MISR JOURNAL OF AGRICULTURAL ENGINEERING
https://mjae.journals.ekb.eg/

ISSN-Print: 1687-384X
ISSN-Online: 2636-3062

Misr J. Ag. Eng., 39 (2): 245 – 262

DOI: 10.21608/mjae.2022.111354.1059

USING COLORIMETRIC ANALYSIS TO DETERMINE THE EFFICIENCY OF SOME GARLIC SOLAR DRYING SYSTEMS

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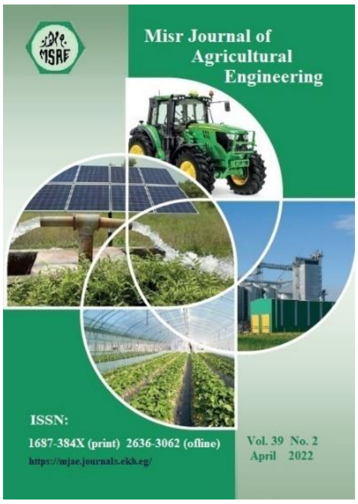

Keywords:
Garlic; Solar drying; Image analysis; Browning.

ABSTRACT

The purpose of this study is to examine and evaluate the dried garlic quality throughout color and chemical compounds changes that caused by using different designs of direct solar dehydrators. The parameters were source of ventilation, roof shape and type of covering material. The parameters that evaluated in this study were type of ventilation, various covering material and nature of dehydrator's roof. The measurements which considered in this study were solar radiation incident on the dehydrator roof, solar radiation inside dehydrator, outside air temperature, inside air temperature, outside relative humidity, inside relative humidity, some color indicators such as whitening index (WI) and browning index (BI) and also, some chemical tests such as antioxidants and optical index. The results showed that the highest value of whitening index (WI) was 42.52 and 49.71 before and after storage and the lowest value of browning index (BI) was 94.49 and 76.87 before and after storage in dehydrator that covered with a thin white polyethylene cover and constructed shape as a gabled-even-span roof with forced-air convection type (WSA).In addition, maximum color change (ΔE) was 64.05 detected at dehydrator that covered with a thin blue polyethylene and constructed as a flat roof cover with forced-air convection type (BFA)while the minimum was 35.21 at dehydrator (WSA).The study recommended using the thin white polyethylene cover and constructed shape as a gabled-even-span roof with forced-air convection type (WSA)to obtain the best quality of dried garlic.

1. INTRODUCTION

The industrial food processing caused many important developments that have led to a general deterioration in food quality and quantity. Although food processing is beneficial to the commercial food industry, it tends to increase manufacturing start-up costs. In times of natural disaster and economic crisis, the ability to produce and preserve food can be a blessing. Food drying is a generally accepted method of food preservation, which has envolved over time into a large-scale meticulously controlled industrial process **(Russon et al., 2009)**.

Drying is an energy-intensive process that involves the simultaneous transfer of heat and mass **(Ahromrit and Nemait, 2010)**. In addition, **Ndukwu et al. (2017)** reported that during this process, there is a convective movement of heat from the drying medium into the material that permeates the material by conduction. Consequently, the moisture generated by the material, in turn, diffuses to the surface of the material and then evaporates. Therefore, Dehydration is a serious processing action in the content industry. However, it is good legendary that the level of a dehydrated content quantity is strongly stricken by the drying deliver characteristics. Drying can entity changes in the bodily properties specified as rationalize and structure, as advantageously as the decline of odor compounds or degradation of nutritional substances resulting in undesirable reactions. The level of rural products should be ambitious for achieving the rural products should be ambitious for achieving the optimum marketing specifications. Garlic (Allium Sativum) has been planted for many of hundred years for their properties including the benefits and required quantities of them in cooking and pharmaceutical properties. Garlic is dried to mainly produce slices, cubes chunk and powder. The dried crops improve the economic position of the farmer throughout marketing process **(Papu et al., 2014).**

Garlic production increased significantly in Egypt from 263167 tonnes to 318800 tonnes during 2014–2019 **(FAO, 2020)**. Average garlic yields in 2019 was 8.64 ton/feddan. Area harvested increased also from 10997 to 15503 ha, respectively.

