Effect of Hhydrogen Peroxide Foliar Spraying on Tuber's Quality of Three Potato Cultivars

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ABSTRACT: Two field experiments concerning potato (*Solanum tuberosum L.*) crop were carried out during two successive winter seasons of 2009/2010 and 2010/2011 in a private farm at a newly reclaimed area, in El-Amria region, Alexandria governorate, Egypt. The experiment was performed to study the effect of hydrogen peroxide (H_2O_2) on the potato processing quality and the economical characters. The split-plot design in three replicates was used, where potato cultivars were placed in the main plots, while doses of foliar spraying with hydrogen peroxide were occupied the sub-plots. Three potato cultivars were tested in this investigation; Lady Rossetta, Valor and Mondial. Four doses of hydrogen peroxide were used as zero, 25, 50 and 75 mM in the first year. Two higher doses, 100 and 125 mM of hydrogen peroxide were added in the second year. Potato plant stem diameter was positively affected with the increasing of H_2O_2 concentrations from zero up to 125 mM. The results showed that the 25, 50 and 75 mM of H_2O_2 concentrations did not affect the potato tuber yield. The other two high levels (100 and 125 mM) of H_2O_2 resulted in lower potato yields. The number of tubers/ 10 Kg weight trait seemed to be affected with H_2O_2 concentrations, in which it was above the accepted number during the second year (more than 112 tubers/10 Kg weight).In the first year, the data indicated that spraying potato plants with 75 or 50 mM of H_2O_2 significantly increased dry matter percentage compared with the control treatment. Both treatments of 75 and 50 mM of H_2O_2, produced the highest levels of tuber starch content in the first year , while the treatment 75 mM of H_2O_2, produced the highly tuber starch content with significant differences among the other tested treatment in the second year of the study. The effect of hydrogen peroxide on parenchyma cell diameter trait differed from year to another. The treatment of 50 mM of H_2O_2 possessed the highest value for parenchyma cell diameter trait, whereas, the treatments of both 25 and 125 mM of H_2O_2 increased the parenchyma cell diameter trait. The lowest chipping defects were produced when potato plants sprayed with 50 mM H_2O_2. The control treatment gave the lowest mean value (result) where this treatment produced highly significant level of tuber chipping defects.

Key words: potato, *Solanum tuberosum L.*, hydrogen peroxide, parenchyma cells, starch accumulation, total sugars, Dry matter percentage and chips defects.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world number one of non-grain food commodity. The global production of potatoes is 324,181,889 tons grown under an area reached about 18,596,233 hectares, and the world seed production was 31,567,656 tons (FAO, 2010). Potato has an important position among all vegetable crops in Egypt, where about 20% of total area devoted for vegetable production, was cultivated with it. In addition, the total cultivation of potato, according to estimates of the Egyptian Ministry of Agriculture for the

year 2012,reached 200 thousands feddans spread over three lugs (summer, Nili and winter) with a total production reached more than 2 million tons, with an average productivity about 10 tons per feddan (FAO, 2010).

In the past ten years, processing potatoes was increased in Egypt, both for the production of potato chips or for French fries. These processes require a number of specifications to keep the products in high quality. Among the most important factors is the high net product ratio which is highly associated with the percentage of dry matter and starch content, in addition to the lack of reducing sugars. Many researches were directed to increase the quality processing. Tuber starch is an important quality character for potato crops. Dry matter is, generally, used as an index of starch content by growers and breeders and it is an important factor to decide the destination of the produce (Gould and Plimpton, 1985; Estrada, 2000). Tubers with high dry matter content, for example, require less energy and absorb less oil during frying, and have a drier texture after cooking (Storey and Davies, 1992). Also; the acceptability of potatoes for processing is largely dependent on the color of the end product. Color is directly related to the quantity of sugars in the tuber. The quantity and composition of sugars in tubers are dependent on cultivar, stage of maturity, occurrence of stress, handling and storage management practices. Regulation of sugar levels in tubers by proper production and storage management practices is essential acceptable processing quality (Prichard, 1993). Delgado *et al*. (2005) demonstrated in their research that field plants treated with 5 or 50 mM hydrogen peroxide significantly enhanced tuber starch accumulation within 6.7% and 30%, respectively. Also, they found that hydrogen peroxide treated stems were up to 27% thicker than control plants. and explained that this result mainly due to enlarged medullar parenchyma cells. However, this research was conducted in an attempt to improve potato plant characteristic and tuber quality, i.e., productivity, specific gravity, starch, reducing and total sugars contents to produce acceptable crisp at the end through spraying the field growing plants with some different concentrations of hydrogen peroxide.

MATERIALS AND METHODS

Three potato cultivars; namely, Lady Rossetta, Valor and Mondial were tested in this investigation during two successive winter seasons of 2010 and 2011. The planting was conducted in the newly reclaimed area in Al-Amria region, Alexandria governorate. This research was existed to test the effect of hydrogen peroxide on the potato yield and tuber quality. Hydrogen peroxide was foliar sprayed once every three days along the growing season starting from the complete plant emergence until the crop maturing. Three doses of hydrogen peroxide (25, 50 and 75 mM) were used in the first season, in addition to the control treatment, which sprayed with water. In the second season, two higher doses; 100 and 125 mM were added to the levels of tested variable. Tubers were planted as a whole, 25 cm apart in the row, 6.25 m long and 0.70 m width.

Each treatment comprised of two rows containing 25 seed tubers each. The experimental plot was 8.75 m^2. The plots were under furrow irrigation. It was

fertilized with 20 m^3 of farm manure/ fed. added with soil preparation. It was fertilized with 45 kg P_2O_5/fed. in the form of super phosphate 15.5 % added within planting in the opened row. Potassium was added at 72 kg k_2O/fed. added on there equal doses, within planting, 45 and 60 days after planting. Nitrogen fertilizer added to the crop in 120 kg N/fed. One quarter of the quantity was added within planting in the form of ammonium sulphate. The rest of the quantity was added in 3 equal placements in the form of urea 48 % N at, 45, 60 and 75 days after planting. All the agricultural practices for potato production i.e. green sprouting, irrigation, pest disease and weed control were practiced as well. The three tested cultivars were randomly distributed in the block and the spraying with hydrogen peroxide was randomly distributed within each cultivar. The split-plot design in three replicates was used, where potato cultivars were placed in the main plots, while doses of foliar spraying with hydrogen peroxide were occupied the sub-plots.

