Role of Hydrogen Peroxide in Improving Potato Tuber Quality

Sameh A.M. Moussa[1], Nashwa I. Abo El-Fadl[1] and Neveen F. Agamy[2]

ABSTRACT

Four potato cultivars were planted during the summer seasons of 2009 and 2010 at Sabaheya Horticultural Research Station, Alexandria governorate, Egypt. The experiments were conducted to study the effect of hydrogen peroxide in increasing the proportion of dry matter in potato tubers which is very important in the production of chips and French fries. The growing plants were sprayed twice a week with hydrogen peroxide in four concentrations (zero, 20, 40 and 60 mM). Tubers' starch percentage was significantly increased with increasing the hydrogen peroxide up to 60 mM. The highest percentage of tubers' dry matter was possessed when plants was sprayed with 40 mM of hydrogen peroxide. Parenchyma cell diameter was affected with hydrogen peroxide concentrations, where, the data detected that the ratio of increasing in tuber parenchyma cell diameter reached 9.34% as compared to with non-treated plants. It could be said that spraying hydrogen peroxide on potato plants at the rate of 40 mM had positive effect on potato yield and tubers' dry matter percentage. Sensory evaluation for potato French fries and chips showed that zero and 20 mM of hydrogen peroxide treatments possessed the highest acceptability of the produced French fries and chips. Anushka and Universal potato cultivars were the best for producing French fries at the levels of zero, 20 and 40 mM hydrogen peroxide, while Dora cultivar was elected for producing potato chips at all hydrogen peroxide concentrations.

Key words: potato, *Solanum tuberosum*, *L.*, hydrogen peroxide, parenchyma cells, starch accumulation, potato processing, French frying and potato chips.

INTRODUCTION

Potatoes (*Solanum tuberosum, L.*) are considered one of the most important vegetable crops which are grown in large areas in Egypt, where the total area planted with potatoes, according to estimates of the Egyptian Ministry of Agriculture for the year 2012 about 200 thousands feddan 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. 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, in addition to the lack of reducing sugars. Many researches are directed to increase the quality processing. It has been suggested that foliar application of salicylate could enhance tuber industrial quality by increasing dry matter and starch content (Nickell 1991). 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). For industrial purposes, millions of tones of starch and dextrins are produced and modified annually from potato tubers, with yields proportional to the starch content of the raw material (Burton 1989). Delgado *et al*. (2005) demonstrated in their research that field plants treated with 5 or 50 mM hydrogen peroxide significantly enhanced tuber starch accumulation by between 6.7% and 30%, respectively, and they found that hydrogen peroxide treated stems were up to 27% thicker than controls, and explained that this result mainly due to enlarged medullar parenchyma cells. Moreover, quantification using image analysis confirmed that stems of hydrogen peroxide treated plants contained up to 3.4-fold more starch and 62% more lignin. This new chemical treatment to promote starch accumulation has potential utility in potato crop production and research (Delgado *et al*., 2005).

This research aimed to improve the quality of processing potatoes and to increase the net products by increasing dry matter and starch percentages of potato tubers, and this will encourage further extension in processes.

MATERIALS AND METHODS

The present investigation was carried out during the two summer seasons of 2009 and 2010 at Sabaheya Horticultural Research Station, Alexandria governorate, Egypt. Planting tuber seeds toke place on the middle of January in both growing seasons; using four potato cultivars; Anushka, Universal, Vivaldi and Dora. Tuber seeds were planted in rows, 60 cm in wide, 4.0 long and at spacing of 25 cm within rows.

Treatments

Each experiment consisted of four cultivars representing the main plots. Each cultivar was grown in sixteen rows. Four concentrations of hydrogen peroxide (H_2O_2) (60 mM, 40 mM, 20 mM and zero mM) were randomly distributed in the sub-plots. Each sub-plot consisted of four rows having an area of 9.60 m^2. Hydrogen peroxide was sprayed to the plants twice

[1]Sabaheya Horticultural Research station, Horticultural Research Institute, Agricultural Research Center, Egypt.
[2]Nutrition Department, Food Analysis Division,
High Institute of Public Health, Alexandria University.
E-mail address for correspondence: samehmoussa@yahoo.com
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Table 1. Physical properties and chemical analyses of the experimental soil

Soil analyses of Sabaheya Farm									
Mechanical analysis			Texture		pH	EC. dS/m		$CaCo_3$ %	O.M. %
Sand %	Silt %	Clay %							
23.90	42.50	33.60	coarse clay shales		8.33	1.8		22.00	0.57
Chemical analysis									
Cations (meq/L)						Anions (meq/L)			
N^+	P^+	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-	HCO_3^-	CL^-	SO_4^{--}
27.5	19.7	0.94	0.39	081	895.0	zero	1.83	0.45	2.00

a week at 40 days from planting up to 90 days. The spraying was carried out early in the morning until plants were dipping wet with a hand pressure sprayer. The two central rows of each sup-plot were used for analytical samples. The physical and chemical analyses of the experimental soil are presented in table, 1. 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: Ten whole plant samples per sub-plot were randomly used, 90 days after planting, for the determination of the vegetative growth (plant height (cm) and number of branches). Stem diameter was measured using a caliper on the fourth internodes from the base. A certain weight of fresh foliage of five plants, fro each sub-plot, was dried and the percentage of dry weight was recorded. Another Ten random plants were used at harvest (110 days) to determine plant tuber yield (kg). Tuber yield was determined in weight and number of all tubers per plant.

Physical characteristics: Random samples 0f 20 tubers per treatment were randomly used to measure the physical characteristics of the tubers; tuber length and diameter were measured to calculate the tuber shape index by dividing the former by the latter. Tuber specific gravity was determined by weighting a certain weight of tubers for each treatment, then the specific gravity was computed according to the following equation:-

$$\text{Tuber specific gravity} = \frac{\text{Tuber' weight in air}}{\text{Tuber' weight in air} - \text{Tuber' weight in water}}$$

Tuber quality: Random samples of 10 tubers per treatment for each replicate were randomly used to determine the tuber quality characters.

1- Tuber dry matter (%): Was carried out by weighing a certain weight of fresh tubers and then dried.

$$\text{Dry matter \%} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

2- Determination of reducing and non-reducing sugars percentages (%): A known mass (5 g) of fresh tuber was taken to determine reducing and non-reducing sugars, using sulphuric acid and phenol (5%); then they were colourimetrically determined, according to the method of **Dubios *et. al*. (1956).**

3- Determination of starch: Tuber starch percentage (%) was determined using a sample of 1 g of fresh tuber, according to the method described in **A.O.A.C. (1970).**

Histology examination (in the second season only): Five random tubers were taken from each treatment in each replicate and then peeled and cut with a sharp cork on sliding microtome into slices 1 mm thickness and 10 mm in diameter. The potato slices were mixed and washed with distilled water. Ten randomly slices were taken for examination under a compound microscope using a high power (400 X) objective to determine the parenchyma cells diameter; in micron (μ), of potato tubers.

Evaluation of potato chips and strips processed

Potatoes (four different cultivars of potatoes, each cultivar which was treated with one of four concentrations of H_2O_2 in two cultivations) and vegetable oil (blend of cottonseed and sun flower with 1:1 ratio) were the raw materials. Potato tubers were stored at 8 $^{\circ}$C and 95% relative humidity. Chips (Slices) (thickness of 3 mm) were cut from the pith of the parenchymatous region of potato tubers using an electric slicing machine (Berkel, model EAS65, UK). Strips were prepared by cutting tubers into strips with base dimension 10X10 mm^2 and different lengths using an electric machine (Berkel, model EAS65, UK)

1-Blanching

Chips and strips were rinsed for 1 min in distilled water, immediately after cutting, to eliminate some starch adhering to the surface prior to frying. All samples were kept between humidified paper towels to avoid excessive dehydration before frying.

2-Frying experiments

The frying time was constant (3 min). Twenty slices or strips per sampling time were deep-fried in hot oil contained in an 3 Liter capacity electrical fryer (Rival, Model CZF575, China) at a temperature (180±1°C).

3-Determination of the dry matter

The raw material was determined for dry matter by drying method at a temperature of 105 ^{o}C (A.O.A.C., 1995). The dry matter was also found to be the ratio of the weight of samples after frying and its weight before frying multiplied by 100.

4-Sensory evaluation

The sensory evaluation was carried out on the processed chips and strips using trained panelists (Staff members of the Department of Nutrition, High Institute of Public Health, Alexandria University) which are frequently used to do such test. Each panelist recorded the results in special sheet using 7-point descriptive category scale for each estimated parameter, in which one indicating very poor and 7 indicates excellent.