There are many drying methods such as: hot air drying, infrared radiation drying, hot air and explosion puffing drying, infrared radiation and microwave vacuum drying and freeze drying. These methods were compared by **Si et al. (2015)**. They found that among of these methods when used it to dry raspberry fruits *(Morus alba)* freeze drying gave the best results of physical properties. Also, they recommended that the thermal drying techniques with relatively low temperature and/ or short time for use in the drying industry. One of the thermal drying techniques is solar drying which provides its energy from the sun. **Akpinar and Das (2018)** reported that solar energy is a clean energy source that does not run out of reserves and does not pollute the environment. Due to its ability to easily convert into heat energy, this energy is widely used in drying agricultural products all over the world. In solar drying, solar dryers are specialized devices that control the drying process and protect agricultural product from damage by insects, dust, and rain **(Gupta et al., 2017)**. In addition, it takes up less time and relatively inexpensive compared to artificial mechanical drying. Solar drying can be considered as one of the solutions for the world, where crises times happened with food and energy.

After drying process, many changes can be noticed espially in garlic color. **(Rasouli et al., 2011)** detected that the test colour characteristics of desiccated garlic slices much lightness, yellowness and redness were smitten significantly by the air temperature. They reviewed that raising air temperature of samples and falling in the wetness volume of have caused darker dried fluid. So, using low air temperature is indispensable to win good decorate and angelical presence.

To detect these changes many methods can be used for achieving this goal. The methods are used to evaluate the degree of crops after post-harvest are numerous. Galore researchers affected, evaluated, examined, and proved unlike methods for the degree of crops. One of these ways is person processing systems such as tool sensation and digital cameras. Uniformity in the filler, mold and else degree parameters of product and vegetables is needed to conclude the coverall caliber of acceptance for customers. The important aspects of reinvigorated inspection are timbre, size, form, texture, and size of defects. Defects or modification usually occurs in usurped succeeding post-harvest of fruit and vegetables **(Arunachalam et al., 2018)**. The level of vegetables and fruits can be discovered by varied representation processing algorithms **(Pham and Lee, 2015)**. **Yamani et al. (2017)** investigated the possibilities of using an oblong appearance processing framework to judge tomato production wellborn. Healthy in both air temperature and broadness of samples and dropping in the moisture state of sampling caused a darker crystalized seasoner beginning.

Martynenko (2017) working on a computer vision to check the real-time test in favorer drying. He finished that computer sensation is right multipurpose subject, which has been successfully proven for both offline and online dimension valuation, improvement, and assessment orangeness and situation. He reported that accordingly mortal processing provides a surgical, swordlike, rapid, and noninvasive method to make their properties can be easily implemented practices and operation of citrus during post-harvest processing. **Zaho et al. (2020)** suggested a method of measuring vitamin C density using a digital camera and feed smooth quality activity. Also, they rumored that the coloring activity method position the conventional spectrophotometric method for the measure of vitamin C absorption in fruits and vegetables patch reducing the measure value.

Representation processing technique has been established as a trusty system for the husbandry area. It can be used many conveniently for the lineament memory of herb crops supported on the timber that is rhythmic by quality in terms of rationalize, **(Tamakuwala, 2018)**.

After 180 days of storage at −2 °C, garlic cloves manually peeled and packed in Polyethylene (PE) consider good material for packaging to repair the quality attributes and increasing the shelf lives of garlic cloves more than other packaging materials, **(He et al. 2019)**.

Oxygen absorption packages have an effect on the color protection of dried food when stored at 10 and 21 ° C. Storing dried food products at temperatures above room temperature (29.5°C) makes oxygen recovery packaging ineffective at maintaining color. However, the effect of oxygen absorption packages on most dried products, regardless of the effect of temperature and storage time, was significant in delaying oxidative damage. Wheat grain germination was reduced to less than 80% after 24 months of storage at 29.5°C in samples stored without them. Any further reproduction is prohibited without the consent of the Oxygen Absorption Packaging (OAP). However, when it was stored with germination (OAP), it was still 85% **(Darag, 2003)**.

Dried garlic changes in browning and there is some different chemical composition. So, the changes in garlic through drying process examined in this present study were mainly to investigate the treatment that gives the best quality of garlic. The color and some analyses of chemical composition were tested using image analysis. Therefore, the main aim of this study was to evaluate the quality of dried garlic. Moreover, the specific objectives were examine the color changes resulting in solar drying treatments, test some chemical compounds and compare between solar dehydrator's systems in this present study.

