



Efficacy of IAA, IBA and magnesium nitrate on summer squash shelf life

Ikbal Muhammed-Gharib AL-Barzinji¹

1Department of Biology, Faculty of Science and Health, Koya University

University Park, Kurdistan Region of Iraq

E-mail: ikbal.tahir@koyauniversity.org

Mob. 07503057640, 07725468222

Article info	Abstract
Original: 22 February 2018	A complete randomized design experiment with ten treatments and three replications was conducted to evaluate the effects of dipping fruits for 5 minutes in one of the following solutions: tap water, 10, 20 and 30 ppm of indoleacetic acid (IAA) or indolebuteric acid (IBA) or 0.1, 0.2 and 0.3% magnesium nitrate salt ($Mg(NO_3)_2$) on the shelf-life characters of summer squash (<i>Cucurbita pepo</i> L.) fruits, including that harvested incorrectly (without remaining part of the stem) as it proceeds by most Iraqi farmers. The results show a significant decrease in each of peroxidase enzyme activity to 4.94 absorbing unit/minute/ml and weight loss to 9.98% in the fruits that treated with 10 ppm of IAA compared to other treatments. Treating fruits with 20 ppm of IAA increased the fruits peel content of chlorophyll a and chlorophyll b. The fruits total soluble solids increased significantly to 5.33% when they dipped in 20 ppm IBA. There were non-significant differences between the treatments firmness, except the significant decrease to 5.14 kg/cm ² when 0.3% magnesium nitrate was used. Nevertheless, most differences between treatments were non-significant compared to the control fruits. Treating the fruits of summer squash with 10 ppm IAA was the best for decreasing peroxidase activity and fruits weight loss after keeping at ambient temperature (20-23°C and 40-55% relative humidity) for 5 days.
Revised: 25 April 2018	
Accepted: 6 December 2018	
Published online: 20 December 2018	
Keywords: <i>Cucurbita pepo</i> L., IAA, IBA, Magnesium nitrate, Shelf life quality.	

Introduction

Summer squash (*Cucurbita pepo* L.) belongs to the Cucurbitaceae family and it is one of the most important vegetables to Iraqi consumer as a food and several medical purposes, in addition to its high yield in a short period (40-70) days, where the fruits harvested during 2-5 days after fully opened flowers, when the fruits on cell enlargement stage and good fruits are shiny with dark green color [1]. During harvest process, summer squash should be cut from the plant by leaving 1.25 to 2.5 cm of the stem attached to the fruit [2]. The commercial maturity of summer squash is immature fruits, which is classified as high respiration rate fruits, and classified as a low production of ethylene and medium relative sensitivity to ethylene, its recommended temperature for storage is ranged 5-10 °C [3]. Summer squash must be market soon without delaying and must not store if possible; if storage is necessary, they can be kept in cool storage for 14-21 days at 5°C and 85-95% relative humidity [4]. Due to containing very high water content (94%) at harvest, summer squash shelf life is very short, because it is exposed to decay, mechanical injuries, and weight loss in addition to decreasing their quality during their exhibition, so it is considered as a perishability product. After harvest, fruits undergo many physiological and biochemical changes during its exhibition in markets, so, the shelf life of fruits could be prolonged significantly through slowing down the process leading to ripening and controlling the microbial decay [5].

Different applications such as plant growth regulators are regarded as one of the most important treatments, used nowadays in plant field, which they are used for prolonging the fruits storage period, extension shelf life and keeping their quality characteristics, for example; Olaiya (2010) [6] revealed that the storability of tomato fruits was better than those of control after ten days of storage at ambient conditions, after their seeds treated with 100 mg/L of IAA, IBA, NAA before planting. Also AL.Hmedawi et al. (2011) [7] tested the effects of NAA on storability of eggplant fruits at 12°C and 85 – 90 % relative humidity for 10 days, which it cause a significant decrease in weight loss percent, total decay, respiration rate, and a significant increase in firmness, color and test values at the end of the storage period compared to control treatment.