Experimental design and statistical analysis

The used experimental layout was arranged as a split-plot in a randomized complete blocks design (R.C.B.D), with three replicates. Four potato cultivars were considered as main plots, and four concentrations of hydrogen peroxide were randomly sprayed in the sup-plots. Collected data of the experiments were statistically analyzed, using the analysis of variance method. Comparisons among the means of different treatments were done, using Duncan's multiple range test procedure at p = 0.05 level of significance, as illustrated by Snedecor and Cochran (1980). Computation was done using SAS (2001).

RESULTS AND DISCUSSION

3. Results and Discussion

A. Potato morphological characters, tuber yield and quality attributes

A.1. Morphological characters

Data presented in table, 2, clearly, showed the existence of significant differences among the examined cultivars for most of studied vegetative traits over the two years with the exception of foliage dry matter during first year of the study. Data of table, 2 Impact the concentrations of hydrogen peroxide on the studied vegetative traits. It became clear from these data that there was no significant effect of the concentrations of hydrogen peroxide on plant height during the two years of study, as well as there were no effects of these concentrations of hydrogen on the number of branches per plant in first year of experiment. The results also showed that the concentrations 40 and 60 mM of hydrogen peroxide gave the best results compared to other concentrations for percentage of foliage dry matter and stem diameter during the two seasons. Mean diameter of sixth internodes of H_2O_2 treated plants was 27% (5 mM) and 21% (50 mM) greater than control (non-sprayed plants) (Delgado *et al*., 2005), the authors discussed that this results mainly due to enlargement of the medullar parenchyma cells.

Values of table, 2 revealed that most of the morphological studied characters did not show any significant differences due to the interaction between cultivars and different concentrations of hydrogen peroxide with the exception of two characters, only during the first season of the experiment, number of branches per plant, and plant height. It is clear from the obtained results that the concentration of 60 mM hydrogen peroxide is generally gave higher values for the studied characters with all the items, followed by the treatment 40 mM, while the lowest values were obtained by using zero level of hydrogen peroxide. The histological data obtained by Delgado *et al*. (2005) illustrated that there were more starch grains in cortex and pith tissue of H_2O_2 treated stems. The authors added that H_2O_2 also increased the number and size of xylem tracheary elements in the vascular bundles and the number and the cell wall thickness of inter-fascicular fibers.

A.2. Potato tuber yield and yield components

Data of table, 3; clearly; appeared that there were significant differences between the four genetic cultivars grown for yield and its components. In this regard, the cultivar Universal gave the highest productivity over the two years of study followed by the cultivar Vivaldi. These results coincided with the cultivar Universal which giving the highest values of the average tuber weight in the study within two years of study. Different results with respect to the proportion of tuber dry matter; where, cultivar Dora gave the highest value followed with cultivar Universal during two years of experiment, while Anushka and Vivaldi cultivars were the lowest, as appears from the data of table, 3.

Data concerning the effect of hydrogen peroxide on tuber yield and its component characters appeared, generally, that hydrogen peroxide non-spraying gave, in general, lower values for all studied traits (No. of tubers per plant, average tuber weight, tuber yield per plant and tuber dry matter percentage)._There was no effect of different concentrations to spray hydrogen peroxide on the status of the average tuber weight trait in the first season of experiment. Non-hydrogen peroxide spray gave less value to the average tuber weight compared to spray any of the concentrations of hydrogen peroxide, while there were insignificant differences between the levels of hydrogen peroxide sprayed (20,40,60 mM) in effect on such character. Particularly with respect to the number of tubers per plant, it became clear that the results of spraying concentration of 60 mM or 40 mM of hydrogen peroxide gave highest values compared to spray concentration of 20 mM or non-spraying with hydrogen peroxide. Spraying with hydrogen peroxide at the rate of 40 mM gave the highest value of tuber yield per plant without significant differences with concentrations 60 and 40 mM, while the non-spraying gave the lowest value, during the year of 2009. Highest productivity was obtained as a result of spraying concentration hydrogen peroxide at 40 mM, followed by significant differences spraying concentrations of 60 and 40 mM hydrogen peroxide, and finally non-spraying hydrogen peroxide ranked last, during the second year of study. The results of Delgado *et al*. (2005) showed that the mean weights and numbers of tubers per plant were not found to be significantly differed under the different H_2O_2 concentrations.

The results of the proportion of tuber dry matter showed the presence of significant differences between the various concentrations of hydrogen peroxide over the two years (Table,3), where the results showed that the spraying concentration of 40 mm hydrogen peroxide gave the highest percentage of tuber dry matter compared to the other concentrations, followed by spraying concentrations of 60 mm and 20 mm, respectively and finally came the treatment non-spraying with hydrogen peroxide in the latter arrangement. Figure, 1 appeared that the tubers' dry matter percentage was gradually increased with increasing hydrogen peroxide up to 40 mM, while with

Table 2. Means of the studied vegetative characters of potato during both summer seasons of 2009 and 2010

seasons		1 st 2009				2 nd 2010			
Treatments		No. of branches/ plant	Plant length (cm)	Foliage dry matter (%)	Branch thickness (cm)	No. of branches / plant	Plant length (cm)	Foliage dry matter (%)	Branch thickness (cm)
Cultivars									
Anushka		3.19b	21.25 b	18.147a	0.835a	3.76b	28.33b	17.617b	0.414a
Universal		3.63a	28.28 a	19.445a	0.810a	4.26a	33.83a	19.600a	0.811a
Vivaldi		3.91a	21.33 b	18.290a	0.665b	3.82b	23.92c	18.467a	0.655b
Dora		3.89a	23.11b	17.535a	0.643b	3.35c	22.42c	17.917a	0.624c
H_2O_2 Concentrations									
60 mM		3.70a	21.42b	19.355ab	0.800a	3.75a	27.83a	19.85a	0.756a
40 mM		3.19b	23.43a	20.691a	0.745b	3.75a	26.75a	20.375a	0.747ab
20 mM		4.06a	24.50a	18.460b	0.735b	3.86a	27.08a	17.85b	0.725ab
Zero		3.66a	24.64a	14.910c	0.675c	3.83a	26.83a	15.525c	0.676c
Cultivars X Concentration interaction									
Anushka	60 mM	3.57bcde	19.9fgh	19.08a	0.90a	3.73a	29.00a	19.00a	0.81a
	40 mM	2.78e	18.8gh	19.05a	0.82a	3.77a	29.00a	18.20a	0.84a
	20 mM	3.00de	22.17defg	19.89a	0.82a	3.53a	27.33a	18.20a	0.83a
	Zero	3.40bcde	24.17	14.57a	0.80a	4.00a	28.00a	15.07a	0.78a
Universal	60 mM	3.29cde	28.27ab	19.20a	0.88a	4.20a	34.33a	20.57a	0.86a
	40 mM	3.18de	28.47ab	24.19a	0.83a	4.23a	33.00a	22.53a	0.83a
	20 mM	4.85a	30.73a	18.50a	0.82a	4.57a	34.00a	18.50a	0.81a
	Zero	3.22de	25.67bcd	15.89a	0.72a	4.00a	34.00a	16.80a	0.76a
Vivaldi	60 mM	3.63bcde	19.50fgh	20.49a	0.72a	3.60a	24.67a	20.47a	0.68a
	40 mM	3.32cde	21.94efg	20.65a	0.67a	3.80a	22.67a	20.67a	0.66a
	20 mM	4.49ab	21.37efgh	17.84a	0.66a	4.00a	24.00a	17.67a	0.66a
	Zero	4.20abc	22.50def	14.18a	0.61a	3.90a	24.33a	15.07a	0.62a
Dora	60 mM	4.33ab	18.00h	18.65a	0.70a	3.43a	23.33a	19.37a	0.68a
	40 mM	3.50bcde	24.50cde	18.88a	0.67a	3.20a	22.33a	20.10a	0.66a
	20 mM	3.91bcd	23.72cde	17.61a	0.64a	3.33a	23.00a	17.03a	0.60a
	Zero	3.81bcd	26.22bc	15.00a	0.57a	3.50a	21.00a	15.17a	0.55a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ from each other, using Duncan's multiple range test procedure at p= 0.05 level of significance.