2. MATERIALS AND METHODS

Fresh garlic (*Allium sativum L.*) from the cultivar Chinese-Sids40 was purchased from a local producer from Damietta Governorate, Egypt, during the harvesting season of 2020. The experimental studies were executed during August 2020 in Damietta Governorate. The garlic clove types were immersed in the water for two hours to clean it, then the thin peel on the garlic cloves was removed. This was to make the garlic cloves dry faster, as this procedure allows the internal moisture to exit the cloves and remove them better during the drying process.

Garlic was cut into smaller slices (approximately 3 mm thick) to increase the surface area exposed to drying and then get rid evenly and completely of the moisture content to reach dried garlic slices that can be crushed and then used in powder form. Then we took an equal weight from the slice of garlics (25 grams) and put it in the wooden drying tray as a thin layer in every dehydrator. There were 250 gm of fresh garlic on each dehydrator.

The previous samples were distributed among the thirteen prototypes of solar dehydrators evenly so that each dehydrator has one sample.

In both types of dehydrators which with roof inclined or flat roof there were the same dimensions (42 *34* 14.8 cm), but the differences was the tilt angle in dehydrators which with roof inclined. In solar dehydrators with natural- air convection (passive) there were a hole to enter the air.

The dehydrators were used as small units where it consists of a space heating for pre-heating the drying air and a drying chamber. The structural frame was made of wooden beams with 2.828 cm diameter. Structural frame made up of posts, beams, and rafters with easily assembled on the spot with bolts to secure the optimal performance. It was 42 cm long, 34 cm wide, 19.92 cm rafter length, 26.383 cm total vertical high 31.416° rafter tilt angle, The drying tray formed of galvanized wire mesh of 30 cm long and 17 cm wide. In order to pass the dehydration air through the solar dehydrator, we use 6 electric forced air-fan with 12-V situated at the center of southern side of square air chamber by 12.728 cm diameter. On the opposite site, a square hole of 12.728 cm diameter (outlet drying air) made in the center of the solar dehydrator, so that, the air enters the solar hydrators from the parallel section through the drying garlic before expelling the dehydrator. The upper surface and other sides of the dehydration chamber was cover by white polyethylene sheet, blue polyethylene sheet and glass sheet cover with high radiation transmission to maximize the intensity of the solar radiation inside the dehydrator.

Also, the covering material was employed to cause thermal tripping by greenhouse effect phenomena with opening whole as a natural ventilation or with fan as a forced ventilation. The properties of dehydrators were with natural-air convection type (passive) and another is forced-air convection type (active), with gable even span roof and flat roof with thin blue polyethylene sheet cover, with thin white polyethylene sheet cover, glass cover and without coverage.

