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Shelf Life Extension of *Allium cepa* and *Allium sativum* Using X-Rays in Benue State, Nigeria

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Abstract:- Food wastage as a consequence of deterioration and short shelf life is a major issue impacting food security and the economy of Nigeria and Cameroon in particular in the context of a rising population and constant natural resources. This study is aimed at investigating the effects of X-Irradiation on the physicochemical properties, and shelf life of red and white onion (*Allium cepa*), and Garlic (*Allium sativum*), in Benue State, Nigeria. The samples were sorted from local markets in Makurdi for homogeneity in shapes, dimensions, colour, freshness, maturation, and weights for the common goal of this research. Six samples each were exposed with $0\,kVp$, $60 - 100\,kVp$ of X-irradiation. The samples were stored at room temperature of 27 – 30°C. The density, moisture content, pH, masses, and physical condition were evaluated. The results for the ranges of density, moisture content, and pH respectively were: $0.8871 - 1.0646\,g/cm^3$, $79.6 - 86.3\%$, and $5.7 - 6.5$ for red Onion, $0.8231 - 1.6\,g/cm^3$, $74.21 - 82.69\%$, and $5.6 - 6.4$ for white Onion, and $1.0247 - 1.2375\,g/cm^3$, $58.43 - 63.2\%$, and $6.2 - 5.1$ for Garlic. The mass shrinkage increased with storage and an increase in kVp values increased shelf life extension. The study showed that the $80 - 100\,kVp$ of X-irradiation was best at preserving Onion for an additional 3 weeks of storage, and the $100\,kVp$ of X-irradiation was best at preserving Garlic for an additional 3 – 4 days of storage. Hence diagnostic X-irradiation is recommended for the preservation of Onion and Garlic.

Keywords:- *Onion, Garlic, X-irradiation, Physicochemical Properties, Shelf Life.*

I. INTRODUCTION

Over time, food has been eaten as processed or in raw form to obtain energy and sustain growth [1]. Human has prioritised concern over availability, access and supply of food since these factors influence food usage. Regarding food-consumption and food-producing patterns, many nations, regions and social groups of the world experience a relatively fixed pattern with minute changes occurring [2]. The following data was reported for food wastage distribution regarding production, processing, distribution, and consumer-generated wastage as 42% for fruits and vegetables, 26% for dairy, 19% for grains, and 13% for others [3–7]. As a consequence of rising population, climate change, inefficient supply chains, a great population experienced a shortage of food supply [8].

Onion is a shallow-rooted, biennial vegetable crop among the Alliums as well as cash crops that are grown as annual [9]. It is considered to be the second most important vegetable crop grown in the world after tomato. It is semi-perishable, can be transported for long distances without much injury, with the number of hybrid varieties increasing rapidly each year [10,11]. Onion is liked for its flavour and pungency which is due to the presence of a volatile oil 'allyl propyl disulphide', an organic compound rich in sulphur. The beneficial compound called 'quercetin' present in onion is a powerful antioxidant. Recently onion is being used by the processing industry to a greater extent for preparing dehydrated forms like powder and flakes [12]. It was reported in 2018, the average highest world production countries of onion according to yield (kg/ha), quantities (tons), and Area (ha); Nigeria was ranked 29th (436 kg/ha), 16th (929,469 tons), and 3rd (2,542,936 ha) respectively, while Korea Rep., China, and India respectively topping the ranking [13]. Garlic is a species of plant of the genus Allium as well, which is not limited to leeks, chives, among other species, and represents one of the largest plant genera on Earth. The name garlic comes from the Anglo-Saxon word "garlec," meaning "spear," [14]. Like onions and other Alliums, garlic forms bulbs (which can either be white or red) that develop entirely underground, and the plant may or may not flower in the spring [15].

Spoilage responses occur in all varieties of food especially vegetables, immediately after harvest that can be countered by food preservation. Finding ways to keep food fresh and edible in ancient times, our ancestors brought about the idea of food preservation, which were not limited to concepts like sun drying, salting, and pasteurization, depending on seasonal factors and climatic conditions [1]. Food preservation refers to the techniques employed to reduce food spoilage and to extend the shelf life of food [16,17]. Different preservation and processing techniques exist which are classified as chemical, biological and physical processes [18–20] which gave a better shelf life extension by controlling the pathogens. Recent it has been shown that food transmission of the coronavirus disease 2019 (COVID-19) is misheed [21].

Nowadays the food industries have widely explored irradiation as a key technique in food processing, preservation, and extending the shelf life of food that employs ionizing energy which alters the physical, chemical, or biological characteristics of food materials and products [22]. The application of ionizing radiation using X-rays, gamma rays, or electron beams can serve many purposes, such as eliminating organisms that cause food-borne illness, un-contamination by killing organisms that cause deteriorations, controlling quarantine insects to check their spread, inhibiting sprouting and delaying ripening, and sterilizing food for patients with impaired immune systems [23]. The safety and endorsement of food irradiation have been approved by the World Health Organization (WHO), the Centres for Disease Control and Prevention (CDC), the US Department of Agriculture (USDA), and many other institutions around the world [24–27].