All the agricultural practices used for commercial potato production, as common in this area, were carried out in both years.

Measurements

Vegetative growth and yield parameters: average of ten plants/ plot was tested 70 days after planting for measuring plant height (cm), stem diameter (mm) and counting number of main stem / plant. At harvesting time (120 days after planting), the following determinations were estimated: total tuber yield / feddan (ton/ fed.); where the produced tubers per plot were weight and converted into tons/ fed. Average number of tubers/ plant was estimated using the average 10 plants. Number of tubers/ 10 kg was determined by taking a random sample of 10 kg of tubers from the yield of each treatment then their tubers were counted. The accepted category is that count 72-112 tubers in such treatment.

Physical and chemical characteristics: Chlorophyll content was determined using the method of (Grodzinsky and Grodzinsky, 1973) 75 days after planting. Tuber shape index was estimated by dividing the length over the width of the tuber.

Dry matter (%): was determined by drying the tuber slices at 70° C for 24 hr until a constant weight by dividing the (dry weight/ fresh weight) x 100 (Haase, 2003).

Specific gravity: was determined using the method described by Dinesh *et al*. (2005):

$$\text{Specific gravity} = \frac{\text{Weight of tuber in air}}{\text{Weight of tuber in air - weight of tuber under water}}$$

Starch (%); it was determined using the method described by A.O.A.C. (1980) on dry matter basis.

Total and reducing sugars (%): were determined using the method of Dubios *et al*. (1956) method on fresh weight basis.

Crisp net percentage (was recorded only in the first year): where some potato slices were weight and deep fried at 170°C and the resulted crisps was weight and related to the fresh weight. Crisps defect evaluation was calculated by showing the size limits (1/2 cm) for sugar browning and defects using chip-check chart method to determine the internal, external and undesirable color defects and dividing the defects to three categories; the first green from 0 - 8 % defects are acceptable potato chips, the second yellow > 8 – 15 % defects are acceptable potato chips but with discarding the percentage over 8 % and the third red > 15 % defects are rejected and not suitable for processing according to (Frito Lay Company, 1999).

Histological examination: random samples of tubers were taken from each treatment (three tubers) then peeled and cut with a sharp cork on sliding microtome into slices 1 mm thickness and 10 mm in diameter. The slices were mixed and washed with distilled water. Ten randomly slices were examined under a compound microscope using a high power (400 x) objective to determine the parenchyma cell diameter, in micron (µm), of potato tubers.

Statistical analysis:

All the collected data from both years were tabulated and statistically analyzed using analysis of variance technique. Duncan's multiple range test (Steel *et al*., 1997) was applied to determine the least significant difference (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

1. Effect of hydrogen peroxide concentrations on the studied vegetative characters:

The data presented in (Table 1) appeared that number of stems per plant did not significantly affected with the differences in tested concentrations of hydrogen peroxide (H_2O_2). Meanwhile, the interaction between the cultivars and the concentrations of H_2O_2 was insignificant. Potato plant stem diameter was positively affected with the increasing of H_2O_2 concentrations from zero up to 125 mM during 2010/2011 season. The data showed that there were significant differences among the tested cultivars during the two years of the study. The cultivars Valor and Mondial positively surpassed the cultivar Lady Rosetta in both years of the study. The interaction between potato cultivars and the levels of H_2O_2 was significantly noticed in the second season only. Mean diameter of sixth internodes of H_2O_2 treated plants was 27% (5 mM) and 21% (50 mM) greater than control plants (Delgado *et al*., 2005). These authors discussed that these results, mainly, taken place due to enlargement of the medullar parenchyma cells. Same trend of results were obtained by Moussa *et al.* (2012).The results of plant height character showed that spraying potato plants with increased levels of H_2O_2, did not significantly affect this character. Same trend of results was, also, noticed for the

results of the interaction between the tested potato cultivars and the H_2O_2 concentrations during both years. Valor cultivar, positively, surpassed both Lady Rosetta and Mondial cultivars in plant height especially in the first season of the study. The results of Moussa *et al*. (2012) appeared that no significant effect of the concentrations of hydrogen peroxide on the plant height during both years of the study, as well as there were no effects of these concentrations of hydrogen peroxide on the number of branches per plant in the first year of the experiment.

The results of leaves chlorophyll content (Table 1), clearly appeared that neither the tested cultivars, nor hydrogen peroxides treatments, nor the interaction between both factors had the ability to affect the leaves chlorophyll content during the first year of this research. In the second year, there were significant difference effects among the tested cultivars. Lady Rossitta and Valor possessed highly significant values than Mondial cultivar. The tested H_2O_2 levels affected the chlorophyll content. The highest mean value was recorded with using 100 mM H_2O_2 with insignificant differences effects with both 50 and 125 mM H_2O_2. The levels of zero, 25, 50, 75 and 125 mM H_2O_2 had, significantly, lower values in comparison with the treatment 100 mM H_2O_2. As in the first year, the interaction between the cultivars and H_2O_2 treatments was not significant.