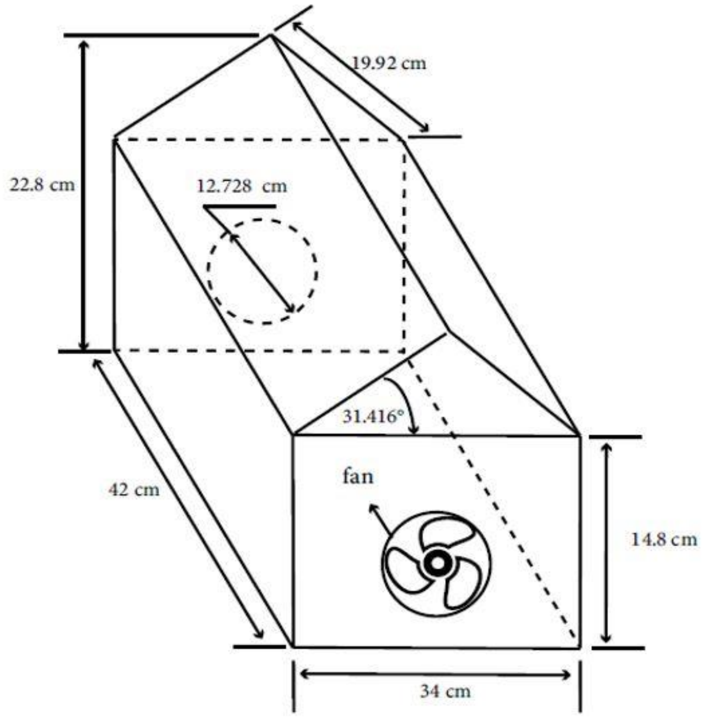

Fig.:1(a): Solar dehydrators with roof inclined

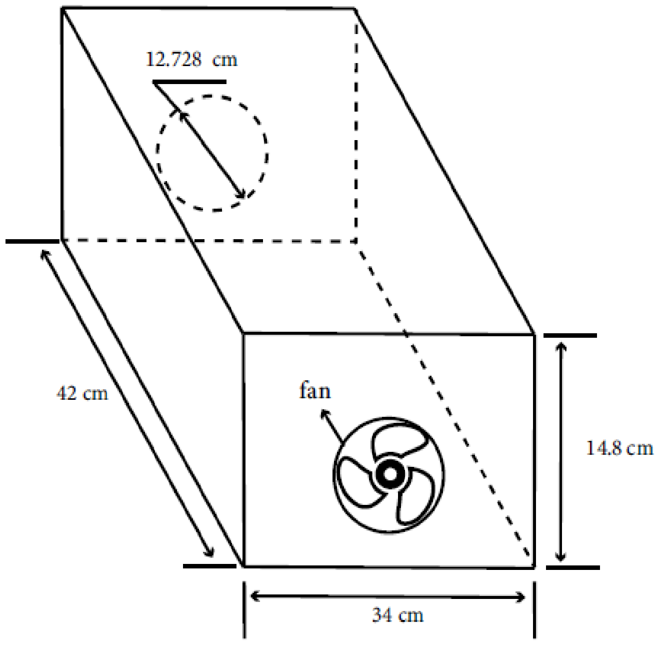

Fig.:1(b): Solar dehydrator with flat roof

Some symbols (letters) were used to describe and ease the dehydrators throughout the context. The first symbol employed to indicate the colored covering as B= blue polyethylene, G= glass material cover, O= without covering (open dehydrator) and W= white polyethylene. Also, the second symbol used to show the shape of dehydrator where F = flat roof dehydrator and S= gabled-even span. In addition, the third symbol put to describe the type of ventilation A= active (forced ventilation) and P= passive (natural ventilation). While UDC is meaning Un-dried cloves. Table (1) explains the symbols which used in results as follows:

Table 1: Symbols of dehydrators that used in the present study.

TREATMENTS	THE DEHYDRATOR TYPE
WSA	White polyethylene cover, gabled-even-span roof solar dehydrator with a forced air convection (active)
WSP	White polyethylene cover gabled-even-span roof solar dehydrator with a natural air convection (passive)
GSA	Glass cover, gabled-even-span roof solar dehydrator with a with forced air convection (active)
GSP	Glass cover, gabled-even-span roof solar dehydrator with a natural air convection (passive)
BSA	Blue polyethylene cover, gabled-even-span roof solar dehydrator with a forced air convection (active)
BSP	Blue polyethylene cover, gabled-even-span roof solar dehydrator with a natural air convection (passive)
WFA	White polyethylene cover, flat roof solar dehydrator with a forced air convection (active)
WFP	White polyethylene cover, flat roof solar dehydrator with a natural air convection (passive)
GFA	Glass cover, flat roof solar dehydrator with a forced-air convection type (active)
GFP	Glass cover, flat roof solar dehydrator with a natural-air convection type (passive)
BFA	Blue polyethylene cover flat roof solar dehydrator with a forced air convection type (active)
BFP	Blue polyethylene cover, flat roof solar dehydrator with a natural air convection (passive)
OFP	Open dehydrator without coverage, natural-air convection direct (Represents the traditional drying method with open-air convection)

2.1. Measurement of macroclimate circumstances

Microclimate parameters of thirteen active and passive solar dehydrators were measured and recorded inside the dehydrators (above the dehydration tray) and outside the dehydrators (above the dehydrators' rafters). In this experimental work we measured the solar radiation inside and outside the dehydrators by using solar power meter (TENMARS TM-207, made in Taiwan) with range about 2000 Watt Per Square Meter,634 BTU, Resolution about 0.1W/m², 0.1 BTU (ft²*h) and Accuracy Typically within ±10 W/m² 【±3 BTU (ft²*h)】 or ±5%, whichever is greater in sunlight; additional temperature induced error ±0.38 W/m² /°C ±0.12 BTU (ft²*h) /°From 25°C.