The effects of elements salts, especially Mg [8], Ca [9], and K [10] on quality attributes to fruits and vegetable storability had been studied. In a study conducted by Lester and Grusak (1999) [8] the fruits of muskmelon (*Cucumis melo* L. (Inodorus Group) ‘Honey Brew’) were dipped for 20 minutes in a solution containing a Ca-chelate, a Mg-chelate, a combination of both chelates, or no mineral chelate, where the fruits from water or Mg-chelate treatments were the less firm, the higher moisture loss and the more hypodermal mesocarp electrolyte leakage compared to Ca-chelate and (Ca+Mg)-chelate treated fruits after 10 days of cold storage (10°C).

In Iraq, studies regarded to extending summer squash shelf life by plant regulators and nutrients are so few, so the present study had been conducted to investigate the effects of IAA, IBA and magnesium nitrate on summer squash fruits shelf life at room temperature of Koya city.

Materials and Methods

Plant material and treatments

An experiment was conducted by using freshly harvested fruits of summer squash *Cucurbita pepo* L. (Mulla –Ahmed cv.) bought from the wholesale market of Koya city in October 2017. 480 fruits of averagely 15 to 25 cm length were used in this experiment by distributing them between 10 treatments which were made of dipping the fruits for 5 minutes in one of the following solutions: tap water (control), 10, 20 and 30 ppm of indoleacetic acid (IAA) or indolebutyric acid (IBA) or 0.1, 0.2 and 0.3% of magnesium nitrate $Mg(NO_3)_2 \cdot 6H_2O$ salt which will be referred to as MN. All treatments were kept in plastic boxes for 5 days in a room with ambient condition (20-23°C and 40-55% relative humidity).

It should be mentioned that the chemicals used in this study were save to human as they used in many studies about treating fruits after harvest, and IAA may be used safely for agricultural purposes and as an external preservative for fruits [11] as well as magnesium nitrate salt [12].

As an incorrect practice many farmers in Iraqi Kurdistan region and other Iraqi regions, the summer squash are harvested without taking the attention to remaining part of the stem with the fruits, so the fruits that bought are contain different stem length even fruits without stem; therefore in order to minimize the bad effect of this practice, the fruits that used in this study include different stem length as they brought from the market (Fig. 1). So the stem length was not determined as a separate factor, but the experimental units contain equal number of fruits with different stem length.



Figure 1. A sample of the summer squash fruits that used in the study containing different stem length.

Studies Characteristics

At the end of the keeping period, the following parameters were measured: peroxidase enzyme activity in fruits which determined as it mentioned by Nezih (1985) [13], chlorophyll a, b and total carotenoids were calculated in the fruits peel according to the method mentioned by (Lichtentaler and Wellburn, 1983) [14], fruits total soluble solids (TSS) measured by using hand-refractometer according to A.O.A.C. (2002) [15] from juice obtained by squeezing discs of the fruits tissue, fruits firmness measured by using hand-penetrometer with 7.9 mm head diameter, fruits weight loss was calculated as a percentage of water loss in comparison with initial weight, and the percent of dry matter content in fruits were calculated as it described by Al-Sahaf (1989) [16] by divided the wet weight of fruits by the dry weight of them multiply by 100.

Statistical Analysis

A complete randomized design (CRD) with ten treatments and three replicates was used for conducting this study; each experimental unit contains 48 fruits. Analysis of variance and Duncan's multiple range test (α 0.05) was used for dealing with the data by SAS program [17].

Results and Discussion

Figure 2 shows a significant decrease in the peroxidase enzyme activity to 4.94 absorbing unit/minute/ml for fruits treated with 10 ppm IAA compared to other treatments, especially the treatment 30 ppm IBA which gave more peroxidase activity (5.75 absorbing unit/minute/ml). The figures 3 and 4 show that treating fruits with 20 ppm IAA increased the content of fruits peel of chlorophyll a and b significantly to 3.41 and 1.10 mg/g fresh weight compared to each of the control, 30 ppm of IAA and IBA and 0.1% magnesium nitrate for chlorophyll a and the control treatment for chlorophyll b. Figure 5 shows that the total carotenoids increased significantly to 1.01 and 0.98 mg/g fresh weight in the peel of fruits that dipped in 0.2% magnesium nitrate and 20 ppm IAA compared to the control treatment which records the lowest value reached 0.70 mg/g fresh weight. All treatments TSS were superior on 0.3% magnesium nitrate (4.21%) except 30 ppm IAA and 10 ppm IBA (Fig. 6). There was a significant decrease in fruits firmness reached 5.14 kg/cm² when 0.3% magnesium nitrate was used for treating the fruits compared to other treatments (Fig. 7). The percent of fruits weight loss decreased significantly in the fruits treated with 10 ppm IAA (9.98%) compared to other treatments that not differ significantly between each other (Fig. 8). The percent of fruits dry matter content increased significantly to 6.59% for the fruits that treated with 0.2% magnesium nitrate compared to the fruits that treated with 10 ppm IBA and 0.3% magnesium nitrate that gave 5.89 and 6.02% respectively (Fig. 9).

