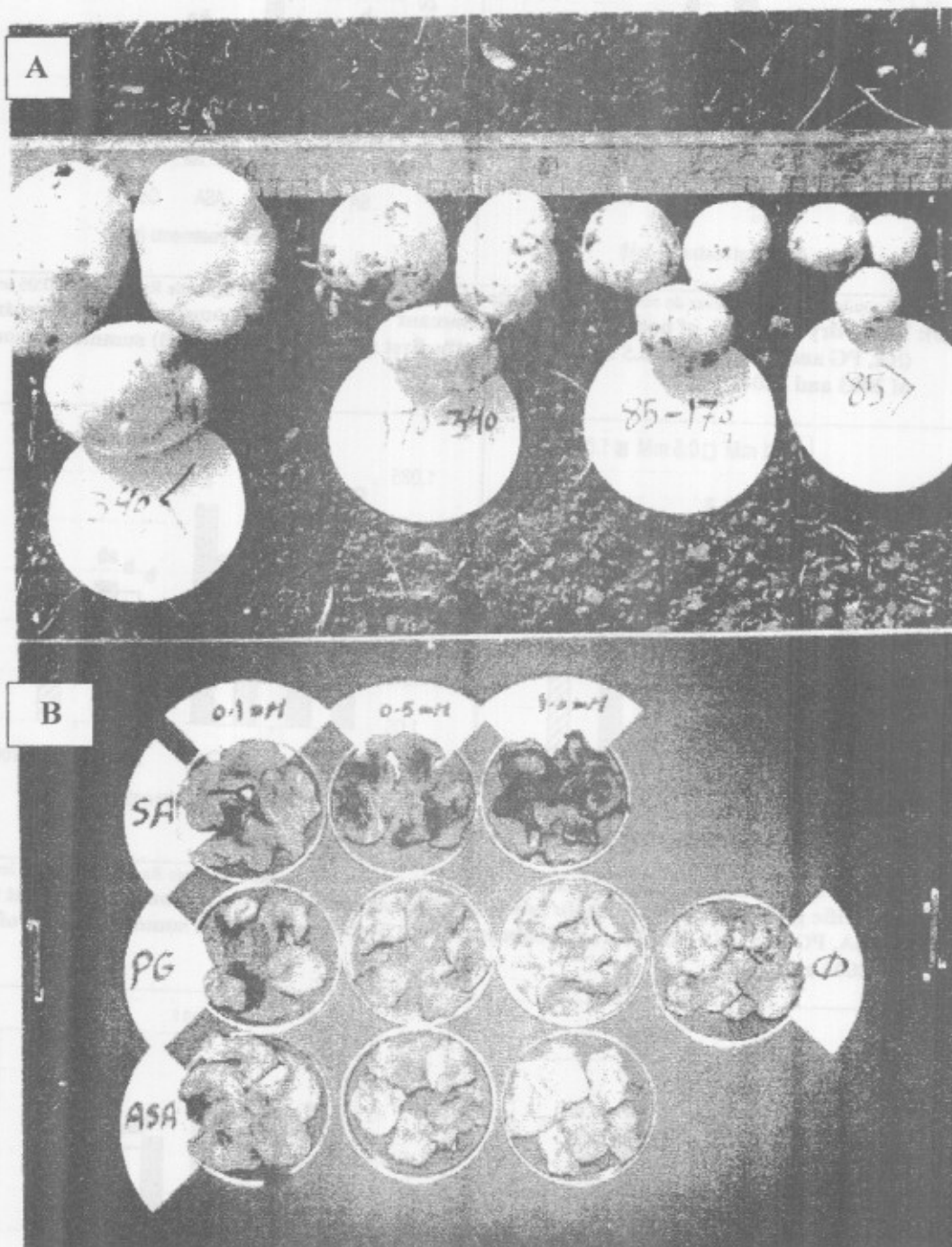
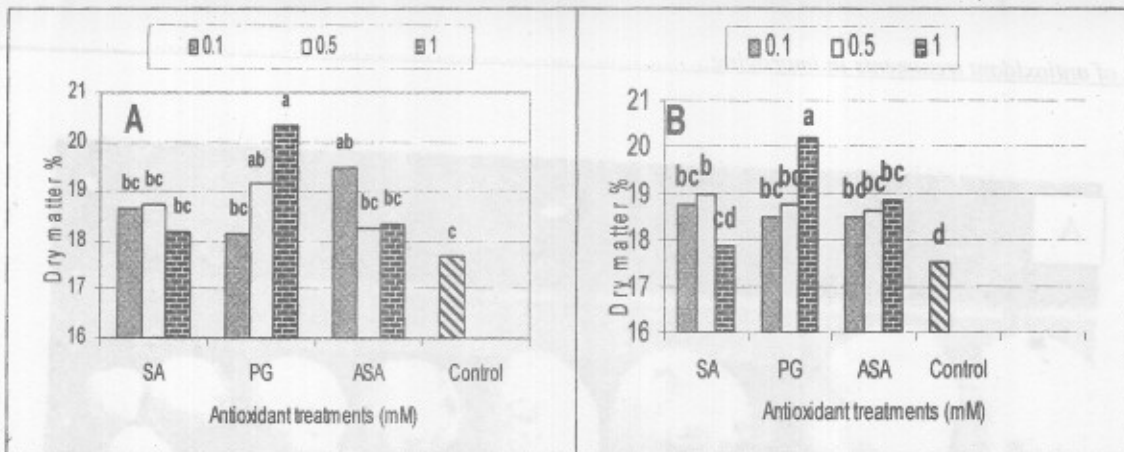
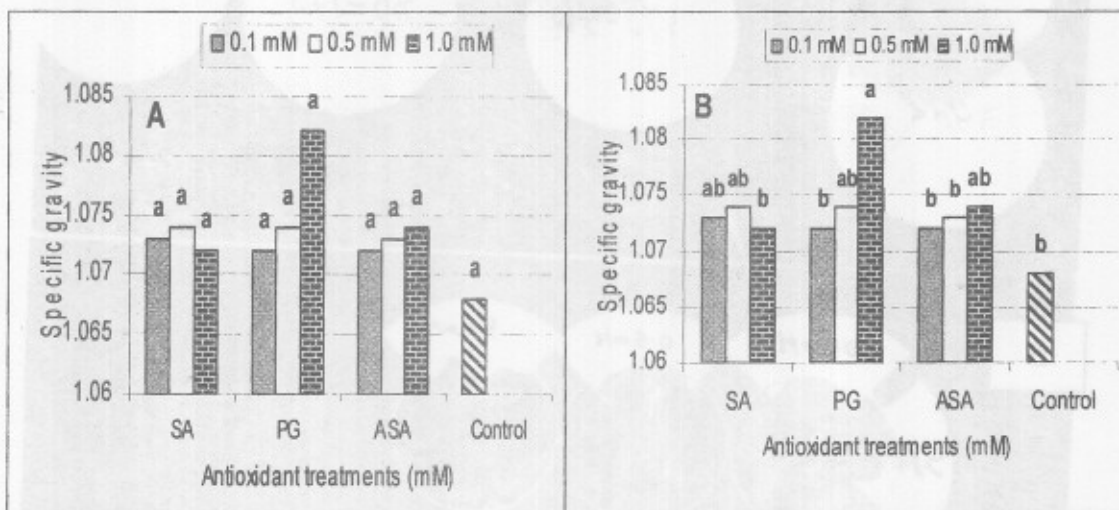