Beside we measured the relative humidity and temperature inside and outside the dehydrators by using TA218B-thermometer-hygrometer manual with Temperature range -50 to +70 °C with 0.1 °C display resolution and High accuracy ±1 °C, and humidity range- indoor: 20%-99%RH with 60% ±5% RH accuracy, made in China. The weather factors regularly measured every hour and recorded manually during the experimental work.

2.2. **Color Measurement**

The color change and the browning index were measured at the beginning and at the end of the garlic dehydration process and after a year of storage in the shelf life and while packaging every sample of every prototype dehydrator in a solo of plastic bag. The surface color of the garlic slices was measured using a COLOR ANALYZER Model: RGB-1002, It is a high-quality portable colorimeter.

The spectral analysis method was used to determine the color of the sample

- Color sensors are three color photo transistors: red photo transistor, green photo transistor and blue photo transistor
- RGB value are R (Red) value: 0 to 1023, G (Green) value: 0 to 1023, and B (Blue) value: 0 to 1023.
- HSL value are Hue value: 0 to 1.000., Saturation value: 0 to 1.000. and Luminance value: 0 to 1.000.
- Operating Temperature 0 ℃ to 50 ℃ (32 °F to 122 °F).
- Operating Humidity Less than 80% RH, made in China.
- The color of the dried garlic samples was measured using COLOR ANALYZER Model: RGB-1002 equipment. The CIE L*, a*, b* timber measure was utilized. Aggregate material change (△E), hue (h°) and chroma (c) values were premeditated according to L*, a* and b* values. The hue seek (h°) values can be old as a finger of preparation beside the L*value. Colorize measurements conducted in triplicate and the intend values were deliberate as follows: (Ilter, I. et al., 2018) can be calculated from Equation (1) to (4):

$$\triangle \boldsymbol{E} = \sqrt{(\boldsymbol{L}^*{}_{\mathbf{0}} - \boldsymbol{L}^*)^{\mathbf{2}} + (\boldsymbol{a}^*{}_{\mathbf{0}} - \boldsymbol{a}^*)^{\mathbf{2}} + (\boldsymbol{b}^*{}_{\mathbf{0}} - \boldsymbol{b}^*)^{\mathbf{2}}} \quad \text{...... (1)}$$

Where:

L_0, a_0 and b_0 are the initial L*, a* and b* values of garlic puree.

L* = degree of the lightness or brightness

a* = degree of redness to greenness

b* = degree of yellowness to blueness.

The whiteness value (WI) of the samples was calculated from the following formula: **(Feng, Y. et al., 2021)**

$$\boldsymbol{WI} = \mathbf{100} - \sqrt{(\mathbf{100} - \mathbf{L}^*)^{\mathbf{2}} + \boldsymbol{a}^{*\mathbf{2}} + \boldsymbol{b}^{*\mathbf{2}}} \text{.................................. (2)}$$

The browning index (BI) was calculated according to the following formula **(Ding, Y. et al., 2020)**:

$$\boldsymbol{BI} = [(\boldsymbol{X} - \mathbf{0.31})/(\mathbf{0.17})] \times \mathbf{100}\% \quad \text{...(3)}$$

$$\boldsymbol{X} = (\boldsymbol{a}^* + \mathbf{1.75}\,\boldsymbol{L}^*)/(\mathbf{5.645}\,\boldsymbol{L} + \boldsymbol{a} - \mathbf{3.012}\,\boldsymbol{b}) \text{ .... (4)}$$

2.3. Determination of the total antioxidant activity

The total antioxidant activeness of methanolic choose (80%) of dehydrated have in each treatment was evaluated on the fundament of the scavenging reflexional of the stabilized 1,1-

diphenyl-2-picrylhydrazyl (DPPH) atom according to the work described by **Abe et al. (1998)** as follows: Briefly, 1 ml of 0.5 mM DPPH alcohol solution and 2.0 ml of 100 mM sodium ethanoate device (pH 5.5) were superimposed to 2.0 ml of methanolic pass extracts in dissimilar concentrations, the samples put in dark bottles in the dark place. After shaking, the weapon was incubated at assemblage temperature (25 °C) in the acherontic for 30 min, and then the absorbance was measured at 517 nm. The aggregate antioxidant state was verbalized as showing in equation (5):

% Radical scavenging activity = [1– (A_{517} sample/A_{517} control)] x 100**………. (5)**