Table 3. Mean performances of tuber root yield, yield components and tuber shape index of potato during both summer seasons of 2009 and 2010

seasons		1 st 2009				2 nd 2010			
Treatments		No. of tubers/ plant	Average tuber weight (gm)	Tuber yield /plant (Kg)	Tuber dry matter (%)	No. of tubers/ plant	Average tuber weight (gm)	Tuber yield /plant (Kg)	Tuber dry matter (%)
Cultivars									
Anushka		6.89c	77.22b	0.531c	21.675c	6.52d	96.77c	0.631c	21.850c
Universal		8.44bc	100.91a	0.846a	22.515b	9.05a	136.71a	1.243a	22.458b
Vivaldi		11.39a	64.64c	0.723b	21.753c	7.02c	115.98b	0.818b	21.816c
Dora		9.28ab	54.89c	0.513c	25.910a	8.13b	92.49c	0.751b	25.300a
H_2O_2 Concentrations									
60 mM		9.58a	72.22a	0.664ab	23.041b	7.92a	111.63a	0.895b	23.214b
40 mM		9.36a	78.80a	0.716a	23.782a	8.22a	115.18a	0.962a	23.416a
20 mM		8.72ab	74.82a	0.642ab	22.815c	7.36b	117.68a	0.860b	22.558c
Zero		8.33b	71.82a	0.592b	22.214d	7.24b	97.46b	0.727c	22.233d
Cultivars X Concentration interaction									
Anushka	60 mM	6.67gh	76.80a	0.511a	21.45gh	6.63a	95.65d	0.633ef	22.30e
	40 mM	6.44h	77.35a	0.494a	22.60f	6.77a	98.52cd	0.667ef	22.23e
	20 mM	7.33fgh	86.11a	0.633a	21.72g	6.50a	100.58cd	0.653ef	21.67f
	Zero	7.11fgh	68.54a	0.489a	21.08h	6.20a	92.33d	0.573f	21.20g
Universal	60 mM	8.67def	92.27a	0.800a	21.60g	9.27a	140.30b	1.300b	22.17e
	40 mM	8.67def	109.63a	0.933a	23.51e	9.40a	163.12a	1.533a	22.83d
	20 mM	8.33efg	92.89a	0.772a	21.57g	8.97a	137.78b	1.233b	22.43e
	Zero	8.11efgh	108.83a	0.881a	22.41f	8.57a	105.63cd	0.907c	22.40e
Vivaldi	60 mM	13.56a	58.98a	0.767a	21.40gh	7.47a	114.52c	0.853cd	22.17e
	40 mM	11.66b	71.31a	0.827a	22.31f	7.90a	108.12cd	0.850cd	22.37e
	20 mM	10.45bcd	67.18a	0.699a	21.46gh	5.80a	141.701b	0.813cd	21.43fg
	Zero	9.89bcde	61.07a	0.599a	21.36gh	6.93a	99.57cd	0.757de	21.30g
Dora	60 mM	9.45cde	60.83a	0.577a	27.73a	8.30a	96.03cd	0.800cd	26.23a
	40 mM	10.67bc	56.90a	0.611a	27.03b	8.80a	90.97d	0.800cd	26.23a
	20 mM	8.78def	53.12a	0.466a	24.88c	8.17a	90.66d	0.740de	24.70b
	Zero	8.22efgh	48.72a	0.399a	24.03d	7.27a	92.29d	0.670ef	24.03c

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.

the concentration of 60 mM H_2O_2, tubers' dry matter was significantly decreased through the two years of the experiment.

The examined cultivars differed in their response to spray with the four concentrations of hydrogen peroxide in a number of attributes: proportion of dry matter to tubers over two years of study; No of tubers per plant only during the first season and each of the characters average tuber weight and tuber yield per plant in the second season (Table, 3). Data of the characters: average tuber weight, tuber yield per plant (during the year of 2009) and No. of tubers per plant (during the year of 2010) showed that the studied cultivars did not differ in their responses with the differences of the concentration of hydrogen peroxide sprayed (Table, 3). It is, generally, appeared there was a general trend towards the exceeds of concentration 40 mm, followed by the concentrations 60 mm and 20 mm, respectively and finally non- spraying came in last order, for the three mentioned traits.

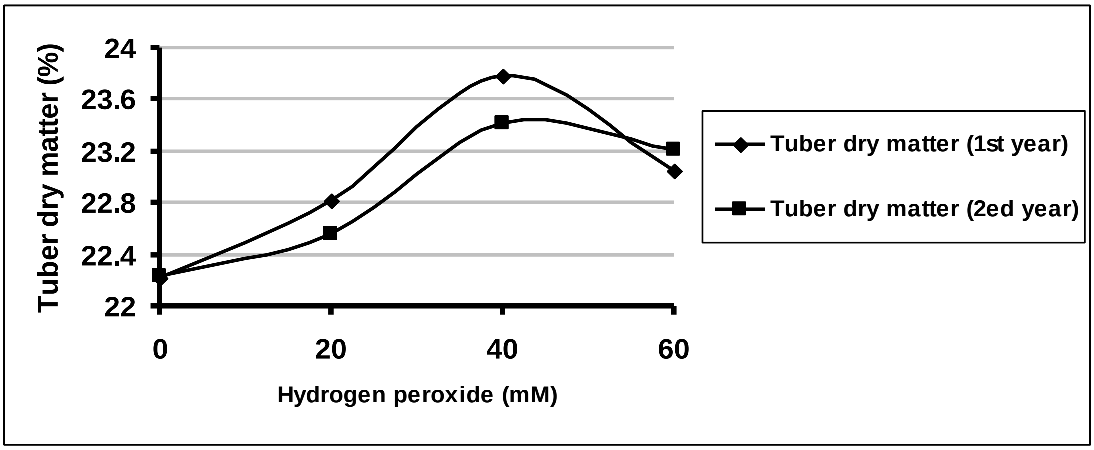

Fig. 1.The relationship between tuber dry matter content (%) and hydrogen peroxide (mM) during the two years

A.3. Potato tuber quality characteristics

The results of table, 4 showed that the four cultivars differed among themselves with respect to tuber specific gravity and tuber starch content traits throughout the years of study. The cultivar Universal possessed the highest tuber specific gravity among the studied cultivars through the two seasons. On the other hand, there were no significant differences among the cultivars; Universal, Vivaldi and Dora for starch content in the first year while, in the second season two cultivars Universal and Dora recorded high values.

The results of the effect of hydrogen peroxide concentrations on tuber quality attributes demonstrated the following results: There were no significant differences between different concentrations of hydrogen peroxide on the status of total sugars during the two seasons. Also there was no significant effect of the concentrations of hydrogen peroxide on the status of tuber reducing sugars content during the first season only, while there were no significant differences between the concentrations of hydrogen peroxide 20, 40, 60 mM in influencing the status of tuber reducing sugars content. The two concentrations 20 and 40 mM possessed higher significant differences values as compared to the control treatment (without spraying hydrogen peroxide). Regarding for tuber specific gravity, the results showed that although there were no significant differences between the three concentrations of hydrogen peroxide (20, 40, 60 mM) in influencing on such trait in first year of study, these three concentrations gave highest significant values comparable with the control treatment. In the second year, the two treatments 60, 40 mM hydrogen peroxide gave higher specific gravity values comparison with the two treatments 20 mM and zero hydrogen peroxide (Table, 4). Tuber starch content affected with the hydrogen peroxide where concentration of 60 mM hydrogen peroxide produced higher starch percentage without significant differences with the concentrations of 40 and 20 mM during the first year. The unsprayed plants (control) were the lowest in tuber starch percentage. In the second year, the concentrations of 60 and 40 mM gave higher significant differences values when compared with the concentrations of 20 and zero mM of hydrogen peroxide. Figure, 2 demonstrated the previous mentioned results, where it is, clearly, appeared that tubers' starch content gradually increased with increasing the concentration of hydrogen peroxide (H_2O_2) from zero up to 60 mM through the two years of the study. The results obtained by Delgado *et al.* (2005) clearly appeared that there was significance increasing for tuber starch percentages ranged from 6.7% to 30% as a result of spraying potato plants twice-weekly with 5 or 50 mM H_2O_2. The authors added that, in appropriate circumstances the treatment might prove of value in commercial production, perhaps by incorporation into existing spray treatments. The authors mentioned that since the potato tuber is morphologically a modified stem, the observed starch accumulation in stems and tubers may reflect a similar cellular response.

The results of Romero and Delgado (2009) detected that treated plants with hydrogen peroxide and antioxidants such as ascorbic acid led to reduce the number of mini-tubers, while enhancing their weights and starch contents; also the leaf pigment content was increased. The authors demonstrated that hydrogen peroxide and antioxidants had positive effect in enhancing potato tuber yield and quality. Same trend of