Generally the increasing in peroxidase enzyme activity will decrease fruits storability due to IAA may be oxidized by peroxidase enzyme [18]. In the current study, the effect of IAA at 10 ppm caused a significant decrease in the enzyme activity, which is may due to that concentration had the best pH for decreasing the activity of that enzyme compared to other concentrations, as it mention by Mizobutsi et al. (2010) [19] who reported that the activity of peroxidase enzyme was maximum at pH 6.5 and 7.0, respectively, and no activity was detected at pH 2.5 and 9.5 in a partially purified preparation of pericarp of the litchi (*Litchi chinensis* Sonn.) fruits that harvested at the ripe stage. From the results we see that 20 ppm of IAA and IBA concentration was the best concentrations for increase the pigments content of fruits peel after 5 days of keeping at ambient temperature, may be as a result of IAA is considered as one of those hormones delaying ripening that leads to loss of chlorophyll and the breakdown of proteins, this result agree with that of Behera et al. (2017) [20] who study the effects of foliar application of 10 or 20 ppm of IAA or NAA at 30 and 45 days after sowing five varieties of sesame (*Sesamum indicum* L.) were the maximum chlorophyll-a and b and total chlorophyll content was recorded from 20 ppm IAA or NAA compared to 10 ppm. At the same time increasing the concentration of magnesium nitrate salt from 0.1 to 0.2% increased the chlorophyll a content significantly as a result of the fact that Mg is the key metallic substance in chlorophylls synthesis [18]. The significant decreases in fruits TSS with the highest magnesium nitrate salt level (0.3%) may due to increasing the nitrogen level, this results agree with many previous studies like that of Wrona (2004) [21]

who stated that the high dose of nitrogen fertilization decreased apple fruit content of soluble solids. It also confirm the finding of Omotoso and Akinrinde (2013) [22] where pineapple (*Ananas comosus* L. Merr.) fruit TSS decreased with increasing rates of nitrogen application at 0, 50, 100, 150 and 200kg N/ha. The significant decrease in fruits firmness when high concentration 0.3% of magnesium nitrate is applied may also due to their content of nitrogen in this salt which may leads to diminishing the cell wall thickness, which in consequence decreases the flesh texture [23]. This result confirm by Fallahi et al. (1997) [24] who indicated that high nitrogen level decreased fruits firmness. Furthermore, it is known that magnesium had an antagonistic property with calcium, and it is stated that high fruit and vegetable Ca concentration resulted in increased firmness and improve storability [9]. The daily water loss from summer squash is 2.2% under 24°C and 25% relative humidity [5]. So the significant decrease in the percent of fruits weight loss for the 10 IAA treatment may due to the decrease in the peroxidase enzyme activity for this treatment (Fig. 1), because of the plant cell walls contain peroxidase activity, which oxidized the aromatic alcohol subunits of lignin cell wall, so in this treatment these substances may undergo less oxidize by cell wall peroxidases enzymes [18]. The significant decrease in the percent of fruit dry matter content for 10 ppm IBA may due to decreasing the percent of TSS (Fig. 6) and increasing the weight loss (Fig. 8) in this treatment, whereas the decrease in the percent of dry matter content when the concentration of magnesium nitrate increased to 0.3% may due to Mg^{2+} is compete with Ca^{2+} ion for binding sites at the cell plasma membrane as a result of an antagonistic effects [25], therefore, membrane permeability is increased by high levels of Mg which can replace Ca at the cells plasma membrane surfaces [26], which may due to increasing water loss (Fig. 8)and as a result increasing percent of dry matter, where its known that Ca salts improves the postharvest quality remarkably for many fruits [27].