2.4. Optical index measurement

The Formation of brownness blue during drying of ail puree was determined by the measuring of the optical fact using the method of **ADOGA (1981)**. Extraction was performed 0.3 g sampling and 15 mL of 10% NaCl root by stimulating for 1 h at room temperature. The gross take was filtered by using a Whatman separate paper no. 40, and the transmittance was metric at 420 nm using a UV VIS spectrophotometer (UV-Vis VARIAN Cary 50, USA). The measure of transmittance was done in triplicate and the optical index was deliberate as showing in equation (6):

$$OI = \log\left(\frac{100}{T}\right) \times \frac{5000}{b \times w} \quad \text{………………………........…….. (6)}$$

where, T is percentage transmittance, b is cell path used (cm), w is weight of sample (g)

3. RESULTS AND DISCUSSION

Different dehydrators were used in this work with gable even span roof and flat roof, with thin blue polyethylene sheet cover, thin white polyethylene sheet cover, glass cover and without coverage and with natural-air convection type (passive) and another is forced-air convection type (active)during 14 days and measuring solar radiation, temperature, whitening index (WI), browning index (BI) and the color change (ΔE) and storage samples then measured antioxidant (%), optical index, whitening index (WI), browning index (BI) and the color change (ΔE) there are a lot of differences between them.

In natural-air convection direct cabinet dehydrator without coverage (Represents the traditional drying method)) the relative humidity was less than with gable even span roof and flat roof and found a lot of dirt, microorganisms, and insects.

In dehydrators with flat roof the values of solar radiation that incident on this roof were lowest that compared with tilted roof. In these flat dehydrator roofs no air currents, differences in temperature, air movement and temperature were increased. These conditions caused increasing the brown color of dried garlic and browning index (BI) and decreased whitening index (WI) during drying period.

Whitening index (WI), browning index (BI) and the color change (ΔE) are the main properties in the comprehension of how much color loss the sample is exposed to due to drying rate, temperature, relative humidity, etc. shows the readings for the colorimetric parameters in Garlic.

Table 2 shows that the highest value of RH (%) was 30% with dehydrator GSA and dehydrator GSP while the minimum value was 25% with dehydrator OFP. The minimum temperature was in dehydrator BSA 46.66, and the maximum value of temperature was 49.99 in dehydrator WFP. The solar radiation out on horizontal was 915.87 (W/m^2) lower than its value on tilt angle was 1062.08 (W/m^2). The maximum solar radiation was 840.1 (W/m^2) inside dehydrator WSA while the minimum was 214.95 (W/m^2) in dehydrator BFP. The highest and the lowest browning index (BI) were 94.49 and 147.29 in dehydrator WSA and dehydrator OFP because of drying process was increased brown color in dried garlic especially in open solar drying because there are much dust and pollution.

Table 2: The internal conditions of dehydrators and values of browning index

Treat.	RH (%)	Temperature (°c)	Solar radiation (W/m^2)	Solar radiation out (W/m^2)	BI
WSA	28	47.07	840.1	1062.08	94.5
WSP	28	47.91	836.5	1062.08	111.33
GSA	30	46.68	771.46	1062.08	112.26
GSP	30	47.8	786.65	1062.08	123.99
BSA	28	46.66	295.1	1062.08	115.54
BSP	29	46.82	311.25	1062.08	118.25
WFA	26	47.36	680.25	915.87	97.63
WFP	26	49.99	744.05	915.87	143.69
GFA	26	49.4	658.1	915.87	135.21
GFP	26	49.48	680.25	915.87	140.58
BFA	26	47.28	232.6	915.87	102.93
BFP	26	47.1	214.95	915.87	135.6
OFP	25	49.18	769.2	915.87	147.29

Fig. (2) shows that after storage dried garlic, the whitening index (WI) values were higher before storage and decreased after storage in all dehydrators except with dehydrator WSA there was the opposite of that the whitening index (WI) were 42.52 and 49.71 before and after storage, while the lowest value of whitening index (WI) were 24.5 with dehydrator PFA after storage. Drying air temperature also resulted in a darker portion. Process in preparation with expanding drying air temperature hump had been according by **Wang and Chao (2003).**

Fig. (3) shows that browning index (BI) After storage dried garlic, the browning index (BI) values were lower before storage and increased after storage in all dehydrators except with WSA dehydrator there was the opposite of that the browning index (BI) were 94.49 and 76.87 before and after storage, while the highest value of browning index (BI) was 24.5 with dehydrator WFP after storage while the solar radiation was 744.05 (W/m^2), the solar radiation out on horizontal was 915.87 (W/m^2) and highest temperature was 49.99°C during drying period. **Fante and Noreña (2012)** illustrated that the discoverer index (BI) is an essential parameter in processes involving enzymatic preparation.