Table 4. Mean performances of tuber root quality attributes of potato during both summer seasons of 2009 and 2010

seasons		1 st 2009				2 nd 2010			
Treatments		Tuber specific gravity	Starch (%)	Total sugars (%)	Reducing sugars (%)	Tuber specific gravity	Starch (%)	Total sugars (%)	Reducing sugars (%)
Cultivars									
Anushka		1.137c	11.784b	6.595a	2.183a	1.142b	12.693b	6.075a	2.016a
Universal		1.223a	12.604a	6.457a	2.220a	1.225a	13.300a	5.991a	2.050a
Vivaldi		1.195b	12.112ab	6.179a	2.112a	1.133b	12.725b	6.366a	2.075a
Dora		1.133c	12.325ab	6.537a	2.729a	1.215a	13.540a	5.966a	2.008a
H_2O_2 Concentrations									
60 mM		1.195a	12.620a	6.300a	2.187a	1.192a	13.541a	6.016a	2.025ab
40 mM		1.181a	12.238ab	6.757a	2.270a	1.187a	13.293a	5.908a	2.175a
20 mM		1.174a	12.116ab	6.237a	2.508a	1.173b	12.815b	6.300a	2.141a
Zero		1.138b	11.850b	6.475a	2.279a	1.164b	12.607b	6.175a	1.808b
Cultivars X Concentration interaction									
Anushka	60 mM	1.130a	12.867a	5.800a	2.233a	1.170a	13.267a	5.933a	2.067a
	40 mM	1.127a	11.300a	7.083a	2.017a	1.147a	13.073a	5.667a	2.233a
	20 mM	1.160a	12.033a	6.333a	2.167a	1.140a	12.033a	6.333a	1.967a
	Zero	1.133a	10.933a	7.167a	2.317a	1.113a	12.400a	6.367a	1.800a
Universal	60 mM	1.260a	12.833a	6.333a	1.733a	1.223a	13.700a	6.100a	2.033a
	40 mM	1.237a	13.133a	6.947a	2.617a	1.237a	13.367a	6.167a	2.133a
	20 mM	1.230a	12.100a	6.417a	2.417a	1.227a	13.333a	6.033a	2.233a
	Zero	1.167a	12.350a	6.133a	2.117a	1.217a	12.800a	5.667a	1.800a
Vivaldi	60 mM	1.230a	11.750a	6.467a	2.083a	1.143a	13.400a	6.033a	2.067a
	40 mM	1.220a	12.000a	6.367a	1.700a	1.150a	12.900a	6.567a	2.167a
	20 mM	1.183a	12.450a	5.733a	2.317a	1.120a	12.367a	6.600a	2.200a
	Zero	1.147a	12.250a	6.150a	2.350a	1.120a	12.233a	6.267a	1.867a
Dora	60 mM	1.160a	13.033a	6.600a	2.700a	1.233a	13.800a	6.000a	1.933a
	40 mM	1.143a	12.517a	6.633a	2.750a	1.217a	13.833a	5.233a	2.167a
	20 mM	1.123a	11.883a	6.467a	3.133a	1.201a	13.530a	6.233a	2.167a
	Zero	1.107a	11.867a	6.450a	2.333a	1.201a	12.970a	6.400a	1.767a

Means having an alphabetical letter in common, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.

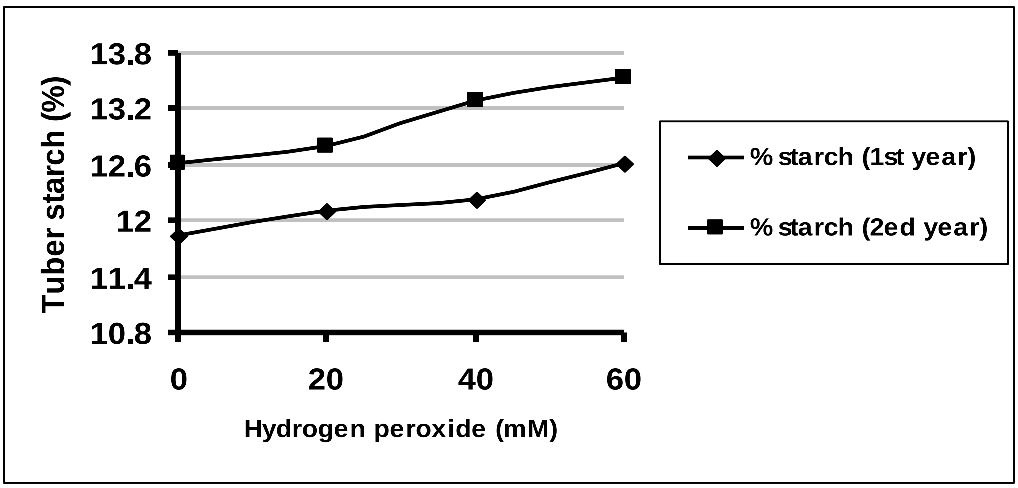

Fig. 2.The relationship between tuber starch content (%) and hydrogen peroxide (mM) during the two years

results were obtained by Gutierrez *et al.* (2012) since their results appeared that H_2O_2 treatment induced higher internal H_2O_2 concentration, which was associated with positive effects on infected mini-tubers with Phytoplasma, such as weight, reduction of number, starch content, sprouting, and tolerance to drought a signal role for H_2O_2 in lessening symptoms is suggested.

The data concerning the cultivar X hydrogen peroxide concentrations, clearly, appeared that none of the studied tuber quality characters showed significant differences as a result of such interactions during the two years of experiment (Table, 2). These results meant that there were same trend for the cultivar performances with spraying with the different concentrations of hydrogen peroxide. Generally, it could be conducted that spraying growing plants with the concentration of 60 mM hydrogen peroxide gave the highest values followed by the concentrations 40 mM and 20 mM and finally came non-sprayed plants in the last order where the latter gave the lowest values of quality potato tubers.

B. Histological data

Data of parenchyma cell diameter are presented in table, 5. It could be conducted that the examined cultivars, significantly, differed for parenchyma cell diameter and this can be traced to genetic reasons that characterize each cultivar for the other. The results demonstrated that the cultivar Universal had the highest value where the parenchyma cell diameter recorded 211.293 micron followed with the cultivars Anushka (203.698 μ) and Vivaldi (200.266 μ) without significant differences between them while the cultivar Dora came in last place (193.262 μ). Parenchyma cell diameter was positively affected with increasing concentrations of hydrogen peroxide from zero up to 60 mM. The data detected that the ratio of increasing in tuber parenchyma cell diameter reached 9.34% as compared to non-treated plants. It could be conducted from figure, 3 that there was positive correlation between the concentration of hydrogen peroxide and the parenchyma cell diameter. It is known that starch is mainly stored in cells located parenchyma cells in tubers and thus increasing the diameter of parenchyma cells leads to an increasing in starch content of tubers and this has a positive impact on increasing the proportion of tuber's dry matter. This result is in harmony with that obtained by Delgado *et al*. (2005). The authors explained that applying hydrogen peroxide led to enlarge medullar parenchyma cells.

Data of table, 5 and Figure, 4 reflected that the different studied cultivars differently responded with the h_2o_2 concentrations. This indicates that there are some cultivars had positively responded to treatment with hydrogen peroxide, while other cultivars did not respond in same trend. The results showed that Anushka was did not respond correctly with the increasing concentrations of hydrogen peroxide while the Universal was responded much positive up to concentration of 40 mM. Only the two cultivars Vivaldi and Dora had responded correctly where the parenchyma cell diameter had increased steadily with increasing the hydrogen peroxide from zero up to 60 mM.

C. Quality Evaluation of potato chips and strips processed

C.1. Dry matter

The results in table, 6 and figure, 5 showed that there was a significance increasing in the dry matter, respecting to the first cultivation (2009), of Universal cultivar treated with 20 mM of H_2O_2 when compared with control sample and with other samples treated with 40 mM and 60 mM H_2O_2 concentrations. It could also be shown that the highest percentage of dry matter could be detected in the control samples of Vivaldi cultivar which was statistically significant

Our results of table, 6 and figure, 6 regarding the second cultivation (2010), showed that using 20, 40 or 60 mM H_2O_2 caused a significant increasing in the percentage of the dry matter for Anushka, compared with zero mM H_2O_2. Using 20 or 60 mM of H_2O_2 with Universal caused the highest dry matter percentages compared with using zero or 40 mM H_2O_2. The treatment 20 mM of H_2O_2 was the best with the cultivar Dora. Vivaldi possessed the highest dry matter percentage when used 40 or 60 mM of H_2O_2.

Our results agreed with that of Delgado *et al*. (2005) who sprayed field-grown potato plants twice weekly, from 21 to 90 days after planting, with 5 or 50mM hydrogen peroxide solutions. Relative to water-sprayed controls, the hydrogen peroxide treatments significantly enhanced tuber starch accumulation and increased dry matter by between 6.7% and 30%. There have been few other reports describing physiological effects of exogenous H_2O_2 on potato tubers; Afek *et al*. (2000) found that tubers treated with a sprout inhibitor based on H_2O_2 showed sprouting inhibition after 6 months of storage.

Given the novelty of our observations on dry matter and starch accumulation, we can only engage in limited speculation on the underlying mechanisms, but it is clear that H_2O_2 treatment could prove an interesting tool for further research on dry matter and starch biosynthesis regulation. It may be that H_2O_2 treatment affects starch biosynthesis indirectly via effects on cellular signaling mechanisms. The treatment might generate a cellular redox imbalance, which would be capable of triggering

Table 5. Means of parenchyma cell diameter during the summer season of 2010

		Parenchyma cell diameter (μ)
		Cultivars
	Anushka	203.698 b
	Universal	211.293 a
	Vivaldi	200.266 b
	Dora	193.262 c
		H_2O_2 Concentrations
	60 mM	210.908 a
	40 mM	204.567 b
	20 mM	200.260 c
	Zero	192.885 d
		Cultivars X Concentration interaction
Anushka	60 mM	197.670 ef
	40 mM	207.185 d
	20 mM	206.97 d
	Zero	202.895 de
Universal	60 mM	209.605 cd
	40 mM	223.025 a
	20 mM	214.500 bc
	Zero	198.000 ef
Vivaldi	60 mM	221.210 ab
	40 mM	196.790 ef
	20 mM	194.315 fg
	Zero	189.145 gh
Dora	60 mM	215.105 bc
	40 mM	191.290 fgh
	20 mM	185.185 hi
	Zero	181.500 i

Means having the same superscript, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.