With the development of pathogen resistance to some of the common chemical synthetic compounds and with the increased wish to receive fresh products free of chemical residues leading to public risk, research for alternative substances or treatments has led to the utilization of ionizing radiation [28–31].

Consumer perception and horticultural commodities are ascertained by the quality of vegetables and fruits which constitutes a great aspect of the physiochemical properties [32,33]. The challenge in elaborating a general definition of quality about horticultural products stems to an extent from the different stakeholders partaking in the horticultural supply chain, each acting importantly as a consumer in relation to the preceding chain member [34,35]. Postharvest recommendations for harvesting, handling and packaging products along with the supply chain aim at maximizing the period of acceptable quality [33]. Hence the physicochemical properties such as pH, density, moisture content as depicted by [36] of the various samples in this study will be discussed and the shelf life associated with preservation. As a consequence of the perishable nature of Onions, and Garlic, the high demand for these products and their daily use as food and spices for other foodstuffs, their preservation via the safest method remain a priority to research. There exist a great number of reports, books, conference proceedings and scientific articles available depicting that irradiation of food products, in the form of X-irradiation, electron beams or gamma rays, is effective in overcoming quarantine barriers in the international market, as a mode of disinfection, decontamination, and improvement of shelf life, physicochemical properties and nutritional attributes [37–43].

II. MATERIAL AND METHOD

A. Materials

The Onion (*Allium cepa*) species and Garlic (*Allium sativum*) were collected freshly from the local markets around Makurdi in the Benue State of Nigeria. The samples were sorted for homogeneity in shapes, dimensions, colour, freshness, maturation (with the help of some experts), and weights for the common goal of this research [44].

B. X-rays spectroscopy

The Five samples of Red Onion, White Onion, and Garlic were sealed in plastic paper and exposed to X-irradiation from an X-ray machine from The Joseph Sarwuan Tarkan University Clinic. A sample of the various species was kept as control (non-irradiated). The product of the tube current and exposure time (mAs) was kept constant, with 32 mA at 2 s, while varying the exposure voltage in the interval of 60-100 kV for different sealed samples, at a distance of 80cm.

C. Physicochemical properties

The percentage moisture content of the samples was obtained using the microwave oven-dry, a balance, and a crucible dish. The sample was cut to a particular shape and size. The mass (M_1) of the crucible dish without the sample was measured. The sample was placed in the crucible dish and the mass (M_2) measured as well. The crucible dish containing the sample was placed in the microwave oven to dry for 4 hours. After this time, the dish containing the dried sample was removed, cooled in a desiccator, and the mass (M_3) was measured.

The moisture content ($M.C$) on a wet basis (w.b) was calculated by Equation (1):

$$M.C(\%) = \frac{M_2 - M_3}{M_2 - M_1} \times 100\% \qquad (1)$$

The density was measured as follows: The juice from the samples was extracted with the help of a Juicer and the solution got from it was used to measure the density via the density bottle, and a balance. The density (ρ) was calculated from the mass M and the volume (V) of the solution from the sample as in Equation (2):

$$Density = \frac{M}{V} \qquad (2)$$

The pH was measured by extracting the juice from the samples with the help of a Juicer. The solution got from it was used for pH measurements via the Radiometer (Cleveland, OH) Model ROHS pH meter with standard glass electrode at room temperature.

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D. Shelf life

The mass of the samples, both the control and X-irradiated were weighed during the storage period. This was done as demonstrated by Dwijananti *et al.* and Akrom *et al.*[41,45].

$$\Delta M = M_i - M_f \tag{3}$$

and,

$$\Delta M(\%) = \frac{M_i - M_{fi}}{M_i} \times 100\%, \tag{4}$$

where ΔM is the mass shrinkage of the sample, $\Delta M(\%)$ is the percentage mass shrinkage of the sample, M_i is the mass of the sample before irradiation, M_f mass of the sample after storage time intervals, and M_{fi} mass of the sample after the final storage period and just before discarding.