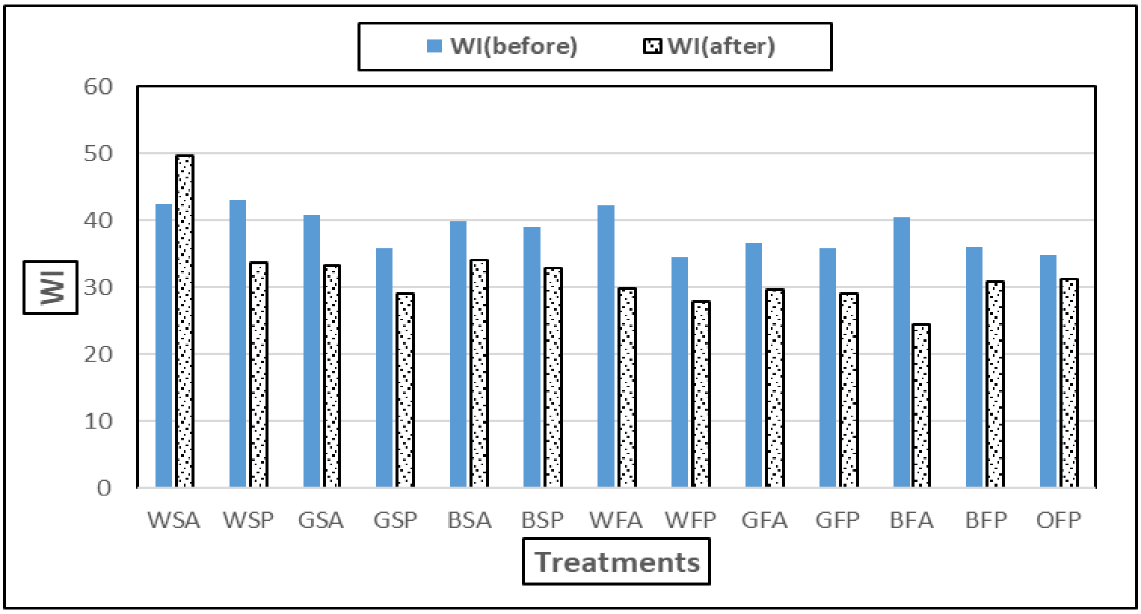

Fig. (2): Relationship between (WI) and different dehydrator's types before and after the storage