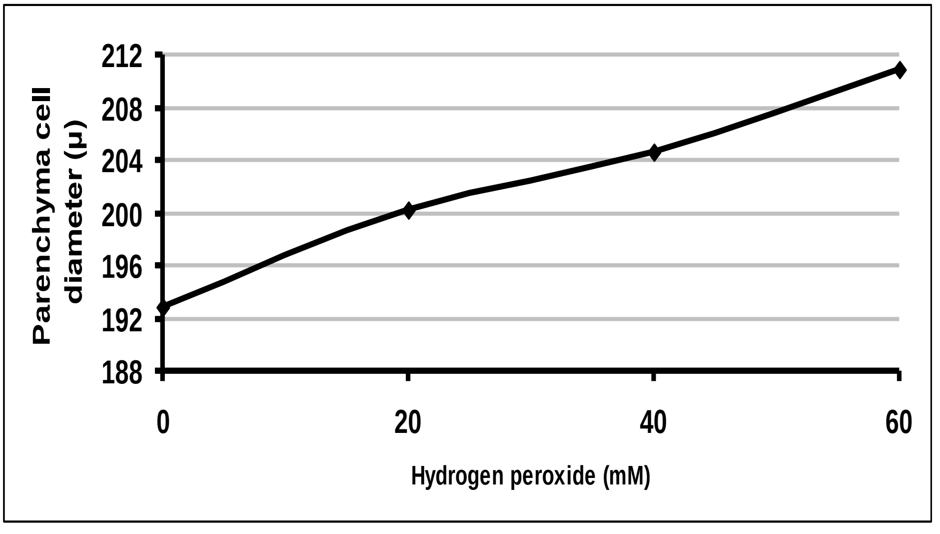

Fig. 3. The relationship between tuber parenchyma cell diameter (μ) and hydrogen peroxide (mM)

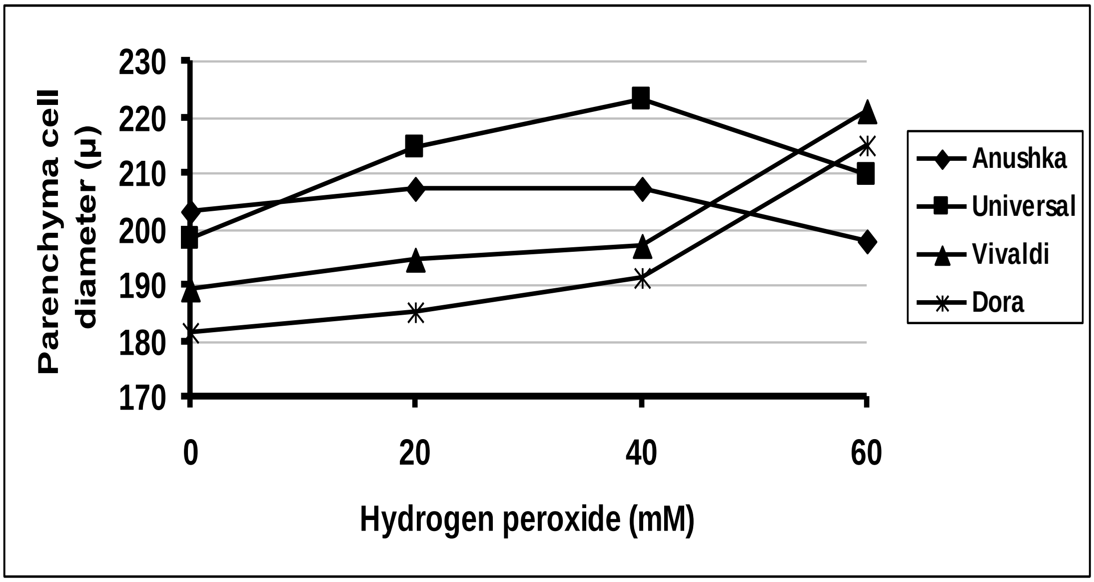

Fig. 4. The relationship between tuber parenchyma cell diameter (µ) and hydrogen peroxide (mM) for the four studied cultivars

Table 6. Dry matter percentages (%) of four potato cultivars treated with different concentrations of H_2O_2 during the first and second cultivations

H_2O_2 concentrations	Season of 2009				Season of 2010			
	Anushka	Universal	Dora	Vivaldi	Anushka	Universal	Dora	Vivaldi
0 mM	20.03 [a]	20.06 [b]	19.50 [a]	24.24 [a]	20.35 [b]	20.13 [b]	19.71 [b]	21.56 [a]
20 mM	19.02 [a]	22.05 [a]	19.30 [a]	17.40 [b]	24.48 [a]	21.48 [a]	22.37 [a]	21.97 [a]
40 mM	17.60 [a]	21.40 [b]	21.31 [a]	19.40 [b]	23.45 [a]	18.68 [b]	20.72 [b]	18.71 [b]
60 mM	18.50 [a]	17.62 [b]	19.87 [a]	18.20 [b]	24.28 [a]	22.26 [a]	20.13 [b]	18.38 [b]

Means having the same superscript, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.

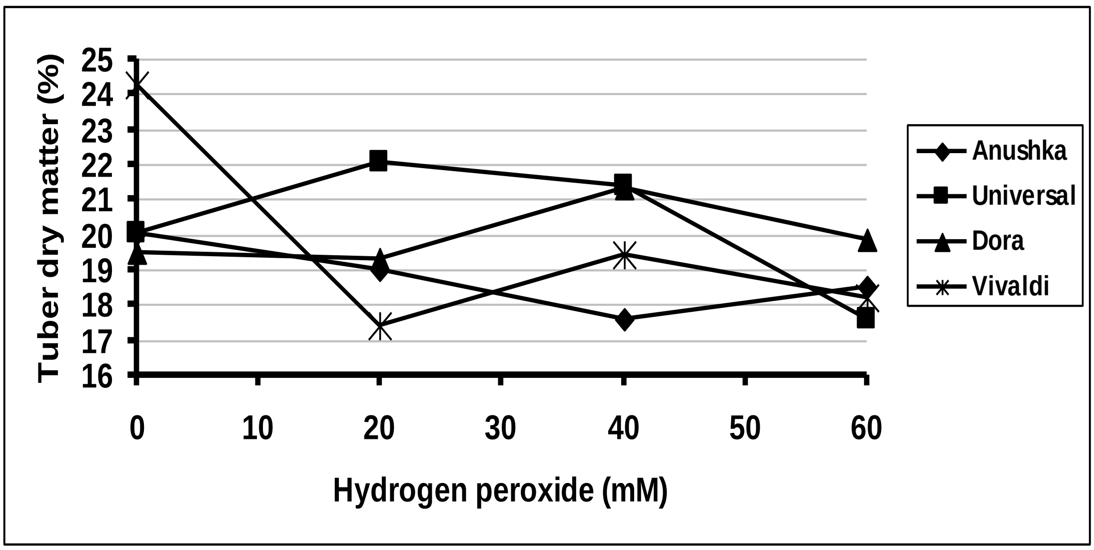

Fig. 5. Dry matter content of different potato cultivars treated with different concentrations of H_2O_2 during the first cultivation