III. RESULTS AND DISCUSSION

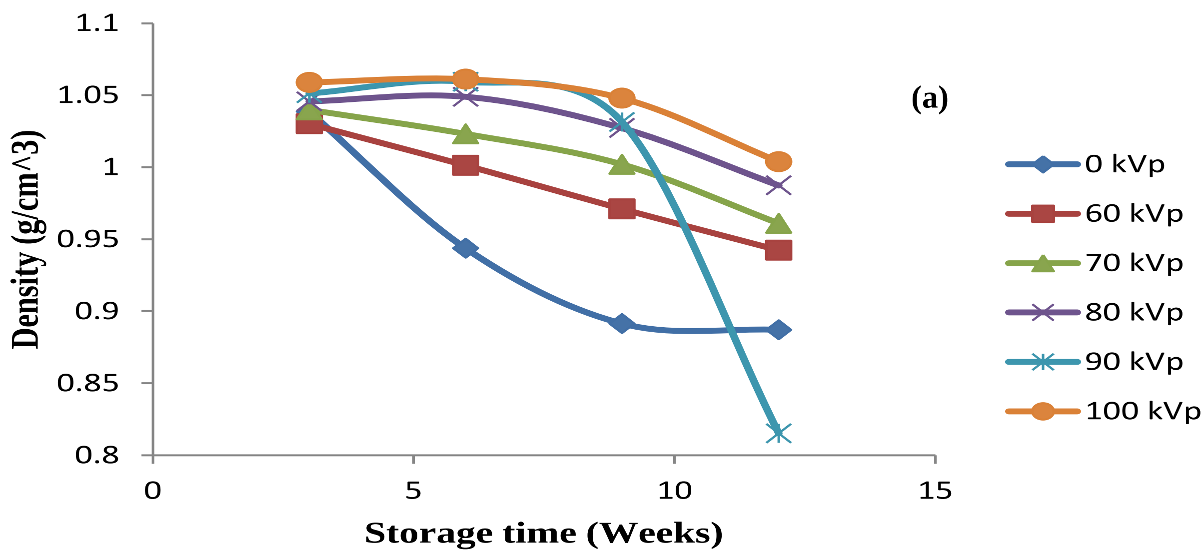
The results of the study evaluated for 4 months periods were in intervals depending on the sample involved. The three most important variables that affect the storage of this perishable commodity include; the quality of the product at the start of the storage process, storage conditions, and the period of storage [46]. Storage losses are often likened to weight losses and losses in the quality of the product which are a consequence of; respiration [47], sprouting [48], evaporation of water from the product [49], changes in chemical composition and physical properties of the product [50,51], and damage by extreme temperatures.

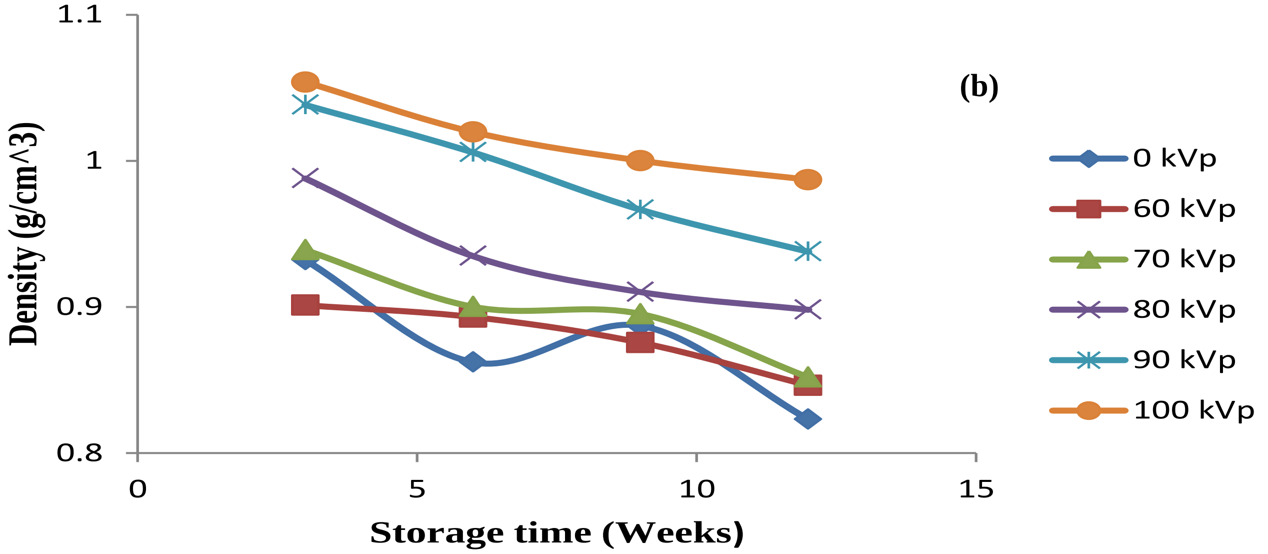
The density of the Onion cultivar for the control sample varies from $1.0477 - 0.8871\ g/cm^3$ for red Onion and $0.9625 - 0.8231\ g/cm^3$ for the white onion species during the storage period as shown in Fig. 1. (a) and (b). X-irradiation has a slight effect on the density of the samples which varies in the intervals $1.0477 - 1.0687\ g/cm^3$, $0.9625 - 1.0750\ g/cm^3$, and $1.1376 - 1.2375\ g/cm^3$ for the Red Onion, White Onion and Garlic respectively. The density observed a decreasing trend during the storage period, with the greater trend observed in the control sample as depicted in Fig. 1. (a-c).