Table (1): Mean values' performances of the studied vegetative traits of tested potato cultivars during both years of 2009/2010 and 2010/2011

Seasons		2009/2010				2010/2011			
Characters		Plant height (cm)	No. of main stems/plant	Stem diameter (mm)	Chloro phyll (mg/g F.W)	Plant height (cm)	No. of main stems/plant	Stem diameter (mm)	Chloro phyll (mg/g F.W)
Cultivars									
Lady rosetta		41.95^{b}*	3.68^{a}	9.34^{b}	1.019^{a}	34.31^{b}	3.49^{b}	10.21^{b}	1.073^{a}
Valor		46.10^{a}	5.15$_{a}$	10.45$_{a}$	1.006^{a}	40.54^{a}	4.73^{a}	11.02^{a}	1.075^{a}
Mondial		40.06^{b}	4.66^{a}	10.11^{a}	0.992^{a}	34.07^{b}	4.63^{a}	10.84^{a}	1.046^{b}
H_2O_2 Concentration									
Control		41.46^{a}	4.47^{a}	8.89^{d}	0.991^{a}	35.82^{a}	4.13^{a}	9.50^{d}	1.053^{b}
25 mM		43.41^{a}	4.62^{a}	9.62^{c}	1.014^{a}	36.41^{a}	4.03^{a}	9.76^{d}	1.038^{b}
50 mM		42.62^{a}	4.40^{a}	10.32^{b}	1.010^{a}	35.80^{a}	4.69^{a}	10.40^{c}	1.068^{ab}
75 mM		42.46$_{a}$	4.49^{a}	11.03^{a}	1.010^{a}	36.66^{a}	4.17^{a}	10.97^{b}	1.045^{b}
100 mM		----	----	----	----	36.83^{a}	4.36^{a}	11.71^{a}	1.119^{a}
125 mM		----	----	----	----	36.31^{a}	4.32^{a}	11.80^{a}	1.066^{ab}
Cultivars x H_2O_2 Concentration									
Lady rosetta	**Control**	42.7^{a}	3.8^{a}	8.1^{a}	1.032^{a}	33.4^{a}	2.8^{a}	8.9^{d}	1.092^{a}
	25 mM	40.4^{a}	3.7^{a}	9.1^{a}	1.014^{a}	34.8^{a}	3.3^{a}	8.9^{d}	1.085^{a}
	50 mM	40.6^{a}	3.5^{a}	9.8^{a}	1.086^{a}	33.3^{a}	3.9^{a}	10.0^{cd}	1.093^{a}
	75 mM	41.7^{a}	3.7^{a}	10.3^{a}	0.947^{a}	35.2^{a}	3.7^{a}	10.3^{c}	1.054^{a}
	100 mM	----	----	----	----	34.9^{a}	3.8^{a}	11.3^{b}	1.110^{a}
	125 mM	----	----	----	----	34.3^{a}	3.4^{a}	11.7^{ab}	1.007^{a}
Valor	**Control**	42.9^{a}	5.3^{a}	9.3^{a}	1.005^{a}	41.0^{a}	4.9^{a}	10.1^{cd}	1.049^{a}
	25 mM	48.9^{a}	5.2^{a}	10.1^{a}	1.005^{a}	41.1^{a}	4.7^{a}	10.5^{c}	1.045^{a}
	50 mM	45.4^{a}	4.6^{a}	10.9^{a}	0.969^{a}	38.9^{a}	5.2^{a}	10.7^{bc}	1.084^{a}
	75 mM	47.2^{a}	5.4^{a}	11.5^{a}	1.047^{a}	40.5^{a}	4.2^{a}	11.2^{b}	1.046^{a}
	100 mM	----	----	----	----	41.5^{a}	4.7^{a}	11.9^{a}	1.117^{a}

	125 mM	----	----	----	----	40.2[a]	4.7[a]	11.8[ab]	1.114[a]
Mondial	**Control**	38.8[a]	4.3[a]	9.3[a]	0.936[a]	33.1[a]	4.7[a]	9.5[d]	1.020[a]
	25 mM	40.9[a]	4.9[a]	9.6[a]	1.025[a]	33.3[a]	4.1[a]	9.9[cd]	0.984[a]
	50 mM	40.7[a]	5.1[a]	10.2[a]	0.975[a]	35.2[a]	4.9[a]	10.5[c]	1.028[a]
	75 mM	39.8[a]	4.3[a]	11.3[a]	1.035[a]	34.2[a]	4.6[a]	11.4[ab]	1.036[a]
	100 mM	----	----	----	----	34.2[a]	4.6[a]	11.9[a]	1.131[a]
	125 mM	----	----	----	----	34.5[a]	4.6[a]	11.9[a]	1.078[a]

* Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance.

----, not treated during the first year

2. Effect of hydrogen peroxide concentrations on potato yield and its component characters:

Total potato yield (ton/ fed.) was significantly affected by the tesyed cultivar (Table 2) during both years. In the first year, Mondial and Valor cultivars over cropped Lady Rosseta, significantly. In the second year, the Valor cultivar surpassed the other two cultivars, significantly. The results showed that the H_2O_2 concentrations did not amend the potato tuber yield, in the first season. The data of the second season appeared that the levels 25, 50, 75 mM of H_2O_2 did not differ in their productivities with the control treatment. The other two high levels (100 and 125 mM) of H_2O_2 resulted in lower potato yields. The interaction effect between cultivars and H_2O_2 was highly significant for both seasons of this research. Moussa *et al*. (2012) declared that the highest productivity was obtained as a result of spraying H_2O_2 at 40 mM, followed by 60 mM. Data presented for number of tubers per plant showed that the cultivar Valor exceeded the other two cultivars all over both years of the study. Non- of the tested hydrogen peroxide levels in the first season resulted in insignificant effect on number of tubers per plant. The results of the second seasons declared that the level of 125 mM H_2O_2 produced the highest number of tubers per plant without significant differences with the levels 25, 50, 75,100 mM of H_2O_2.The control treatment (zero level of H_2O_2) recorded the lowest mean value without significant differences with the levels 25, 50, 75, 100 mM of H_2O_2. No interaction effect was found to change tuber number of plants in the first year. On the other hand, the interaction was found to be highly significant effects on such character in the second year of this investigation. The results of Romero and Lopez-Delgado (2009) detected that the treated plants with H_2O_2 and antioxidant such as ascorbic acid lead to reduce the number of mini- tubers, while enhancing their weights and starch content. Moussa *et al*. (2012) pointed that increasing the concentration of H_2O_2 led to positive effect on the number of tubers

per plant. Average tuber weight of "Lady Rossitta" cv. was the significantly lower among the tested cultivars in both seasons of the experiment (Table 2). Non-significant differences between "Valor and Mondial" cv. in the average tuber weight in both seasons were detected.