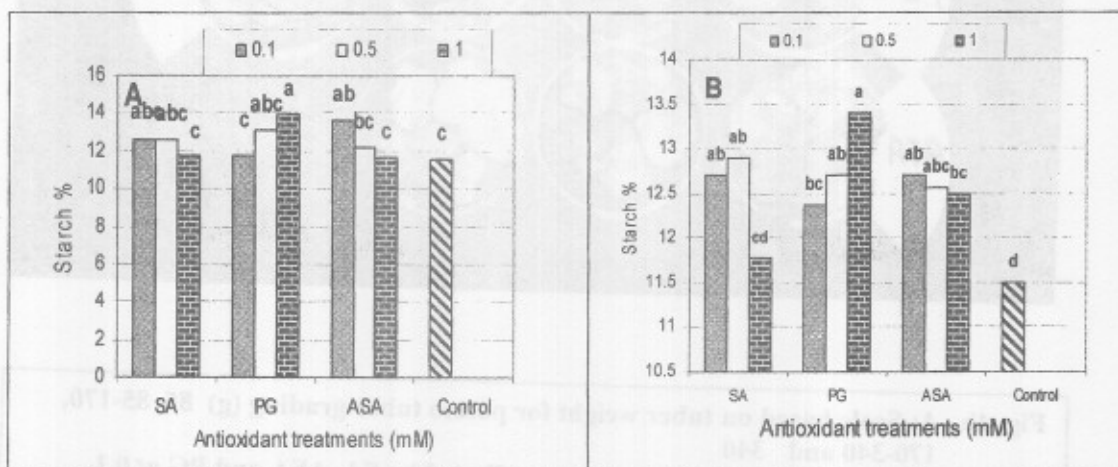
Fig. 4b. A: Scale based on tuber weight for potato tuber grading (g) 85, 85-170, 170-340 and 340
B: colors of potato tuber slices as affected by SA, ASA and PG at 0.1, 0.5 and 1.0 mM



Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.
Fig. (5): Tuber dry matter % of potato tubers cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at 0.1, 0.5 and 1.0 mM in the first (A) and the second (B) summer seasons of 2003 and 2004.

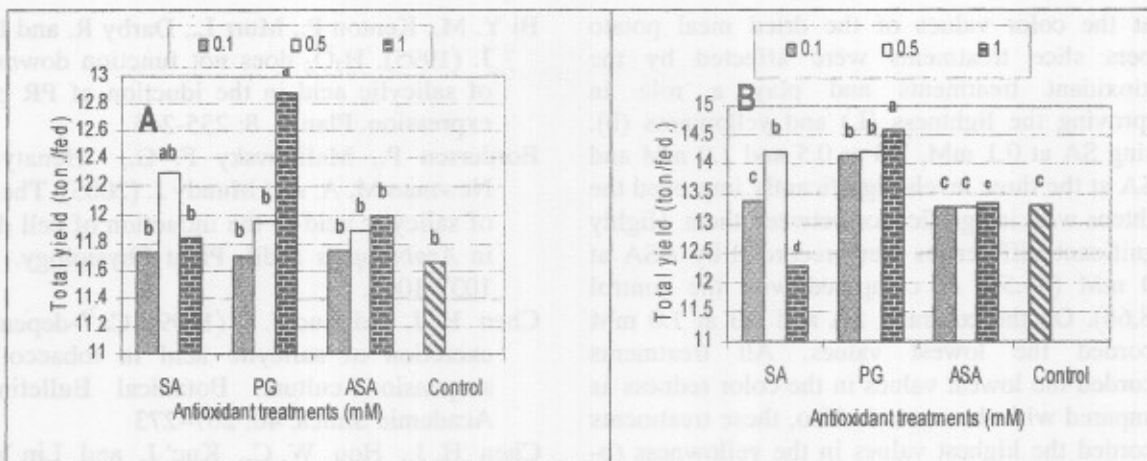


Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.
Fig. (6): Specific gravity (Sp.Gr) of potato tubers cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different treatments in the first and the second summer seasons of 2003 and 2004.