The samples lost moisture and the moisture content decreases during storage with a decreasing trend as observed in Fig. 2. (a-c). The moisture content of the control sample varies from 81.3% - 79.6%, for red Onion, 76.670% - 74.210% for white Onion and $62.610\% - 61.021\%$ for Garlic. The 100 kVp sample showed a minimum decrease of 86.3% - 84.4%, 82.696% - 78.689%, and 63.380% - 61.021% for Red Onion, White Onion and Garlic respectively.

The pH of the samples turns toward the acidic stage as the storage period increases. The trend is observed to be decreasing as depicted in Fig. 3. (a-c). The control samples registered a pH range of 6.5 – 5.8, 6.2 – 5.6, and 6.2 – 5.1 for the Red Onion, White Onion, and Garlic respectively. The minimum decreasing trend was observed in the 100 kVp of X-irradiated samples in the range 6.3 – 5.8, 6.4 – 6.0, and 6.5 – 6.0 for Red Onion, White Onion, and Garlic respectively.

Storage of foods encounters an exceeding range of environmental conditions such as temperature, humidity, oxygen, and light which trigger several reaction mechanisms that may lead to food degradation. This is not limited to post-harvest losses reducing the benefits of freshness in produce due to mishandling, rotting, sprouting, and dehydration [52]. As a consequence of these mechanisms, it is therefore imperative that a good understanding of different reactions that cause food deterioration is gained before developing specific procedures for the evaluation of the shelf life of foods [53].





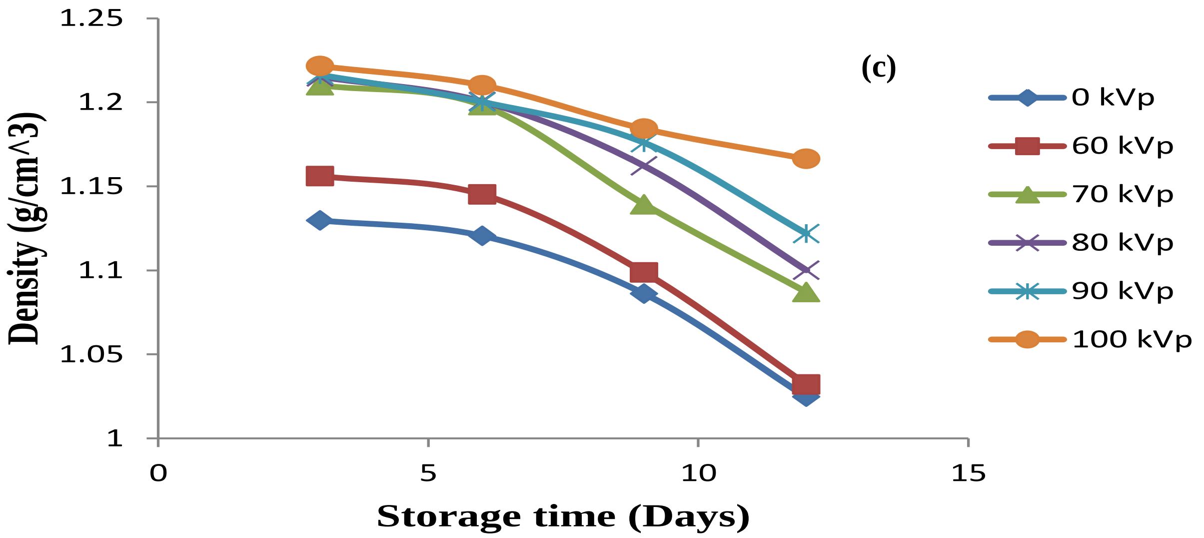
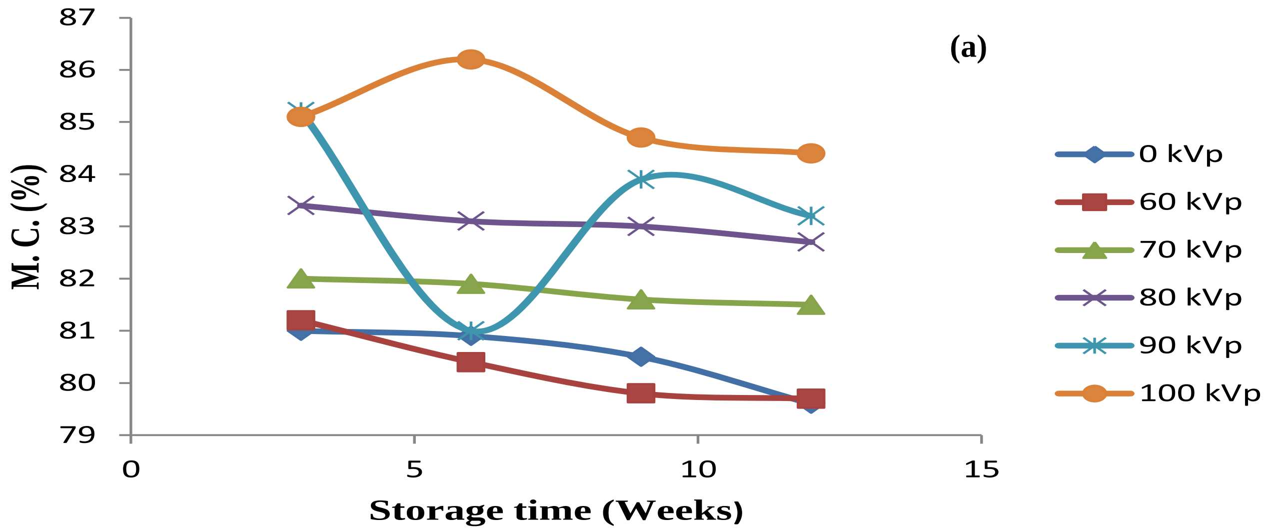
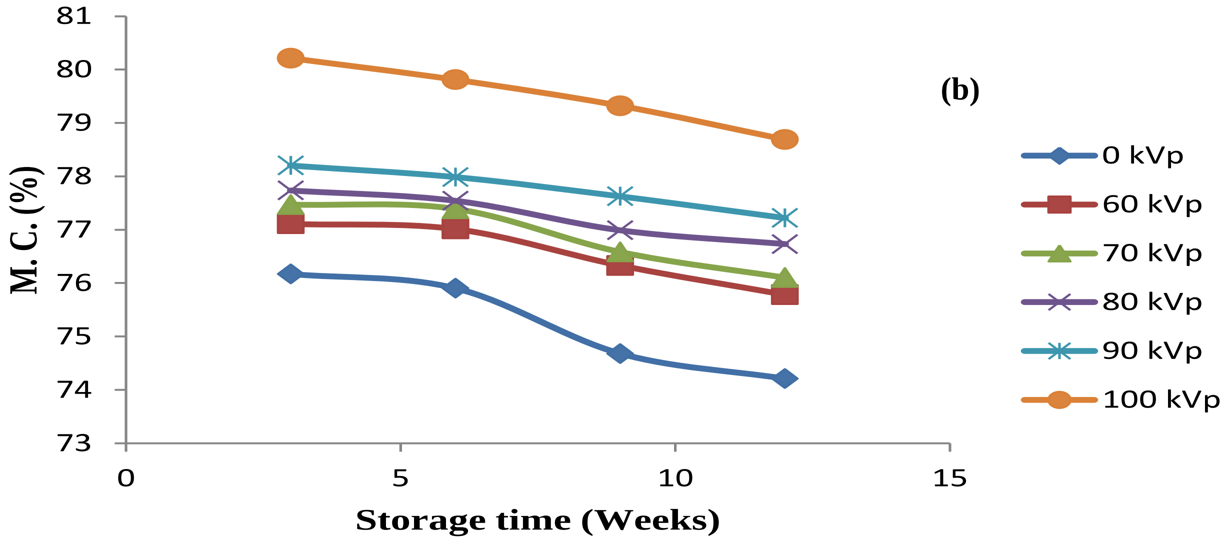