Hydrogen peroxide levels did not show any significant difference effects on the average tuber weight during both years of the study. No interaction effect between H_2O_2 level and potato cultivar was noticed to enlarge the average tuber weight character. Gutierrez *et al*. (2012) reported that H_2O_2 treatment induced higher internal H_2O_2 concentration, which was associated with positive effects on tuber weight, starch content and reduction tuber number. The number of tubers per 10 kg was recorded. This character indicates the suitability of potato cultivars for chipping. There is general agreement among potato processors to use this record. It ranks between 72-112 tubers/ 10 kg of potatoes, less than 72 tubers/ 10 kg indicate that the tubers are too large for processing. Data of (Table 2) revealed that in the first season of the study. All the studied cultivars were in the acceptable range of this record, meaning that all the tested cultivars are acceptable for potato processing, with some significant differences among them. In the second season, all the tested cultivars did not meet the acceptable record for number of tubers/ 10 kg, in which it was above the accepted number. The interaction effect was clearly noticed to amend the number of tubers/ 10 kg trait.

Table (2): Mean values' performances of yield and yield components of tested potato cultivars during both years of 2009/2010 and 2010/2011

Seasons	2009/2010					2010/2011				
Characters	No. of tubers/ Plant	Avr. tuber weight(gm)	Crop yield (ton/fed.)	Tuber shape index	No. of tuber/ 10kg	No. of tubers/ plant	Avr. tuber weight (gm)	Crop yield (ton/fed.)	Tuber shape index	No. of tuber/ 10kg
Cultivars										
Lady rosetta	9.2^{b*}	34.5^{b}	16.16^{b}	0.96^{c}	109.5^{a}	7.9^{b}	49.93^{b}	5.40^{c}	0.94^{c}	199.9^{a}
Valor	10.6^{a}	53.6^{a}	20.70^{a}	1.12^{b}	86.1^{b}	8.2^{a}	70.01^{a}	9.20^{a}	1.04^{b}	121.6^{c}
Mondial	9.9ab	66.6a	21.40a	1.44a	78.7c	7.3c	77.38a	7.02b	1.36a	135.7b
H_2O_2 Concentration										
Control	9.8^{a}	53.3^{a}	19.37^{a}	1.19^{a}	86.7^{b}	7.4^{b}	60.48^{a}	7.51^{a}	1.10^{a}	140.2^{c}
25 mM	9.8^{a}	53.2^{a}	19.77^{a}	1.14^{b}	91.1^{ab}	7.8^{ab}	64.53^{a}	8.03^{a}	1.11^{a}	156.7^{ab}
50 mM	9.9^{a}	49.0^{a}	19.33^{a}	1.18^{a}	95.8^{a}	7.6^{ab}	69.38^{a}	7.70^{a}	1.12^{a}	140.2^{c}
75 mM	10.2^{a}	50.8^{a}	19.21^{a}	1.18^{a}	92.2^{ab}	7.8^{ab}	70.8^{4a}	7.66^{a}	1.11^{a}	152.0^{b}
100 mM	----	----	----	----	----	7.9^{ab}	69.49^{a}	5.77^{c}	1.13^{a}	153.1^{ab}

	125 mM	----	----	----	----	----	8.3[a]	59.92[a]	6.56[b]	1.10[a]	157.8[a]
						Cultivars x H_2O_2 Concentration					
Lady rosetta	**Control**	9.9[a]	35.1[a]	17.06[a]	1.02[c]	114.3[a]	7.8[a]	42.0[a]	5.34[a]	0.96[ef]	213.3[a]
	25 mM	8.8[a]	33.5[a]	15.63[a]	0.87[d]	107.7[a]	7.6[a]	51.9[a]	5.94[a]	0.98[ef]	196.3[a]
	50 mM	9.3[a]	34.0[a]	15.63[a]	0.99[c]	106.7[a]	7.8[a]	48.1[a]	5.51[a]	0.97[ef]	165.7[a]
	75 mM	9.0a	35.8[a]	16.37[a]	0.99[c]	104.3[a]	8.5[a]	50.7[a]	6.38[a]	0.94[ef]	196.3[a]
	100 mM	----	----	----	----	----	8.7[a]	51.5[a]	4.47[a]	0.92[ef]	203.3[a]
	125 mM	----	----	----	----	----	7.4[a]	48.9[a]	4.95[a]	0.88[f]	214.7[a]
Valor	**Control**	10.4[a]	61.1[a]	20.97[a]	1.13[b]	79.3[a]	8.8[a]	72.0[a]	10.1[a]	1.00[e]	132.7[a]
	25 mM	11.3[a]	59.7[a]	22.01[a]	1.09[b]	88.3[a]	8.9[a]	70.5[a]	10.8[a]	1.02[de]	133.7[a]
	50 mM	9.7[a]	44.4[a]	19.84[a]	1.14[b]	96.0[a]	8.3[a]	74.2[a]	9.81[a]	1.10[d]	126.3[a]
	75 mM	10.6[a]	49.6[a]	20.41[a]	1.14b	96.0[a]	8.7[a]	78.7[a]	10.4[a]	1.10[d]	121.0[a]
	100 mM	----	----	----	----	----	8.8[a]	75.2[a]	7.51[a]	1.10[d]	129.3[a]
	125 mM	----	----	----	----	----	8.7a	71.7a	7.25a	1.00e	128.7a
Mondial	**Control**	9.8[a]	63.9[a]	21.80[a]	1.46[a]	79.0[a]	7.2[a]	70.8[a]	7.68[a]	1.40[b]	132.7[a]
	25 mM	9.4[a]	66.6[a]	21.93[a]	1.47[a]	77.7[a]	6.8[a]	69.1[a]	7.68[a]	1.32[bc]	131.0[a]
	50 mM	10.1[a]	68.7[a]	21.84[a]	1.43[a]	75.0[a]	6.8[a]	74.3[a]	8.12[a]	1.30[c]	128.0[a]
	75 mM	10.4[a]	67.2[a]	20.71[a]	1.43[a]	71.0[a]	5.9a	83.2[a]	6.51[a]	1.34[bc]	138.7[a]
	100 mM	----	----	----	----	----	8.1[a]	78.1[a]	5.60[a]	1.50[a]	131.3[a]
	125 mM	----	----	----	----	----	8.1[a]	80.5[a]	6.68[a]	1.40[b]	152.7[a]

*Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance.