Conclusions and recommendations

From this study, we can conclude that IAA at 10 and 20 ppm was the most favorable treatments for improving summer squash shelf life and keeping the fruits with good quality for 5 days of keeping at ambient temperature, especially for fruits harvested in incorrect way. It is recommended to conduct farther studies about the effects of the length of fruits stem as an independent factor, also studying the changes in the internal hormones levels as result to the different treatments.

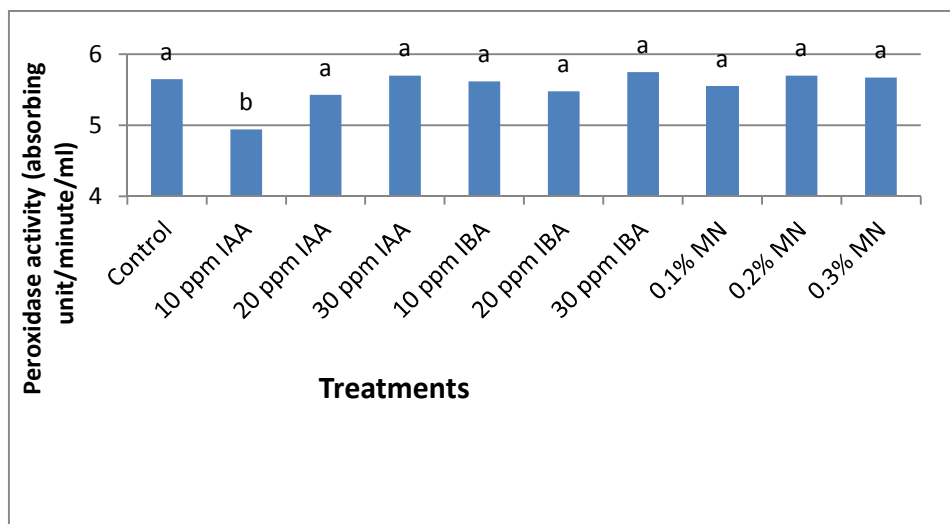


Fig. 2. Peroxidase enzyme activity of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

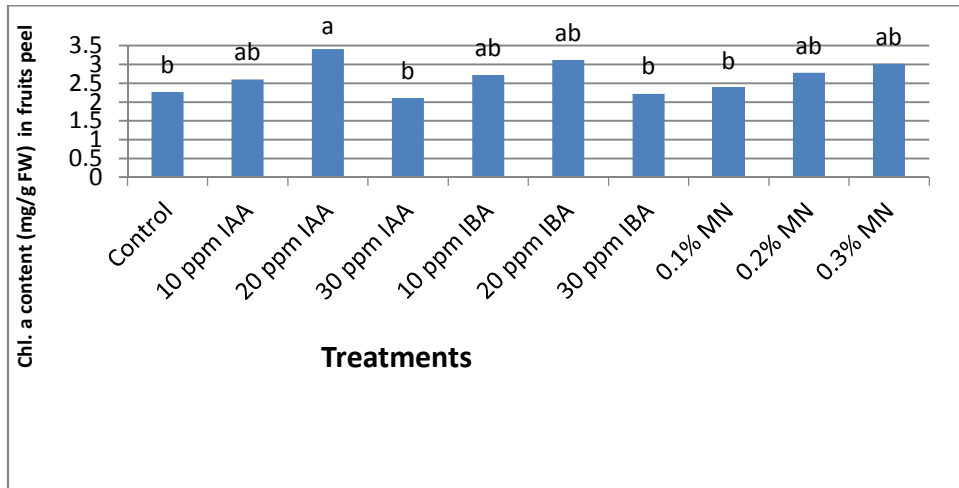


Fig. 3. Chlorophyll a content of peels of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