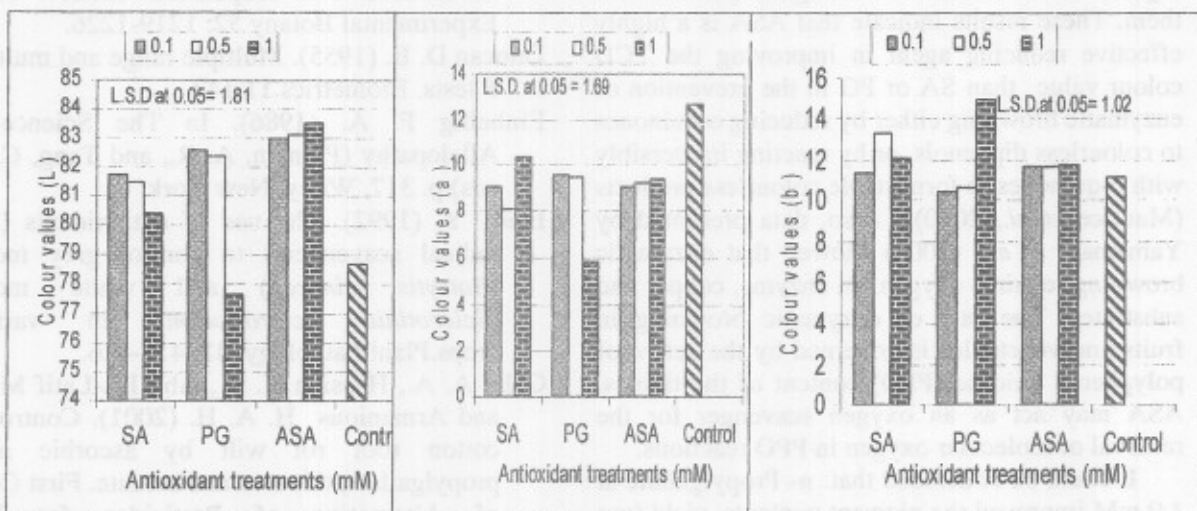
Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Fig.(7): Percentage of starch of potato tubers cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at 0.1, 0.5 and 1.0 mM in the first and the second summer seasons of 2003 and 2004.



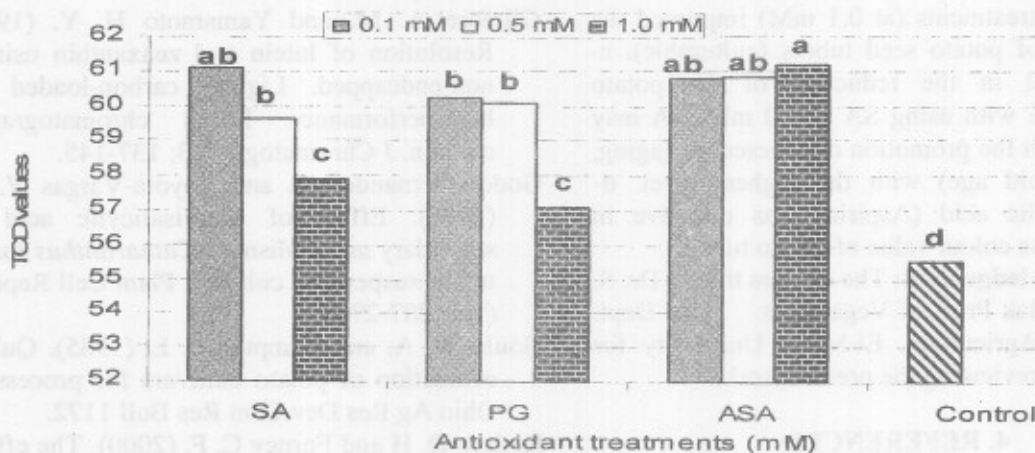
Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Fig. (8): Yield (ton/fed.) of potato tubers cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different concentrations in the first and the second summer seasons of 2003 and 2004.



Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

L= 100 (white) to zero (black); a= + (red); b= + (yellow)



Values with similar alphabetical letter do not significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Fig. (9): Color and TCD values of dried meal potato tuber slices cv. "Diamant" as affected by some antioxidant treatments (SA, PG and ASA) at different concentrations.

that the color values of the dried meal potato tubers slice treatments were affected by the antioxidant treatments and play a role in improving the lightness (L) and yellowness (b). Using SA at 0.1 mM, PG at 0.5 and 1.0 mM and ASA at the three levels significantly improved the lightens with insignificance between them. Highly significant differences were recorded by ASA at 1.0 mM (83.56) as compared with the control (78.68). On the contrary, SA and PG at 1.0 mM recorded the lowest values. All treatments recorded the lowest values in the color redness as compared with the control. Also, these treatments recorded the highest values in the yellowness (b-values) as compared with the control. Both SA at 0.1 mM and ASA at the three levels recorded the highest TCD values with insignificant between them. These results indicate that ASA is a highly effective reducing agent in improving the TCD colour value than SA or PG in the prevention of enzymatic browning either by reducing o-quinones to colourless diphenols, or by reacting irreversibly with o-quinones to form stable colourless products (Maurice *et al.*, 2000). Also, data presented by Yamamoto *et al.*, (2004) showed that enzymatic browning requires oxygen, an enzyme, copper and substrates. The rate of enzymatic browning in fruits and vegetables is governed by the active of polyphenol oxidase (PPO) content of the tissues. ASA may act as an oxygen scavenger for the removal of molecular oxygen in PPO reactions.

It could be concluded that: a- Propylgallate at 1.0 mM improved the pigment contents, yield (ton/fed.), plant height (cm), dry matter, specific gravity, and starch. b- Low levels of these antioxidant treatments (at 0.1 mM) improved the production of potato seed tubers (culturable). c-Improvement in the reduction of the potato feathering % with using SA at 1.0 mM, SA may play a role in the promotion of senescence (aging, effects of old age) with the highest level. d- Acetylsalicylic acid (Aspirin) was effective in improving the colour value of potato tubers.

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دور المعاملات بمضادات الأكسدة في تحسين جودة وإنتاجية البطاطس

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ملخص

أجريت هذه الدراسة بمحطة البحوث الزراعية بملوى - المنيا - مصر خلال الموسمين الصيفيين ٢٠٠٣ و ٢٠٠٤ لدراسة دور مضادات الأكسدة في تحسين جودة وإنتاجية البطاطس. تم استخدام ثلاث معاملات من مضادات الأكسدة [حمض السالسليك - البروبيل جلات - حمض الاسيتيل سالسليك (الاسبرين)] بتركيزات ٠,١ و ٠,٥ و ١,٠ مللي مولر عن طريق نقع التقاوى ورشا على المجموع الخضري لنباتات البطاطس صنف "دايمونت" في فترة تكوين الدرناات. وقد اوضحت النتائج ان:

أدت مضادات الأكسدة المستخدمة الى زيادة محتوى الاوراق من الصبغات (كلوروفيل أ و ب والكاروتينات) وتم الحصول على هذا التأثير بالمعاملة بالبروبيل جلات عند التركيز ٠,٥ مللي مولر في كلا الموسمين اما التركيز ١,٠ مللي مولر من هذه المادة في الموسمين فقد اعطى اعلى محتوى من تلك الصبغات عدا كلوروفيل أ في الموسم الاول فقط. سجل ايضا حمض السالسليك والاسبرين عند كل التركيزات المختبرة زيادة طفيفة بدون اختلافات معنوية بينهم. وادى حمض السالسليك بتركيز ١,٠ مللي مولر في كلا الموسمين الى خفض مستوى كل الصبغات المختبرة.