----, not treated during the first year

3. Effect of hydrogen peroxide concentrations on potato physical, chemical and quality characters:

Mondial cultivar showed the biggest mean value of tuber shape index among the studied cultivars in both years (Table 3). This means that this cultivar has more long tubers than the others. The data recorded that in the first season 25 mM of hydrogen peroxide resulted in significant difference than the other

treatments, in which it decreased the tuber shape index. This means that the tuber became more round than the other treatments. In the second season, H_2O_2 concentrations had nothing to do with the tuber shape index. The interaction was only significant in the second year of the study. Specific gravity of tubers of Lady Rossitta cultivar was the highest among all the studied cultivars in both seasons (Table 3).

Kunkel *et al*. (1951) and Lana *et al*. (1970) reported that specific gravity of row potato is widely accepted by the potato processing industry as a measure of total solids, starch concentration and other qualities. Neither the tested H_2O_2 nor its interaction with potato cultivar had the capacity to change potato tuber specific gravity in the study. Moussa *et al*. (2012) detected that the specific gravity trait was positively affected with foliar application with H_2O_2 compared with the untreated plants. Tuber dry matter was significantly affected by potato cultivar in both seasons of the study (Table 3). "Lady Rossitta" cultivar was the significantly higher one in dry matter content in both seasons. "Valor" cultivar ranked the second in dry matter content after "Lady Rossitta" in the second season. This result may point to that "Lady Rossitta" is the more suitable cultivar among the tested cultivars in chipping industry. Duran *et al*, (2007) stated that dry matter is particularly important in the production of potato chip because of greater surface area to volume ratio in chips compared with fries. Stevenson *et al*. (1964) explained that dry matter concentration of tubers is an important measure of quality to assess suitability for processing purpose as it influence process efficiency, product yield and oil absorption. None of the studied levels of H_2O_2 treatments and their interactions with potato cultivars showed significant effect on potato tuber dry matter content during the second year of this study. In the first year, the data of (Table 3), appeared that spraying potato plants with 70 or 50 mM of H_2O_2 significantly increased dry matter percentage compared with the control treatment. Delgado *et al.* (2005) reported that H_2O_2 used to spray potato plants and lead to increase dry matter. "Lady Rossitta" cv. showed the highest significant level of starch content compared with the other tested cultivars (Table 3) during both years of this investigation. "Valor" cv. was not significantly different than "Mondial" cv. in the first year. In the second year, there was significantly difference between these two previous cultivars. "Mondial" cv. came the third one in this respect. This result may be related to the cultivars differences. This result may point to that "Valor" cv. is more suitable than both others cultivars to be used in crisp production depending on its starch content. Owing to its economic importance, potato tuber starch has the subject of considerable research effort, with an accelerating rate of progress in recent years. The data cleared that there were pronounced effects noticed as a result of hydrogen peroxide on potato tuber starch content. Both treatments 75 and 50 mM of H_2O_2 produced the highest levels of tuber starch content in the first year of the study. Spraying potato plants with 75 mM of hydrogen peroxide produced the highly tuber starch content with significant differences among the other tested treatment in the second year of the study. No interaction effects were found between cultivar and H_2O_2 level to change tuber starch contents during both seasons of this study. Generally, it could be calculated that spraying growing plants

with the concentration of 75mM H_2O_2 gave the highest values of potato tuber quality. Total sugars were not affected by neither potato cultivar nor H_2O_2 concentration or their interaction during the first season. The differences among potato cultivars were found only in the second season, as well as the differences among the H_2O_2 concentrations. The interaction was not affected significantly. Reducing sugars content did affect neither H_2O_2 concentrations nor the interaction between potato cultivar and H_2O_2 concentration in the present study. The significance in total sugars was only detected among the tested cultivars. Reducing sugars of "Valor" cv. showed higher significantly value than the other tested cultivars in the first season of the study. "Lady Rossitta" possessed the highest significant value for reducing sugars comparable with valor and Mondial cultivars during the second season. Talburt and Smith (1987) claimed that level of reducing sugars is one among of the four primary factors determining French fry quality. French fry color is largely determine by the reducing sugars content of the potato tuber; potatoes with high reducing sugars level make dark fries, when potatoes are fried, the reducing sugars react with amino acids in the tuber to form dark products in amino-enzymes browning reaction. The concentration of reducing sugars in the potato tuber depends on cultivar, growing conditions, maturing and storage conditions (Surmacka, 2002). As with French fries, the color of potato chips depends on the reducing sugars content of the potato (Biedermann, 2003). However, potato chip processors have slightly loss control over reducing sugars levels because blenching is not option in chipping process. The net crisp product of Mondial exceeded Lady Rossitta and Valor, significantly (Table 4). Likely, "Lady Rossitta" produced much net crisp than Valor. This result means that the high net crisp production cultivar is desired by the potato processors because the cost production will be reduced. Potato crisp have been popular salty snacks for ISO years and it sale in USA are about 6 $ billion/ year, repressing 33% of the total sales of their market (Gurayo and Moreira, 2000 and Clarke, 2003). Applying H_2O_2 at 25 or 50 mM increased the net crisp production. Application of 75 mM slightly reduced the net crisp production significantly than 25 or 50 mM treatments. The control treatment was significantly differed than any of the tested H_2O_2 levels used in this study. It gave the lowest net crisp percentage. No interaction effect was noticed between potato cultivars and the levels of H_2O_2 to change the net crisp production.