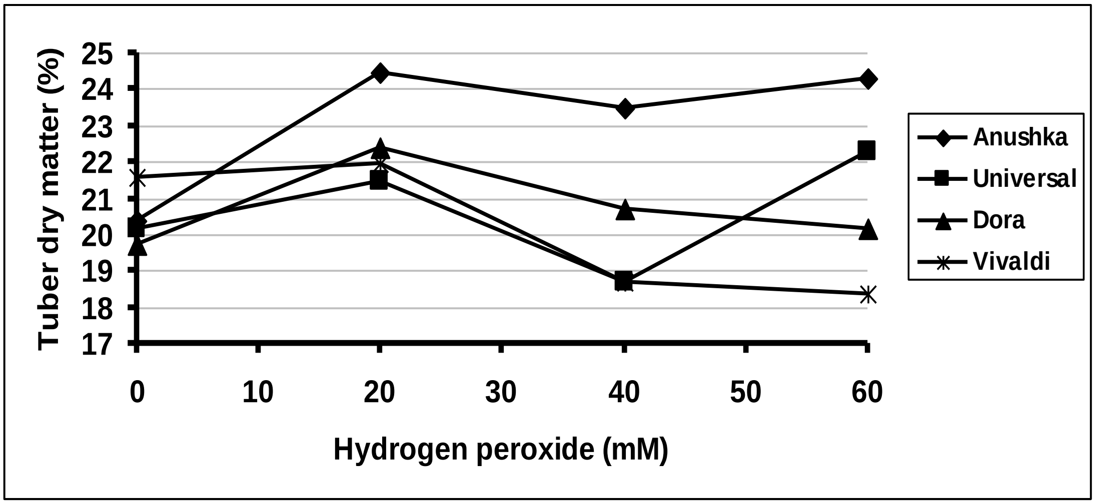

Fig.6. Dry matter content of different potato cultivars treated with different concentrations of H_2O_2 during the second cultivation

signaling cascades activating various adaptive responses, currently known examples of which include pathogen defense responses, photosynthetic adjustments, stress acclimation, and cell cycle control (Neill *et al*. 2002; Pastori and Foyer 2002; Dietz and Scheibe 2004).**C.2. Sensory evaluation**

C.2.1. Potato strips (French fry) Quality

Four primary factors determine French fry quality: dry matter, levels of reducing sugars, defects and flavor. One of the most important qualities of French fry potatoes is high dry matter, French fry processing removes water from the potato, hence the higher the water content of the potato, the more water or weight lost during processing resulting in a lower yield of fries (Talburt & Smith, 1987). Results of table, 7, for the first year, showed that there was a significant difference in the taste attributes of Anushka variety at 0 mM and 40 mM H_2O_2 while the overall acceptability of the same variety increased significantly at 0 mM and 20 mM treatments. Taste values were increased significantly in Universal cultivar treated with 40 mM H_2O_2. Colour values were statistically significant at 20 mM and 40 mM H_2O_2 of Dora cultivar while the consistency value was statistically significant at 0 mM treatment (control untreated group) of the same cultivar.

Table (7) also illustrated that values of odor attributes were statistically insignificant in all evaluated samples of the tested cultivars at different treatment concentrations.

Potatoes with high dry matter content produce a greater yield of fries than potatoes with low dry matter content. Dry matter also has a direct bearing on the amount of oil absorbed by the potato slices during the deep frying process. Fries made from tubers with low dry matter absorb more oil than fries from tubers with high dry matter. Although some oil absorption during deep frying is desirable for flavour development, too much results in limp, greasy fries. Low dry matter content increase production costs because more oil is used in the frying process (Lisińska and Gołubowska, 2005).

Basic quality characteristics of fries include: colour, taste, odor, texture and fat content (Lisiñska & Leszczyñski, 1989). They affect the attractiveness of the ready product to a substantial extent. The results of table, 7, for the second year of the study illustrated that the taste and overall acceptability values were statistically increased for Anushka using 20 mM of H_2O_2 followed with the treatments zero and 40 mM. For Universal cultivar, taste and overall acceptability showed significantly high values with zero, 20 and 40 mM of H_2O_2 compared with the treatment 60 mM.

The colour of Dora cultivar statistically possessed high significant values at 0 mM and 40 mM H_2O_2 while the consistency was significantly of higher value in the control group of Dora cultivar. Colour is one of the appearance attributes of food materials, since it influences consumer acceptability (Desilkan *et al*., 2001). It is desirable that French fries be of a light, golden colour without any brown over colouring or black spots and traces (Lisiñska and Leszczyñski, 1989).

It can be shown from the data of table, 7 that there were not any significant differences in the mean results of sensory evaluation parameters of potato strips (French fries) produced from Vivaldi cultivar treated with the different H_2O_2 concentrations in the second cultivation.

Table 7. Mean results of sensory evaluation of potato strips (French fries) produced from four potato cultivars treated with different H_2O_2 concentrations during the first and second cultivations

Treatments	Season of 2009					Season of 2010				
H_2O_2 concentrations	Colour	Odor	Taste	Consistency	Acceptability	Colour	Odor	Taste	Consistency	Acceptability
					Anushka					
0 mM	3.38 a	4.46 a	4.83 a	3.02 a	4.36 a	3.89^{a}	4.35^{a}	4.49^{b}	3.84^{a}	4.36^{b}
20 mM	3.21 a	4.50 a	4.21 b	3.36 a	4.85 a	3.53^{a}	4.96^{a}	4.82^{a}	3.38^{a}	4.85^{a}
40 mM	3.86 a	4.88 a	4.60 a	3.83 a	3.75 b	3.98^{a}	4.28^{a}	4.75^{b}	3.38^{a}	4.48^{b}
60 mM	3.60 a	4.00 a	3.23 b	3.32 a	4.03 b	3.48^{a}	4.26^{a}	4.06^{c}	3.65^{a}	4.03^{c}
					Universal					
0 mM	3.31 a	4.15 a	3.87 b	4.65 a	4.35 a	3.56^{a}	4.21^{a}	4.37^{a}	4.37^{a}	4.62^{a}
20 mM	3.86 a	4.25 a	4.06 b	4.26 a	4.22 a	3.21^{a}	4.37^{a}	4.61^{a}	4.85^{a}	4.24^{a}
40 mM	3.14 a	4.11 a	4.31 a	4.77 a	4.17 a	3.53^{a}	4.41^{a}	4.74^{a}	4.35^{a}	4.37^{a}
60 mM	3.75 a	4.39 a	3.75 b	4.66 a	4.57 a	3.48^{a}	4.35^{a}	4.01^{b}	4.39^{a}	4.17^{b}
					Dora					
0 mM	4.40 b	4.47 a	3.00 a	4.50 a	4.04 a	4.64^{a}	4.34^{a}	3.17^{a}	4.34^{a}	4.11^{a}
20 mM	4.62 a	4.24 a	3.22 a	3.54 b	3.76 a	4.46^{b}	4.10^{a}	3.62^{a}	3.89^{b}	3.28^{a}
40 mM	4.36 a	4.37 a	3.55 a	3.71 b	3.42 a	4.57^{a}	4.48^{a}	3.44^{a}	3.39^{b}	3.41^{a}
60 mM	4.12 b	4.61 a	3.53 a	3.93 b	3.85 a	4.34^{b}	4.37^{a}	3.56^{a}	3.56^{b}	3.36^{a}
					Vivaldi					
0 mM	3.52 a	4.71 a	3.49 a	3.45 a	4.34 a	3.53^{a}	4.46^{a}	3.46^{a}	3.72^{a}	4.06^{a}
20 mM	3.64 a	4.56 a	3.19 a	3.30 a	4.02 a	3.82^{a}	4.47^{a}	3.29^{a}	3.04^{a}	4.43^{a}
40 mM	3.72 a	4.97 a	3.17 a	3.25 a	3.94 a	3.67^{a}	4.32^{a}	3.57^{a}	3.38^{a}	3.57^{a}
60 mM	3.17 a	4.71 a	3.56 a	4.65 a	3.84 a	3.43^{a}	4.81^{a}	3.72^{a}	3.61^{a}	3.71^{a}

Means having the same superscript, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.
5-Point descriptive category scale for each estimated parameter, where one indicating very poor and 5 indicates excellent

French fry colour is largely determined by the reducing sugars content of the potato tuber; potatoes with high reducing sugars levels make dark fries. When potatoes are fried, the reducing sugars react with amino acids in the tuber to form dark products in a non-enzymatic browning reaction. The concentration of reducing sugars in the tubers depends on cultivar, growing conditions, maturity, and storage conditions (Surmacka, 2002).

C.2.2. Potato Chip Quality

Potato chips have been popular salty snacks for 150 years and its retail sales in USA are about $6 billion/year, representing 33% of the total sales of this market (Garayo and Moreira, 2002; and Clark, 2003).

Our results of table, 8 showed that the mean results of sensory evaluation parameters of potato chips produced from Anushka cultivar treated with different H_2O_2 concentrations in the first cultivation did not significantly differ, except that of the colour and taste. Colour, taste, consistency and overall acceptability significantly increased with the 40 mM H_2O_2 treatment of Universal cultivar. Dora cultivar showed a significant increasing in color, taste, consistency and overall acceptability of the control group and a significant decrease in consistency at 20 mM and 60 mM H_2O_2 treatments. There was no significant difference in the Mean results of sensory evaluation of potato chips produced from Vivaldi cultivar treated with different H_2O_2 concentrations in the first cultivation except the color of the control group.

Frying in hot oil is characterized by very high water removal rates, which critically influence the mechanical; as well as, structural properties of the chips (Baumann and Escher, 1995; Hindra and Baik, 2006). The moisture content of chips decreases from around 80% to almost 2% when they are fried. However, the moisture removal inevitably leads to a considerable uptake of oil which amounts to around 35% of the mass of the chip (Aguilera and Gloria-Herna´ndez, 2000).