و توضح هذه النتائج اهمية البروبيل جلات في حماية نباتات البطاطس من الضرر الناتج عن الاضاءة. - وجدت زيادة معنوية في ارتفاع النبات (سم) عند استخدام البروبيل جلات بالثلاثة مستويات في كلا الموسمين و كانت هذه الزيادة مصاحبة لزيادة التركيز اما باقى المعاملات فسجلت اقل القيم. علاوة على ذلك مع زيادة مستويات حمض السالسليك والاسبرين وجد انخفاض في ارتفاع النبات (سم) ولكن بدون اختلافات معنوية مع معاملة المقارنة.

توضح هذه النتائج ان المستوى العالى من الاسبرين ربما يمكن استخدامه كمثبط للنمو اما المستويات المنخفضة منه فتعمل على تشجيع تكوين الدرناات - انخفضت النسبة المئوية للترييش في الدرناات مع استخدام حمض السالسليك بتركيز ١,٠ مللي مولر و تراوحت ما بين ٢٤,٨٦ % الى ٢٧,٤٨ % في كلا الموسمين مقارنة بباقى المعاملات.

فيما يتعلق بالنسبة المئوية للتدرج للدرناات على اساس الوزن فقد وجد ان المستويات المنخفضة (٠,١ مللي مولر) من المواد المستخدمة حسنت من انتاج الدرناات الصالحة كتقاوى وبلغت الزيادة (١٤,٩٤%) عند استخدام البروبيل جلات و ١١,٩٦% عند استخدام الاسبرين و ١٠,٦٧% عند استخدام حمض السالسليك) اما المستويات الاخرى فظهرت اقل القيم - اعطى البروبيل جلات عند المستوى ٠,٥ مللي مولر في اموسم الاول وعند المستوى ١,٠ مللي مولر في الموسم الثانى اعلى نسبة مئوية للدرناات الاكبر من ٣٤٠ جم (٧,٠٨% و ٧,١٤%) يليها البروبيل جلات عند التركيز ٠,٥ مللي مولر في الموسم الثانى (٥,٩٩%). بينما المستويات العالية (١,٠ مللي مولر) من كل من حمض السالسليك والاسبرين اظهروا انخفاض.

وجدت زيادة في النسبة المئوية للمادة الجافة و الوزن النوعى والمحصول الكلى (طن/فدان) والذى سجل زيادة مقدارها ١٠,٥٠% في الموسم الاول و ٩,٥٤% في الموسم الثانى مع استخدام البروبيل جلات عند التركيز ١,٠ مللي مولر يليها حمض السالسليك بالتركيزات المنخفضة (٠,١ و ٠,٥ مللي مولر).

اعطى الاسبرين كعامل مختزل اعلى تحسن في قيم اللون لشرائح البطاطس المطحونة وكذلك المستويات المنخفضة من حمض السالسليك والبروبيل جلات ولكن بدون اختلافات معنوية بينهما.

ويستخلص من النتائج الآتى:

- ١- تلعب بعض المعاملات دور ايجابى في تحسين جودة وإنتاجية البطاطس وتأثيراتها تعتمد على تركيزها.
- ٢- زادت المعاملة بالبروبيل جلات بتركيز ١,٠ مللي مولر من محتوى الصبغات و من ارتفاع النبات (سم) و من المادة الجافة ومن الوزن النوعى ومن النشا ومن المحصول الكلى (طن/فدان).
- ٣- حسنت المستويات المنخفضة (٠,١ مللي مولر) من هذه المعاملات من انتاج تقاوى الدرناات.
- ٤- زادت المستويات العالية (١,٠ مللي مولر) من حمض السالسليك من انخفاض النسبة المئوية للترييش فى الدرناات فربما يكون له دور فعال في تشجيع الدخول في مرحلة الشيخوخة مع التركيزات العالية.
- ٥- وجد ان حمض الاسيتيل سالسليك (الاسبرين) ذو فعالية في تحسين اللون في شرائح درناات البطاطس وذلك ربما لتقليله التفاعل البنى المعروف لتكوين اللون البنى.