Table (3): Mean values' performances of tuber quality characteristics of tested potato cultivars during both years of 2009/2010 and 2010/2011

Seasons		2009/2010					2010/2011				
Characters		Starch%	Total Sugars %	Reduce Sugars %	Dry matter %	Specific Gravity	Starch%	Total Sugars %	Reduce Sugars %	Dry matter %	Specific Gravity
Cultivars											
Lady rosetta		14.62[a*]	6.8[a]	3.56[ab]	23.1[a]	1.089[a]	10.50[a]	11.7[c]	4.97[a]	18.8[a]	1.074[a]
Valor		12.94[b]	7.3[a]	4.10[a]	19.1[c]	1.078[b]	10.10[b]	12.5[a]	4.55[b]	18.2[b]	1.071[b]
Mondial		12.91[b]	7.4[a]	3.37[b]	19.9[b]	1.078[b]	9.04[c]	11.9[b]	4.27[b]	17.5[c]	1.067[c]
H_2O_2 Concentration											
Control		13.13[b]	7.1[a]	3.56[a]	20.1[b]	1.081[a]	10.10[b]	12.0[b]	4.36[a]	17.9[a]	1.070[a]
25 mM		13.42[b]	7.0[a]	3.82[a]	20.7[ab]	1.082[a]	9.73[b]	12.1[b]	4.31[a]	18.2[a]	1.071[a]
50 mM		13.10[b]	7.1[a]	3.66[a]	21.0[a]	1.082[a]	10.10[b]	13.1[a]	4.41[a]	18.1[a]	1.070[a]
75 mM		14.31[a]	7.5[a]	3.67[a]	21.0[a]	1.082[a]	10.85[a]	11.8[b]	4.53[a]	18.1[a]	1.070[a]
100 mM		----	----	----	----	----	9.15[c]	12.2[b]	5.04[a]	18.2[a]	1.071[a]
125 mM		----	----	----	----	----	9.45[c]	11.0[c]	4.94[a]	18.3[a]	1.071[a]
Cultivars x H_2O_2 Concentration											
Lady rosetta	**Control**	14.35[a]	6.5[a]	3.0[a]	23.3[a]	1.087[a]	10.70[a]	11.4[a]	4.51[a]	18.7[a]	1.073[a]
	25 mM	14.55[a]	6.8[a]	3.7[a]	23.1[a]	1.087[a]	9.80[a]	11.4[a]	4.31[a]	19.0[a]	1.074[a]
	50 mM	14.10[a]	6.9[a]	3.6[a]	23.0[a]	1.089[a]	10.70[a]	11.4[a]	4.58[a]	18.8[a]	1.070[a]
	75 mM	15.50[a]	7.0[a]	3.5[a]	23.1[a]	1.089[a]	11.40[a]	12.4[a]	5.61[a]	18.8[a]	1.073[a]
	100 mM	----	----	----	----	----	10.00[a]	12.6[a]	5.02[a]	18.6[a]	1.073[a]
	125 mM	----	----	----	----	----	10.50[a]	11.0[a]	5.80[a]	19.0[a]	1.075[a]
Valor	**Control**	12.95[a]	7.5[a]	3.9[a]	18.6[a]	1.077[a]	10.40[a]	12.7[a]	4.18[a]	18.0[a]	1.070[a]
	25 mM	12.60[a]	7.3[a]	3.5[a]	19.6[a]	1.076[a]	10.50[a]	13.5[a]	5.07[a]	17.9[a]	1.069[a]
	50 mM	12.60[a]	7.4[a]	3.9[a]	19.0[a]	1.077[a]	10.20[a]	13.5[a]	4.20[a]	18.1[a]	1.071[a]
	75 mM	13.60[a]	7.3[a]	3.7[a]	19.3[a]	1.078[a]	11.65[a]	12.7[a]	4.26[a]	18.5[a]	1.072[a]
	100 mM	----	----	----	----	----	9.15[a]	11.4[a]	4.72[a]	18.1[a]	1.072[a]
	125 mM	----	----	----	----	----	8.70[a]	10.8[a]	4.90[a]	18.3[a]	1.071[a]

Mondial	**Control**	12.10[a]	7.4[a]	3.2[a]	18.7[a]	1.079[a]	9.20[a]	11.7[a]	4.41[a]	17.2[a]	1.066[a]
	25 mM	13.10[a]	7.2[a]	3.4[a]	20.2[a]	1.079[a]	8.90[a]	12.1[a]	4.11[a]	17.6[a]	1.068[a]
	50 mM	12.60[a]	7.1[a]	3.5[a]	20.5[a]	1.077[a]	9.20[a]	12.6[a]	4.45[a]	17.3[a]	1.066[a]
	75 mM	13.85[a]	8.1[a]	3.4[a]	20.0[a]	1.078[a]	9.50[a]	11.3[a]	3.73[a]	17.1[a]	1.065[a]
	100 mM	----	----	----	----	----	8.30[a]	12.6[a]	5.38[a]	17.9[a]	1.069[a]
	125 mM	----	----	----	----	----	9.15[a]	10.7[a]	4.12[a]	17.8[a]	1.069[a]

* Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance

----, not treated during the first year

Table (4): Means values' performances of the net crisp production of tested potato cultivars during winter season of 2009/ 2010

Seasons	**2009/2010**
Characters	**Net crisp production**
Cultivars	
Lady rosetta	32.57 [b]*
Valor	31.33 [c]
Mondial	34.65 [a]
H_2O_2 Concentration	
Control	31.81 [c]
25 mM	33.31 [a]
50 mM	33.39 [a]
75 mM	32.89 [b]
100 mM	----
125 mM	----
Cultivars x H_2O_2 Concentration	
Lady rosetta **Control**	32.48 [a]
25 mM	32.40 [a]
50 mM	32.90 [a]
75 mM	32.89 [a]

	100 mM	----
	125 mM	----
Valor	**Control**	29.46 [a]
	25 mM	32.00 [a]
	50 mM	31.20 [a]
	75 mM	30.52 [a]
	100 mM	----
	125 mM	----
Mondial	**Control**	34.06 [a]
	25 mM	35.59 [a]
	50 mM	34.90 [a]
	75 mM	34.96 [a]
	100 mM	----
	125 mM	----

* Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance.