Fig 1 Variation of Density with storage periods of samples at different kVp values of X-irradiation for: (a) Red Onion; (b) White Onion; (c) Garlic.





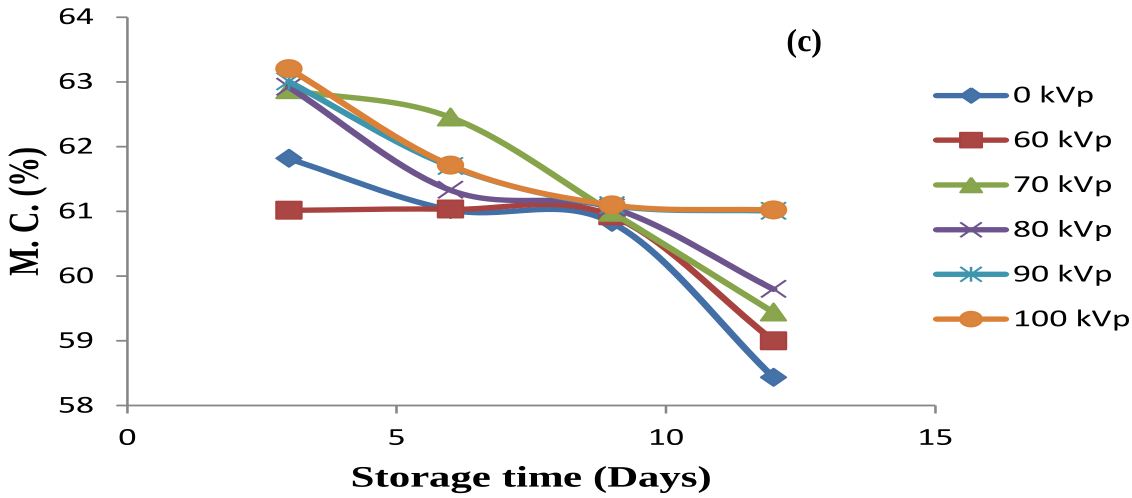
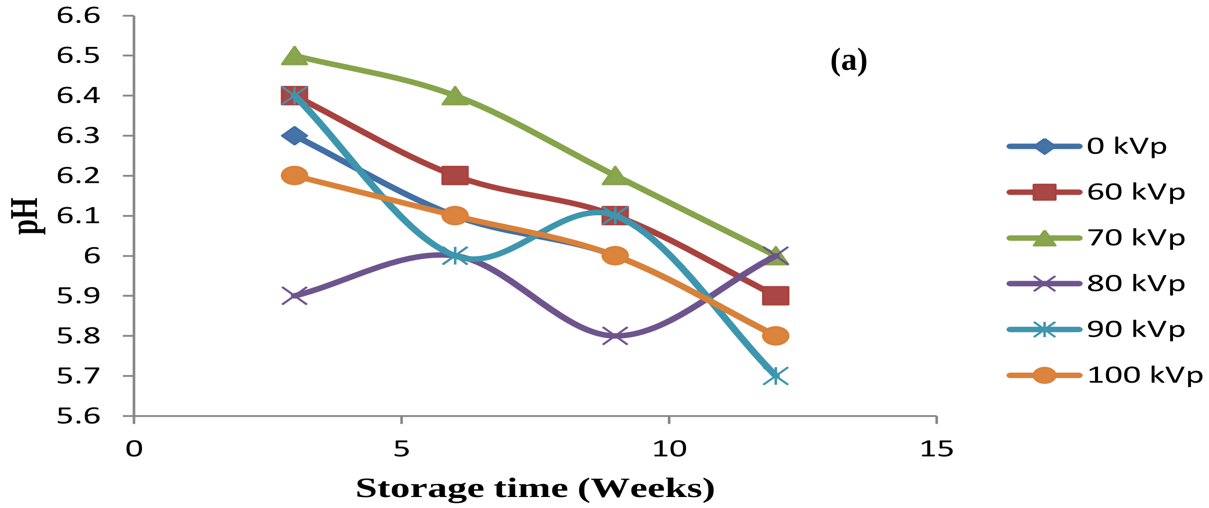
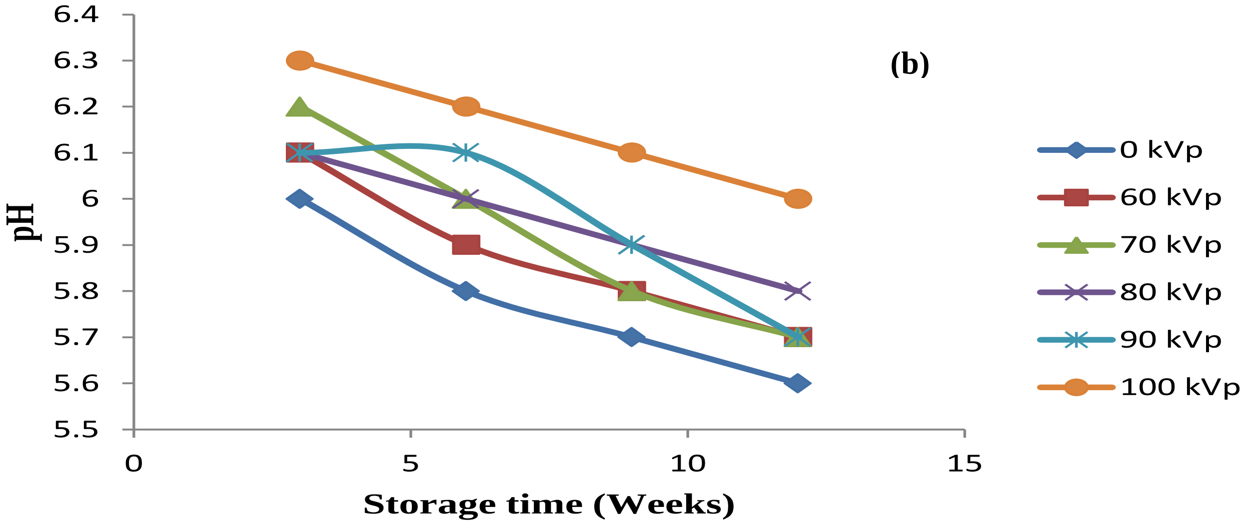


Fig 2. Variation of Moisture Content with storage periods of samples at different kVp values of X-irradiation for: (a) Red Onion; (b) White Onion; (c) Garlic.