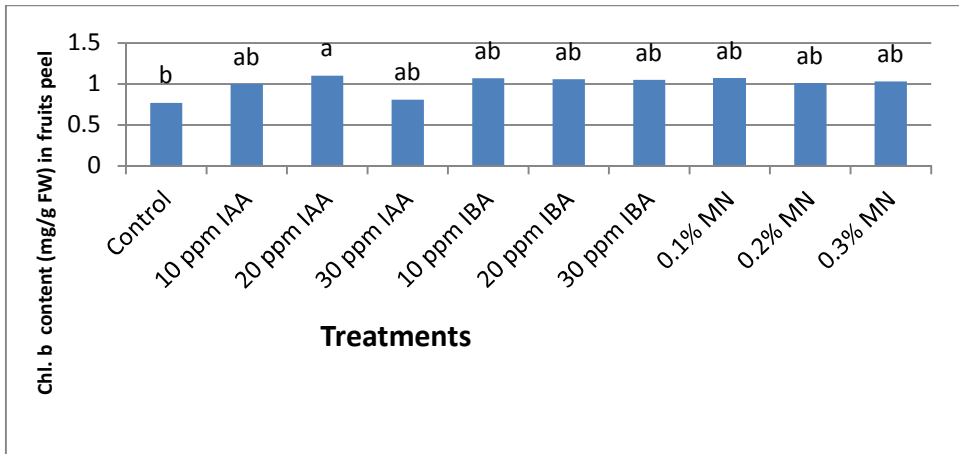


Fig. 4. Chlorophyll b content of peels of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

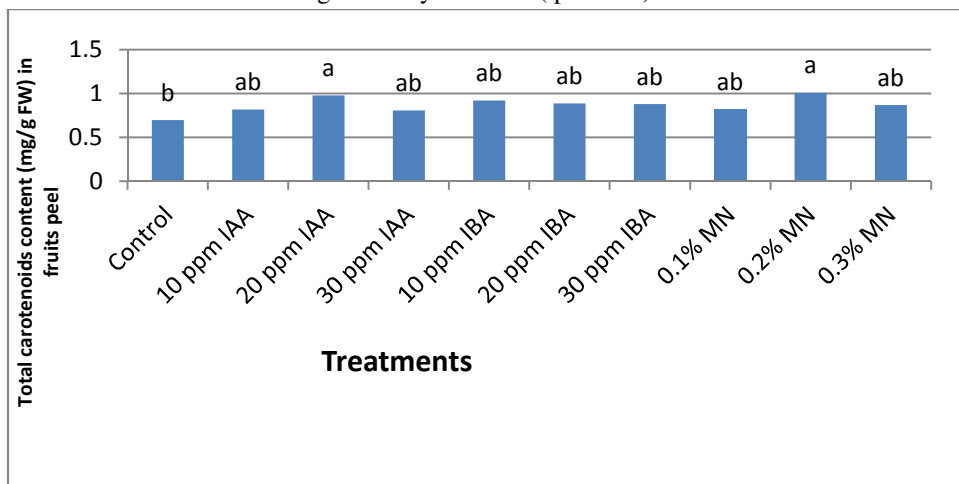


Fig. 5. Total carotenoids content of peels of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

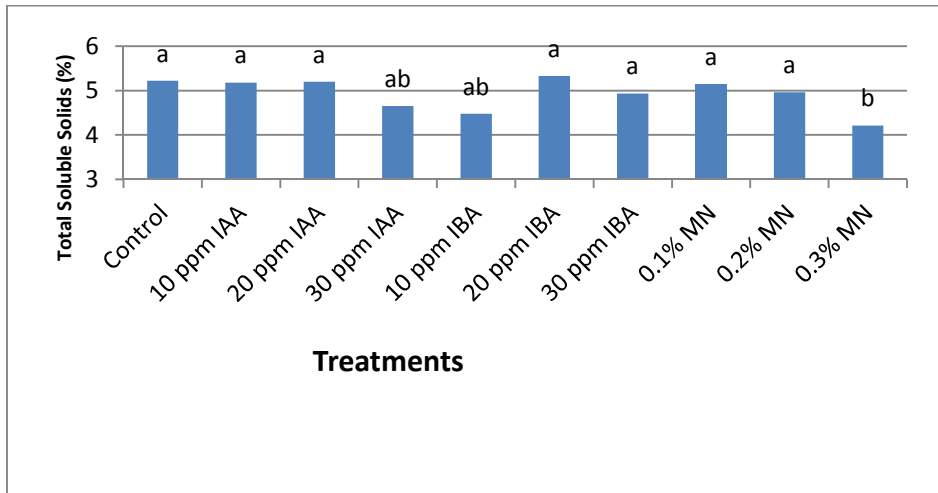


Fig. 6. Percent of total soluble solids of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