----, not treated during the first year

4. Effect of hydrogen peroxide on both tuber parenchyma cells diameter and tuber chipping defects:

Parenchyma cell diameter (µm) of the tubers of "Valor" cultivar was higher significantly than the other two cultivars in the first season (Table 5). In the first second, "Valor" and "Mondial" cvs. parenchyma cells were the significant widest cells than "Lady Rossitta" cv. which ranked the third. In the first season, H_2O_2 treatments affected parenchyma cell diameter. The treatment 50 mM possessed the highest value with insignificant different effects with the treatments zero and 75 mM H_2O_2. The lowest value was produced by the treatment 25 mM. In the second season, spraying potato plants with 25 or 125 mM of H_2O_2 increased the diameter of parenchyma cells. The treatment 100 mM ranked the second followed with both the treatments 50 and 75 mM, while the unsprayed plants treatment produced the lowest value for parenchyma cell diameter. Moussa *et al*. (2012) reported that parenchyma cells diameter was affected with H_2O_2 concentrations. The ratio of increasing in tuber parenchyma cell diameter reached 9.34 % as compared with none treated plants. It is known that starch is mainly stored in cells located parenchyma cells in tubers and thus increasing the diameter of parenchyma cells lead to an increasing in starch content of tubers and these tubers has a positive

impact on increasing the proportion of tubers dry matter. This result is in harmony with that obtained by Delgado (2005) who stated that the applying H_2O_2 lead to enlarged medullar parenchyma cells. The interaction effect between cultivar and H_2O_2 was significant during the two years of this study.

The data of Potato chips defects are tabulated in (Table 6). This character was tested only in the season of 2009/2010. Chips quality is a collection of many characteristics and color is one of the most important traits. In general, yellowish brown (Burton *et al*., 1992), uniform light golden (Stevenson *et al*., 1964), and lighter colored (Cunningham and Stevenson, 1963) crisps are preferred. The results showed that the tested cultivars differed significantly for potato chips defects. It appeared that the cultivar "Lady Rossetta" pronounced the lowest defects followed by the cultivar "Mondial" while the cultivar "Valor" gave the highest value for chipping defects. Crisps quality is influenced by both genotypic and environmental factors (Stevenson *et al*., 1964). The data presented clearly showed that spraying potato plants with hydrogen peroxide treatment had significant effects on the tuber chipping defects. The lowest defects were produced when the plants sprayed with 50 mM H_2O_2. There were no significant differences effects between the two treatments 25 and 75 mM H_2O_2. The control treatment gave the worst result where this treatment produced highly significant level of tuber chipping defects. This result may be related with the previous obtained results for tuber dry matter, tuber starch content and parenchyma cell diameter where the control treatment gave the lowest level for these traits. This research explained that the best results for the previous mentioned traits were given when the plants were sprayed with 50 or 75 mM of H_2O_2. There were no significant interactions effects noticed between the tested cultivars and the hydrogen peroxide treatments.

Table (5): Means values' performances of parenchyma cell diameter of tested potato cultivars during both years of 2009/2010 and 2010/2011

Seasons	2009/2010	2010/2011
Characters	Parenchyma cell diameter (µm)	Parenchyma cell diameter (µm)
	Cultivars	
Lady rosetta	208.3 [b]*	186.9 [bc]
Valor	234.4 [a]	217.1 [a]
Mondial	216.2 [b]	220.9 [a]
	H_2O_2 Concentration	
Control	219.0 [ab]	200.3 [d]
25 mM	212.1 [b]	216.6 [a]
50 mM	225.9 [a]	202.1 [cd]
75 mM	221.4 [ab]	205.4 [c]

	100 mM	----	209.5 [b]
	125 mM	----	215.9 [a]
		Cultivars x H_2O_2 Concentration	
Lady rosetta	**Control**	192.5 [c]	194.9 [bc]
	25 mM	207.7 [bc]	188.8 [c]
	50 mM	220.6 [bc]	176.6 [c]
	75 mM	212.6 [bc]	184.5 [c]
	100 mM	----	169.8 [c]
	125 mM	----	194.3 [bc]
Valor	**Control**	256.0 [a]	199.8 [bc]
	25 mM	223.6 [bc]	224.2 [ab]
	50 mM	226.7 [b]	232.8 [ab]
	75 mM	224.3 [bc]	202.2 [bc]
	100 mM	----	224.3 [ab]
	125 mM	----	208.9 [bc]
Mondial	**Control**	212.6 [bc]	212.6 [b]
	25 mM	202.2 [c]	233.4 [ab]
	50 mM	223.6 [bc]	202.8 [bc]
	75 mM	213.8 [bc]	231.0 [ab]
	100 mM	----	217.5 [ab]
	125 mM	----	235.8 [a]

*Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance

----, not treated during the first year

Table (6): Means values' performances of chips defects of tested potato cultivars during winter season of 2009/ 2010

Seasons		2009/2010
Characters		Chipping defects
	Cultivars	
	Lady rosetta	0.28 [c*]
	Valor	10.25 [a]
	Mondial	4.63 [b]
	H_2O_2 Concentration	
	Control	6.11 [a]
	25 mM	5.07 [b]
	50 mM	3.94 [c]
	75 mM	5.08 [b]
	100 mM	----
	125 mM	----
	Cultivars x H_2O_2 Concentration	
Lady rosetta	**Control**	0.87 [a]
	25 mM	0.2 [a]
	50 mM	0.0 [a]
	75 mM	0.0 [a]
	100 mM	----
	125 mM	----
Valor	**Control**	10.93 [a]
	25 mM	11.27 [a]
	50 mM	8.40 [a]
	75 mM	10.40 [a]
	100 mM	----
	125 mM	----
Mondial	**Control**	6.53 [a]
	25 mM	3.77 [a]
	50 mM	3.43 [a]

75 mM	4.80 [a]
100 mM	----
125 mM	----

*Values with an alphabetical letter, in a comparable group of means, don't differ significantly from one another using Duncan's Multiple Range Test, at 0.05 level of significance.