Table 8. Mean results of sensory evaluation of potato chips produced from four potato cultivars treated with different H_2O_2 concentrations during the first and second cultivations.

Treatments	Season of 2009					Season of 2010				
H_2O_2 concentrations	Colour	Odor	Taste	Consistency	Acceptability	Colour	Odor	Taste	Consistency	Acceptability
					Anushka					
0 mM	4.00^{a}	4.34^{a}	4.07^{a}	3.93^{a}	3.95^{a}	3.57^{a}	4.76^{a}	4.15^{a}	3.76^{a}	4.36^{b}
20 mM	3.35^{b}	4.23^{a}	3.79^{b}	3.36^{a}	3.63^{a}	3.31^{a}	4.46^{a}	4.38^{a}	3.57^{a}	4.85^{a}
40 mM	3.21^{b}	4.31^{a}	3.50^{b}	3.50^{a}	3.62 a	3.47^{a}	4.39^{a}	4.02^{b}	3.66^{a}	4.28^{c}
60 mM	3.36^{b}	4.32^{a}	3.64^{b}	3.43^{a}	3.43^{a}	3.84^{a}	4.43^{a}	4.04^{b}	3.73^{a}	4.03^{c}
					Universal					
0 mM	4.10^{b}	4.42^{a}	3.90^{b}	3.33^{b}	3.84^{b}	3.23^{a}	4.23^{a}	4.54^{a}	4.37^{a}	4.39^{a}
20 mM	3.43^{b}	4.26^{a}	4.06^{b}	3.50^{b}	3.81^{b}	3.08^{a}	4.75^{a}	4.65^{a}	4.85^{a}	4.56^{a}
40 mM	4.44^{a}	4.53^{a}	4.31^{a}	4.44^{a}	4.43^{a}	3.58^{a}	4.28^{a}	4.11^{b}	4.35^{a}	4.41^{a}
60 mM	3.86^{b}	4.62^{a}	3.75^{b}	3.56^{b}	3.72^{b}	3.46^{a}	4.59^{a}	4.01^{b}	4.39^{a}	4.17^{b}
					Dora					
0 mM	4.50^{a}	4.16^{a}	4.07^{a}	4.19^{a}	4.25^{a}	4.64^{a}	4.47^{a}	4.52^{b}	4.45^{a}	4.77^{a}
20 mM	3.56^{b}	4.24^{a}	3.43^{b}	2.50^{c}	3.43^{b}	4.46^{b}	4.27^{a}	4.63^{b}	4.53^{a}	4.74^{a}
40 mM	4.00^{b}	4.04^{a}	3.50^{b}	3.19^{b}	3.68^{b}	4.57^{b}	4.29^{a}	4.67^{a}	4.46^{a}	4.48^{b}
60 mM	3.29^{b}	4.38^{a}	3.08^{b}	2.36^{c}	3.46^{b}	4.34^{b}	4.63 a	4.74^{a}	4.58^{a}	4.66^{b}
					Vivaldi					
0 mM	4.29^{a}	4.28^{a}	3.86^{a}	3.86^{a}	4.07^{a}	3.32^{a}	4.37^{a}	4.09^{a}	3.75^{a}	4.30^{a}
20 mM	3.36^{b}	4.10^{a}	3.71^{a}	3.36^{a}	3.63^{a}	3.82^{a}	4.84^{a}	4.13^{a}	3.64^{a}	4.21^{a}
40 mM	3.29^{b}	4.72^{a}	3.57^{a}	3.07^{a}	3.66^{a}	3.67^{a}	4.35^{a}	3.50^{b}	3.05^{a}	3.87^{b}
60 mM	4.00^{b}	4.63^{a}	3.50^{a}	2.93^{a}	3.48^{a}	3.43^{a}	4.41^{a}	3.91^{b}	3.48^{a}	3.24^{b}

Means having the same superscript, within a comparable group of means, do not significantly differ, using Duncan's multiple range test procedure at p= 0.05 level of significance.

5-Point descriptive category scale for each estimated parameter, where one indicating very poor and 5 indicates excellent.

Results of table, 8, for the second year of the study, showed that Taste and over all acceptability significantly increased in most tested cultivars of potato chips at 0 mM and 20 mM H_2O_2 concentrations which have high dry matter percentages, except for Dora cultivar where the treatments 40 and 60 mM possessed highest values. High dry matter is particularly important in the production of potato chips because of greater surface area to volume ratio in chips compared to fries. Chip crispness and lack of oiliness increases with increasing dry matter content (Duran *et a*l., 2007).

Chips produced from Dora cultivar (Table, 8) showed a highly significant increasing in all tested sensory evaluation parameters at all H_2O_2 concentrations. The colour was of very good scores. Good quality potato chips have a light colour with little vascular discolouration. As with French fries, the colour of potato chips depends on the reducing sugars content of the potatoes (Biedermann-Brem, 2003). However, potato chip processors have slightly less control over reducing sugars levels because blanching is not an option in the chipping process.

Potato chips must have a pleasing and desirable flavor, thus potatoes used in chipping must not be bitter or have other off-flavors. The flavor of potato chips is more complex than that of boiled, baked or mashed potatoes, since the cooking temperatures are higher, and the absorbed oil contributes to the overall flavor profile of the product (Bouchon *et al*., 2003).

CONCLUSIONS

This research is the first work in Egypt, which deals with the effect of hydrogen peroxide on the quality of potato tubers involved in potato processes. It could be concluded that the hydrogen peroxide has a good positive role in increasing the proportion of tubers' starch by increasing the breadth of parenchyma cell diameter, which are considered the main store of starch in tubers and thus increases the dry matter and then insuring increase the proportion end result of the processing. The concentration of 40 mM hydrogen peroxide was considered as the best concentration, under the conditions of this study, to obtain higher percentage of tubers' dry matter. At the same time, we must recall that some of the studied cultivars might have responded much positive and better for treating with hydrogen peroxide, while some other cultivars did not respond much. So it must be doing of other researches using a greater number of cultivars to study the various aspects of the effect of hydrogen peroxide on the potato tuber quality for clear-cut conclusions. Our results demonstrated that Anushka and Universal cultivars showed highly accepted in potato strips (French fries) while Dora cultivar was the most acceptable in potato chips.

REFERENCES

Afek, U. J. Orenstein, and E. Nuriel (2000). Using HPP (Hydrogen Peroxide Plus) to inhibit potato sprouting during storage. Amer. J. Potato Res. 77:63-65.

Aguilera, J.M. and H.Gloria-Herna´ndez (2000). Oil absorption during frying of frozen parfried potatoes. Journal of Food Science 65, 446–1479.

A.O.A.C. (1970). Official Methods of Analysis Association of Official Analytical Chemists. Official and tentative methods of analysis. 11th ed., Washington. D.C.

A.O.A.C. (1995). Official Methods of Analysis of A.O.A.C. International, 16th edn . The Association of Analytical Chemists.

Baumann, B. and E. Escher (1995). Mass and heat transfer during deep fat frying of potato slices. Rate of drying and oil uptake. Lebensmittel- Wissenschaft und-Technologie 28, 395–403.

Biedermann-Brem (2003). How much reducing sugar may potatoes contain to avoid excessive acrylamide formation? Eur. Food Res. Technol. 217:369–373.

Bouchon, P., J.M. Aguilera and D.L. Pyle (2003). Structure oil-absorption relationships during deep-fat frying. Journal of Food Science 68, 2711–2716.

Burton W.G. (1989). The Potato, 3ed. Wiley, New York.

Clark, J.P. (2003). Happy birthday, potato chip! And other snack developments. Food Technology 57 (5), 89–92.

Delgado, L.; H.A.Z. Mancera, M.E.M. Herrera, M. V. Rivera, F. X. F. Gutiérrez and I.M. Scott (2005). Hydrogen Peroxide Increases Potato Tuber and Stem Starch Content, Stem Diameter, and Stem Lignin Content. American journal of potato research. P. 367-71

Desikan R, S.A.H. Mackerness, J.T. Hancock and S.J. Neiu (2001). Regulation of the Arabidopsis transcriptome by oxidative stress. Plant Physiol. 127:159-172.

Dietz K.J. and R. Scheibe (2004). Redox regulation: an introduction. Physiol. Plant 120:1-3.

Dubios, M, K. Gulles, J. Hamilton, P. Rebers and F. Smith (1956). Colourimetric method for determination of sugars and related substances. Analytical Chemistry. 28: 350-356.

Duran, M., F. Pedreschi, P. Moyano, and E. Troncoso (2007). Oil partition in pre-treated potato slices during frying and cooling. Journal of Food Engineering 81, 257–265.

Estrada, R.N. (2000). La Biodiversidad en el Mejoramiento Gentico de la Papa. Centro International de al Papa, Lima, Pero.

Garayo, J. and R.G. Moreira (2002). Vacuum frying of potato chips. Journal of Food Engineering 55, 181–191.