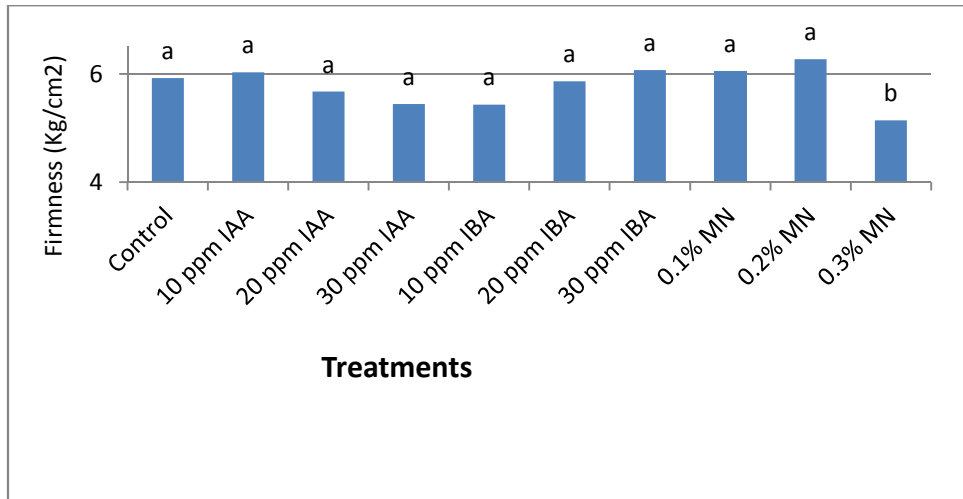


Fig. 7. Firmness of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

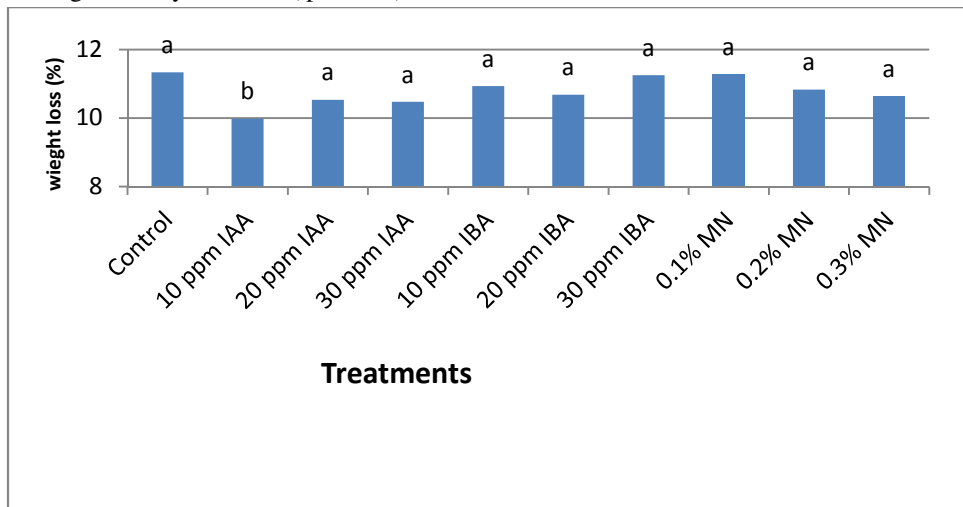


Fig. 8. Percent of weight loss of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