----, not treated during the first year

Conclusions

It could be concluded that spraying potato plants with hydrogen peroxide positively affected the breadth of parenchyma cell diameter leading to increase tubers starch content, under the conditions of this study. The final results of this research conducted that spraying potato plants with hydrogen peroxide at the rates of 50 or 75 mM starting from 40 days of planting twice a week until maturity stage led to enhancement potato tuber quality which produced the highest values for both tubers starch and dry matter, highest percentage of net crisp with lowest percentage of chipping processing defects.

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الملخص العربى

تأثير الرش بفوق أكسيد الهيدروجين علـى صفـات جودة الدرنـات لثلاثة أصناف من البطاطس

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**محطة بحوث البساتين بالصبحية – معهد بحوث البساتين

نفذت تجربتان حقليتان خلال العروة المحيرة (الشتوية) لعامى ٢٠٠٩/٢٠١٠ ، ٢٠١٠/٢٠١١ وذلك فى إحدى المزارع الخاصة بمنطقة العامرية بمحافظة الإسكندرية ،ج . م. ع .

أجرى البحث بغرض دراسة تأثير مادة فوق أكسيد الهيدروجين على بعض الصفات الإقتصادية لمحصول البطاطس وكذلك على صفات جودة الدرنات والمتعلقة بعملية تصنيع البطاطس ونسبة تصافى المنتج النهائى بأقل نسبة عيوب تصنيعية تؤثر على جودة المنتج.

زرعت ثلاثة أصناف من البطاطس وهى ليدى روزيتا ، فالور ، موندیال . رشت نباتات البطاطس بتركيزات مختلفة من مادة فوق أكسيد الهيدروجين مرة كل ثلاثة أيام بداية من إكتمال الإنبات وحتى النضج ،حيث رشت النباتات فى السنة الأولى من التجربة بأربعة تركيزات من الهيدروجين بيروكسيد وهى صفر ، ٢٥ ، ٥٠ ، ٧٥ مللي مول. أما فى السنة الثانية فقد أضيف تركيزان آخران من فوق أكسيد الهيدروجين وهما ١٠٠ ، ١٢٥ مللي مول.

أستخدم فى تطبيق التجربتين خلال السنتين نظام القطع المنشقة فى تصميم القطاعات الكاملة العشوائية، وذلك بثلاث مكررات، حيث وزعت عشوائيا الأصناف على القطع الرئيسية ، بينما معاملات الرش بتركيزات فوق أكسيد الهيدروجين فقد تم توزيعها عشوائياً على القطع تحت الرئيسية.

أهم النتائج المتحصل عليها :-

١- إزداد قطر سيقان نباتات البطاطس مع زيادة تركيز الرش بفوق أكسيد الهيدروجين من صفر وحتى تركيز ١٢٥ مللي مول.

٢- لم يكن لتركيزات فوق أكسيد الهيدروجين وحتى تركيز ٧٥ مللي مول أية تأثير على محصول البطاطس ، أما التركيزات الأعلى (١٠٠، ١٢٥ مللي مول) فقد أدت الى إنخفاض محصول البطاطس .

٣- كانت هناك زيادة معنوية لنسبة المادة الجافة بالدرنات مع ارتفاع تركيز الرش بفوق أكسيد الهيدروجين الى ٥٠ ، ٧٥ مللي مول فقط خلال السنة الأولى من التجربة .

٤- إزداد محتوى الدرنات من النشا بدرجة معنوية مع زيادة تركيز الرش بفوق أكسيد الهيدروجين الى ٥٠ ، ٧٥ مللي مول خلال السنة الأولى من التجربة . أما فى السنة الثانية فإن تركيز ٧٥ مللي مول من فوق أكسيد الهيدروجين كان له تأير معنوى على زيادة نسبة النشا بالدرنات.

٥- إختلف تأثير الرش بفوق أكسيد الهيدروجين على صفة قطر الخلايا البارانشيمية من سنة الى أخرى حيث أدى الرش بتركيز ٥٠ مللي مول فى السنة الأولى من التجربة الى زيادة قطر الخلايا البارانشيمية والمخزنة لحبيبات النشا زيادة معنوية مقارنة بباقى التركيزات ، أما فى السنة الثانية فإن التركيزان ٢٥ ، ١٢٥ مللي مول من فوق أكسيد الهيدروجين أديا الى زيادة قطر الخلايا البارانشيمية بدرجة معنوية عن باقى التركيزات الأخرى .

٦- سجلت البطاطس المصنعة أقل نسبة عيوب تصنيعية عند رش نباتات البطاطس بتركيز ٥٠ مللي مول فوق أكسيد الهيدروجين ، ثم أتى التركيزان ٢٥ ، ٧٥ مللي مول فى المرتبة الثانية ، وأخيرا جاءت المعاملة الكنترول (بدون رش) فى المرتبة الأخيرة حيث سجلت أعلى نسبة من العيوب التصنيعية .

هذا ويوصى البحث بناءا على النتائج السابقة برش نباتات البطاطس بفوق أكسيد الهيدروجين مرتين إسبوعيا بتركيز ٥٠ أو ٧٥ مللي مول بدءا من عمر أربعون يوما وحتى مرحلة نضج الدرنات وذلك للحصول على أعلى نسبة تصافى للمنتج المصنع وأقل نسبة من العيوب التصنيعية وذلك تحت ظروف هذه التجربة.