Gould, W.A, and S.L. Plimpton (1985). Quality evaluation of potato cultivars for processing. Ohio Agric. Res. Dev. Cent. Res. Bull. 1172.

Gutierrez, R.M., M.E.M. Herrera and H.A.L. Delgado (2012). Genous H_2O_2 in Phytoplasma-infected potato plants promotes antioxidant activity and tuber production under drought conditions. American Journal of Potato Research, Vol. 89: 53-62.

Hindra, F. and O.D. Baik (2006). Kinetics of quality changes during food frying. Critical Reviews in Food Science and Nutrition 46, 239–258.

Lisińska, G. and G. Gołubowska (2005). Structural changes of potato tissue during French fries production. Food Chem. 93, 681-687

Lisińska G. and W. Leszczyński (1989). Potato Science and Technology, Elsevier Applied Science, London, New York., p. 391.

Neill S.J., R. Desikan, A. Clarke, R.D. Hurst and J.T. Hancock (2002). Hydrogen peroxide and nitric oxide as signalling molecules in plants. J. Exp. Bot. 53: 1237-1247.

Nickell, G.L. (1991). Proceedings 18th Annual Meeting. Plant Growth Regulation Society of America, LaGrange, GA. Pp 115-120.

Pastori, G.M. and C.H. Foyer (2002). Common components, networks, and pathways of cross-tolerance to stress. The central role of "redox" and abscisic acid-mediated controls. Plant Physiol. 129:460-468.

Romero, R.M.T. and H.A.L. Delgado (2009). Ameliorative effects of hydrogen peroxide, ascorbate and dehydroascorbate in *solanum tuberosum* infected by pytoplasma. American Journal of Potato Research, Vol. 86: 218-226.

SAS Institute (2001). SAS for Windows, SAS User's Guide: Statistics.Version 8.0 e. SAS Institute Inc., Cary, NC, USA.

Snedecor, G. H. and W. C. Cochran (1980). Statistical Methods. 7 th ed. Iowa State University Press, IA, USA University press, Ames., Iowa, U.S.A.

Storey, R.MJ., and H.V. Davies (1992). Tuber quality. In: PM Harris (ed), The Potato Crop: The Scientific Basis for Improvement, 2ed. Chapman and Hall, London, pp 507-569.

Surmacka, S. A. (2002). Texture is a sensory property. Food Quality Pref., 13, 215-225.

Talburt, W. F. and O. Smith (1987). Potato Processing. (4th ed). Avi Van Nostrand Reinhold Company. New York, p. 796.

الملخص العربي

دور الهيدروچين بيروكسيد فى تحسين جودة درنات البطاطس

سامح عبد المنعم مُحَمَّد موسى، نشوة إبراهيم أبوالفضل، ونيڤين فهمى عجمى

أجريت هذه الدراسة خلال الموسمين الصيفيين لعامى 2009 ، 2010 بالمزرعة البحثية لمحطة بحوث البساتين بالصبحية – الإسكندرية.

أجرى البحث بغرض دراسة تأثير مادة الهيدروجين بيروكسيد رشاً على النباتات على زيادة جودة وتحسين درنات البطاطس الداخلة فى عمليات التصنيع(الشبس، التحمير) بهدف زيادة نسبة تصافى المنتج النهائى بأقل قدر من العيوب والذى يقلل من قيمة المنتج النهائى الخارج من المصنع وتأثير ذلك على رفع قيمة البطاطس بصفة عامة لدى المزارع وكذلك زيادة العائد من التصنيع وبالتالى تشجيع المستثمرين على الإقبال أكثر على تصنيع البطاطس .

أستخدم فى التجربة عدد أربعة أصناف من البطاطس وهى أنوشكا، يونيڤرسال، ڤيڤالدى، دورا . رشت نباتات البطاطس بدءاً من عمر 45 يوماً من الزراعة بالهيدروجين بيروكسيد مرتين اسبوعياً وحتى عمر 90 يوما. كانت هناك اربعة معدلات للرش بالهيدروجين بيروكسيد هى صفر، 20، 40، 60 ميلليمولار.

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 الهيدروجين بيروكسيد فقد تم توزيعها عشوائياً على القطع تحت الرئيسية 0بينما فى تجربة الإختبارات الحسية للبطاطس المصنعة(الأصابع المحمرة ، الشيبس) فقد أستخدم تحليل التباين وطريقة أقل فرق معنوى لدراسة الفرق بين معاملات الهيدروجين بيروكسيد الأربعة فى التأثير على مزاج المتذوقين.

أوضحت الدراسة النتائج التالية :-

1- هناك تأثير إيجابى بصفة عامة للتركيزات المرتفعة من الهيدروجين بيروكسيد(40، 60 ميلليمولار) على الصفات الخضرية المدروسة، وبصفة خاصة على صفة سمك الفروع حيث ازداد السمك بزيادة معدلات الرش.

2- نباتات البطاطس التى تم رشها بالهيروجين بيروكسيد أعطت بصفة عامة انتاجية من محصول الدرنات أعلى من المعاملة الكنترول(بدون رش).

3- سجلت النسبة المئوية للمادة الجافة بدرنات البطاطس أعلى نسبة لها مع المعاملة بتركيز 40 ميلليمولار وتلتها المعاملة بتركيز 60 ميلليمولار ثم المعاملة بتركيز 20ميلليمولار وأخيراً جاءت المعاملة كنترول(بدون رش) فى المرتبة الأخيرة ، مما يبرهن على أن الرش بالهيدروجين بيروكسيد ساهم بطريقة إيجابية فى زيادة محتوى درنات البطاطس من المادة الجافة.

4- أوضحت النتائج أن نسبة النشا بدرنات البطاطس قد ازدادت تدريجياً بزيادة تركيز الرش بالهيدروجين بيروكسيد ،وأن التركيزين60، 40 ميلليمولار هيدروجين بيروكسيد هما الأفضل للحصول على محتوى أعلى من النشا مما يعكس التأثير الجيد فى عملية تصنيع البطاطس.

5- لم يكن للهيدروجين بيروكسيد تأثير ملحوظ على محتوى درنات البطاطس من السكريات الكلية.

6- بينت إختبارات الهيستولوجى إزدياد قطر الخلايا البارانشيمية المخزنة لحبيبات النشا تدريجياً مع زيادة تركيزات الهيدروجين بيروكسيد من صفر وحتى تركيز 60 ميلليمولار بنسبة زيادة مقدارها 34, 9% مقارنة بالكنترول.

7- إختلفت الأصناف فيما بينها بالنسبة لإستجابتها للتركيزات المختلفة من الهيدروجين بيروكسيد فى التأثير على محتواها من المادة الجافة وذلك على مدار عامى التجربة.

8- أظهرت الإختبارات الحسية(اللون-الرائحة- الطعم- التماسك – القبول العام) التى أجريت على البطاطس المصنعة للأربعة أصناف المدروسة مايلى:-

أ- عند تصنيع البطاطس من أجل إنتاج الأصابع المحمرة (المقلية) فقد أظهرت النتائج بصفة عامة أن المعاملات صفر، 20، 40 ميلليمولار هيدروجين بيروكسيد سجلت قيما أعلى بدرجة معنوية من ناحية القبول العام والطعم لدى جمهور المتذوقين مقارنة بالمعاملة60 ميلليمولار هيدروجين بيروكسيد وذلك للصنفين أنوشكا، و يونيڤرسال.

ب- عند تصنيع البطاطس من أجل إنتاج الشيبس فإن النتائج بشكل عام أظهرت تفوق المعاملتين صفر، و20 ميلليمولار من حيث القبول العام والطعم لدى جمهور المتذوقين مقارنة بالمعاملتين 40، و60 ميلليمولار هيدروجين بيروكسيد وذلك للأصناف أنوشكا، يونيڤرسال ، ڤيڤالدى.

ج- أظهرت النتائج أن الصنفين أنوشكا ، يونيڤرسال هما الأفضل عند تصنيع البطاطس من اجل انتاج الأصابع المحمرة حيث أنهما سجلا أعلى القيم من حيث الطعم والقبول العام مع المعاملة بأى من الأربعة تركيزات من الهيدروجين بيروكسيد، بينما الصنف دورا هو الأفضل فى حال التصنيع من أجل انتاج الشيبس ؛يث أنه سجل أعلى القيم لكل الصفات الحسية مقارنة بالأصناف الأخرى وذلك عند جميع معاملات الهيدروجين بيروكسيد.

وبناءاً على النتائج السابقة وتحت ظروف هذه التجربة فإنه يوصى برش نباتات البطاطس بتركيز 40 ميلليمولار هيدروجين بيروكسيد حيث أدى ذلك الى زيادة محصول البطاطس و الحصول على أعلى نسبة للمادة الجافة بدرنات البطاطس مما يؤدى الى زيادة نسبة تصافى المنتج الداخل فى التصنيع.