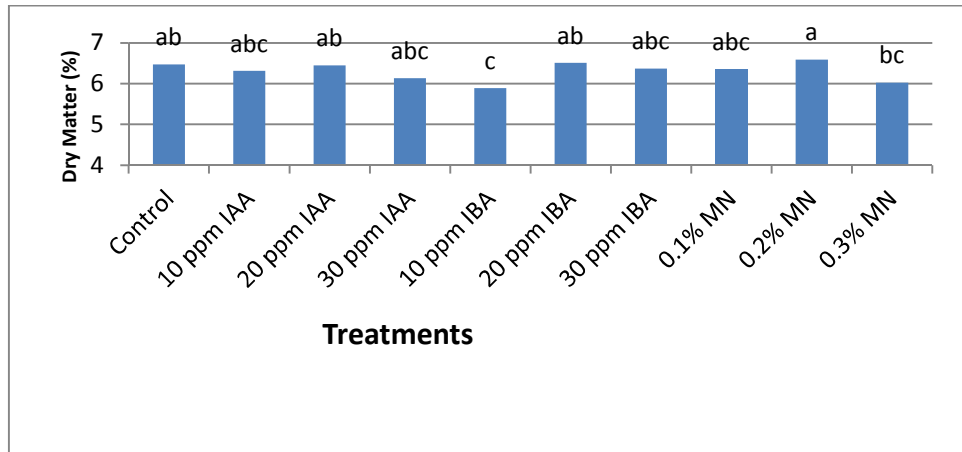


Fig. 9. Percent of dry matter content of summer squash fruits dipped in different treatments solutions for 5 min, and kept for 5 days under ambient temperature, (IAA: indoleacetic acid, IBA: indolebutyric acid, MN: magnesium nitrate). Columns with same letter are not significantly different ($p < 0.05$).

References

- [1] Matlob, A.N., E. Sultan and K.S. Abdul. "Vegetable Production", Part-I and II. Dar Al-Kutub Publ. Mosul Univ. Iraq. (1989). [In Arabic].
- [2] Shubin, K. S., E. Pfeufer, R. Bessin, S.Wright and J. Strang. "Vegetable Production Guide for Commercial Growers", ID-36. Corporative Extension Service, University of Kentucky, College of Agriculture, Food and Environment, Lexington, KY, 40546. (2017).
- [3] Nirmal, K. S., Y.H. Hui, E. O. Z. Evranuz, M. Siddiq and J. Ahmed. "Handbook of Vegetables and Vegetable Processing". John Wiley & Sons Ltd., Publication. USA. (2011).
- [4] Rahman, M.S. "Handbook of Food Preservation". Second Edition. CRC Press, Taylor and Francis Groups. New York. (2007).
- [5] Al-Ani, A. M. "Postharvest Physiology of Horticultural Crops". Part I. Dar-Alkutub for printing and Publishing. Mosul University Printing Press. Iraq. pp.576. (1985). [In Arabic].
- [6] Olaiya, C.O. "Influence of auxin bioregulators on physiological changes and shelf-life of tomato vegetable crops". Research Bulletin, Vol. 72, pp. 129-136. (2010). DOI: 10.2478/v10032-010-0012-0.
- [7] AL.Hmedawi, A.M.S., R.M. AL-Numani and W.H.M. AL-Shmery. "Effect of GA_3 , NAA and polyethylene on storability of eggplant fruits". AIKufa Journal for Agricultural Sciences, Vol. 2, No. 1, pp. 121-128. (2011).
- [8] Lester, G.E. and M. A. Grusak. "Postharvest application of calcium and magnesium to honeydew and netted muskmelons: effects on tissue ion concentrations, quality, and senescence". Journal of American Society Horticultural Sciences, Vol. 124, No. 5, 545–552. (1999).
- [9] Luna-Guzma'n, I. and D.M. Barrett. "Comparison of calcium chloride and calcium lactate effectiveness in maintaining shelf stability and quality of fresh-cut cantaloupes". Postharvest Biology and Technology, Vol. 19, pp. 61–72. (2000).
- [10] Lester, G.E., J.L. Jifon and D.J. Makus. "Impact of potassium nutrition on postharvest fruit quality: Melon (*Cucumis melo L*) case study". Plant Soil, Vol. 335, pp. 117–131. (2010). DOI 10.1007/s11104-009-0227-3
- [11] Morshed, M.H., M.SH. Hossain, M.A. Habib, M.M. Ahmed, M. Ibrahim, M. Umar and M. A. Islam. "The effect of plant hormone indoleacetic acid (IAA) on hematological and biochemical parameters in mice". Bangladesh Journal of Physiology and Pharmacology, Vol. 21m No. 1-2, pp. 5-8. (2006).
- [12] Scherm, B., G. Ortu, A. Muzzu, M. Budroni, G. Arras and Q. Migheli. "Biocontrol activity of antagonistic yeasts against *Penicillium expansum* on apple". Journal of Plant Pathology, Vol. 85, No. 3, pp. 205-213. (2003).