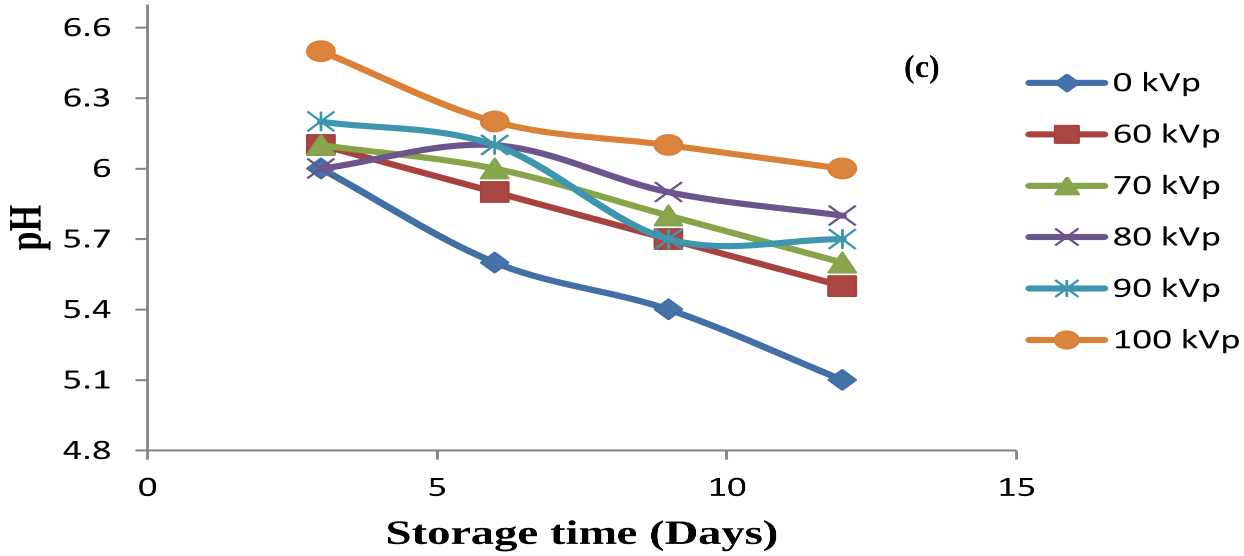


Fig 3. Variation of pH with storage periods of samples at different kVp values of X-irradiation for: (a) Red Onion; (b) White Onion; (c) Garlic.

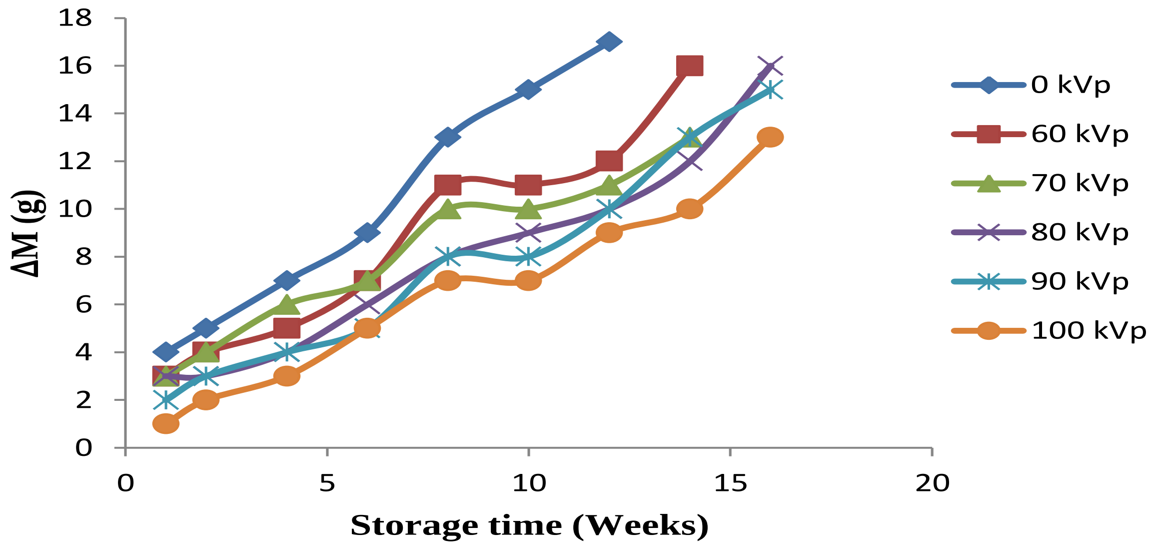


Fig 4. Mass shrinkage ΔM (g) of red Onion against storage period in weeks of samples for different kVp values of X-irradiation.

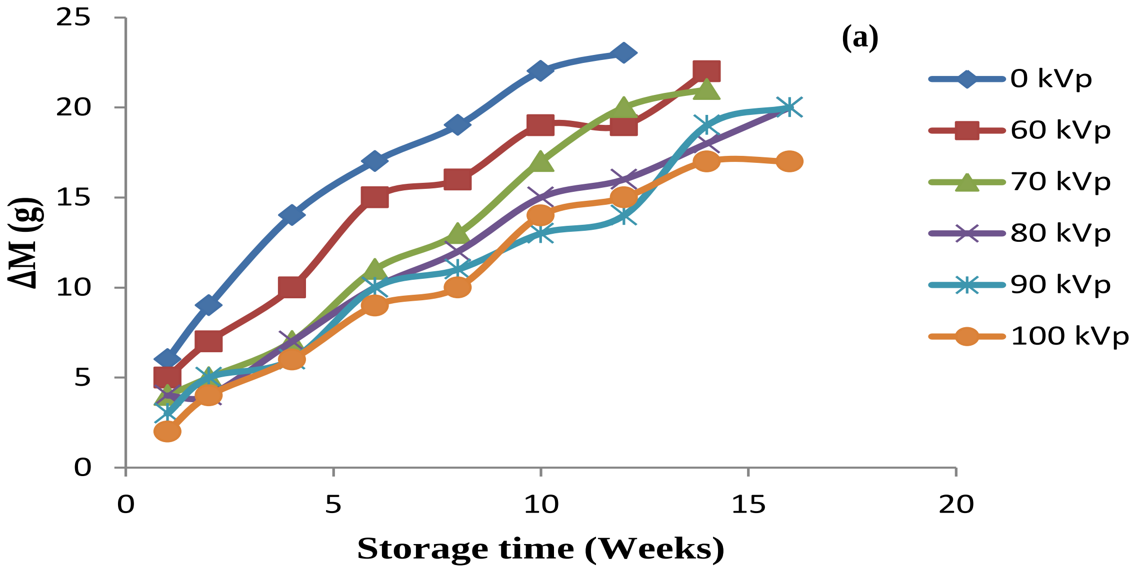


Fig 5. Mass shrinkage ΔM (g) of white Onion against storage period in weeks of samples for different kVp values of X-irradiation.

The mass shrinkage ΔM is shown to increase with storage. This increase was relative since the control sample had the greatest increasing variation and the 100 kVp had the lowest increasing variation as seen in Fig. 4, 5, and 6 for the Red Onion, White Onion and Garlic respectively. The percentage mass shrinkage $\Delta M(\%)$ for the 0 kVp and 100 kVp samples respectively were: 29.8% and 24.7%, 28.2% and 21.1%, and 7.9% and 4.0% for the Red Onion, White Onion, and Garlic respectively.

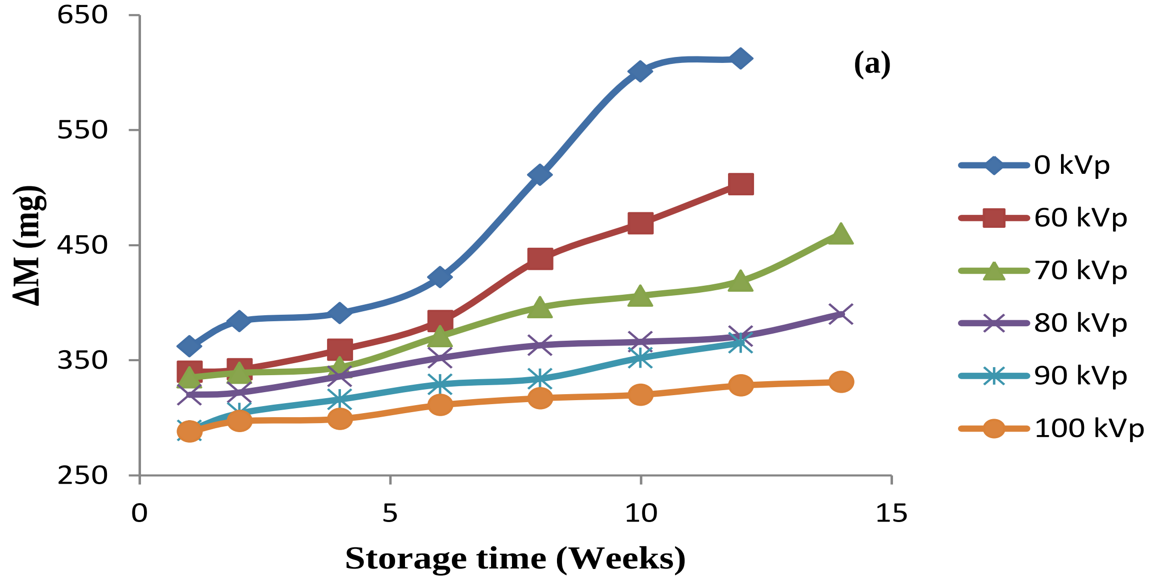


Fig 6. Mass shrinkage ΔM (g) of Garlic against storage period in weeks of samples for different kVp values of X-irradiation.

IV. CONCLUSION

The study revealed that diagnostic X-rays affect the density, moisture content, and pH of Red Onion, White Onion, and Garlic. It was concluded that increasing kVp values of X-irradiation from 0, 60, 70, 80, 90, and 100 kVp values have slight changes in the physicochemical properties like the density, moisture content, and pH, keep the firmness, and freshness of the product which affected the products shelf life as; the 80-100 kVp of X-irradiation was best at preserving Onion for an additional 3 weeks of storage, the 100 kVp of X-irradiation was best at preserving Garlic for an additional 3 – 4 days of storage.

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