- [13] Nezh, M. "*The peroxidase enzyme activity of some vegetables and its resistance to heat*". Food Agric. Vol. 36, pp. 877–880. (1985).
- [14] Lichtenthaler, H.K. and A.R. Wellburn. "*Determination of total carotenoids and chlorophylls a and b of leaf extracts in different solvents*". Biochemical Society Transactions. Vol. 11, No. 5, pp. 591-592. (1983).
- [15] A.O.A.C. "*Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis*". 17th ed. Washington D.C.,U.S.A. (2002).
- [16] Al-Sahaf, F. H. "*Applied Plant Nutrition*". Baghdad, Al-Hikma House. (1989). [In Arabic].
- [17] Al-Mohammadi, SH. and Fadhil, A. "*Statistics and Experimental Design*". Darosama for publishing and distribution. Amman, Jordan. pp. 376. (2002). [In Arabic].
- [18] Taiz, L. and E. Zeiger. "*Plant Physiology*". 3rd ed., Sunderland, Massachusetts. U.S.A: Sinauer Associates Inc. Publishers. pp. 623. (2002).
- [19] Mizobutsi, G.P., F.L. Finger, R.A. Ribeiro, R. Puschmann, L. L. de Melo Neves and W. Ferreira da Mota. "*Effect of pH and temperature on peroxidase and polyphenoloxidase activities of litchi pericarp*". Scientica Agricola (Piracicaba, Braz.), Vol. 67, No. 2, pp. 213-221. (2010).
- [20] Behera, S., A. K. Padhiary, P. K. Nanda, S. Rout, A. Nayak and D. Behera. "*Influence of plant growth regulators on chlorophyll content of different sesame (Sesamum indicum L.) cultivars*". International Journal of Pure and Applied Bioscience. Vol. 5, No. 5, pp. 1439-1444. (2017).
- [21] Wrona, D. "*Effect of nitrogen fertilization on growth, cropping and fruit quality of 'Šampion' apple trees during 9 years after planting*". Folia Horticulture, Vol. 16, No. 1, pp. 55-60. (2004).
- [22] Omotoso S. O and E. A. Akinrinde. "*Effect of nitrogen fertilizer on some growth, yield and fruit quality parameters in pineapple (Ananas comosus L. Merr.) plant at Ado-Ekiti Southwestern, Nigeria*". International Research Journal of Agricultural Science and Soil Science, Vol. 3, No.1, pp. 11-16. (2013).
- [23] Jia, H.J., K. Mizuguchi, K. Hirano and G. Okamoto. "*Effect of fertilizer application level on the pectin composition of Hakuho peach (Prunus persica Batsch) during maturation*". HortScience, Alexandria, Vol. 41, No. 7, pp. 1571-1575. (2006).
- [24] Fallahi, E., W. M. Colt, and M.M. Seyedbagheri. "*Influence of foliar application of nitrogen on tree growth, precocity, fruit quality, and leaf mineral nutrients in young 'Fuji' apple trees on three rootstocks*". Journal of Tree Fruit Production, Vol. 2, No. 1, pp. 1–12. (1997).
- [25] Yermiyahu, U., S. Nir, G. Ben-Hayyim, and U. Kafkafi. "*Quantitative competition of calcium with sodium or magnesium for sorption sites on plasma membrane vesicles of melon (Cucumis melo L.) root cells*". Journal of Membrane Biology, Vol. 138, pp. 55–63. (1994).
- [26] De Freitas, S.T, and E. J. Mitcham. "*Factors involved in fruit calcium deficiency disorders*". In: Horticultural Reviews, ed. J. Janick, Vol. 40, pp. 107–146. New York: Wiley-Blackwell. (2012)
- [27] Wojcik, P., and M. Borowik. "*Influence of pre-harvest sprays of a mixture of calcium formate, calcium acetate, calcium chloride and calcium nitrate on quality and 'Jonagold' apple storability*". Journal of Plant Nutrition, Vol. 36, pp. 2023–2034. (2013).