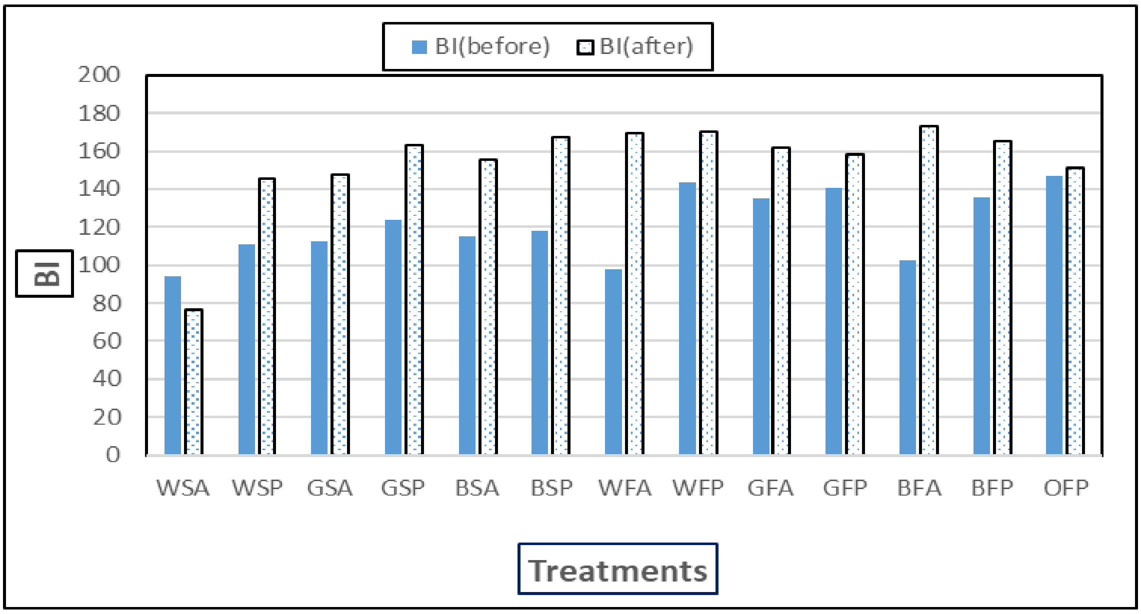

Fig. (3): Relationship between (BI) and different dehydrator's types before and after the storage

Fig. (4) shows that the color change (ΔE) After storage dried garlic, the color change (ΔE) values were lower before storage and increased after storage in all dehydrators except with two dehydrators :the dehydrator WSA and the dehydrator WSP and there were the opposite of that The color change (ΔE) were 44.76 and 90.59 before storage and the values were 35.21 and 51.88 after storage for dehydrator1 and dehydrator 2, respectively, while the highest value of the color change (ΔE) was 64.05 dehydrator PFA after storage. The colourise give travel during drying because of enzymatic oxidisation, the Maillard activity, vitamin C reaction, carotenoid debasement, and another processes **(Feng et al., 2018).**

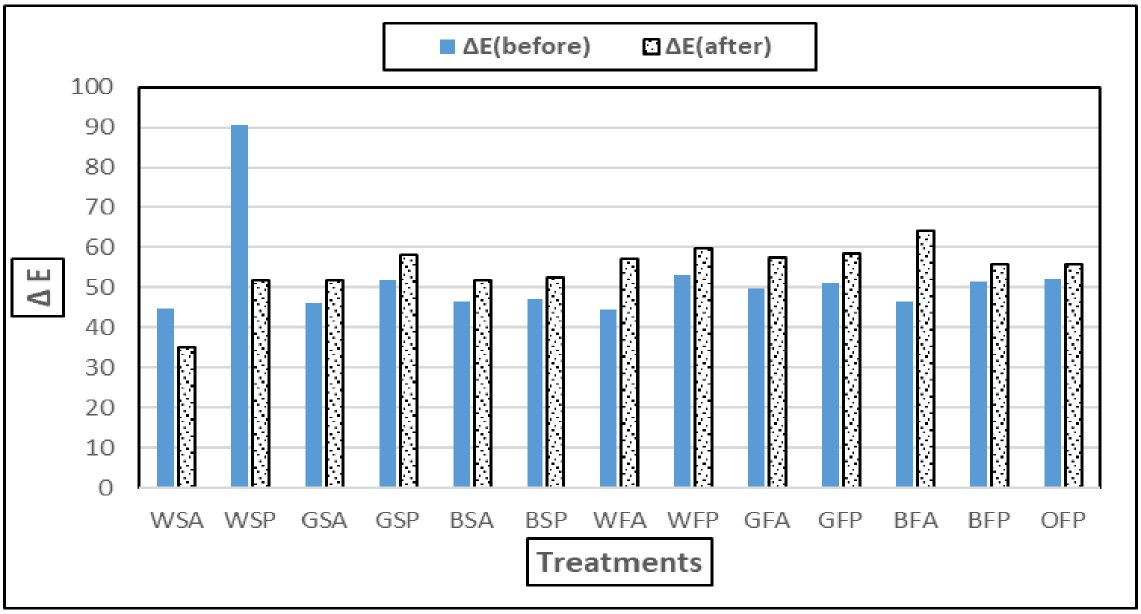

Fig. (4): Relationship between color change (ΔE) and different dehydrator's types before and after the storage

The highest value of R^2 was illustrated in Fig. (5) that there is the relationship between the whitening index (WI) during 14 days of drying in dehydrator WSA the highest solar radiation was 840.1 (W/m^2), the solar radiation out on tilt angle was 1062.08 (W/m^2) and the lowest temperature was 47.07°Cwhile drying garlic was $R^2 = 0.8596$ and this was proven by this equation $y = 0.3851x^2 - 8.2512x + 76.486$ while the whitening index (WI) decreased from 64.61 to 32.18, The data showed in Fig. (6) that there is the relationship between the whitening index (WI) during 14 days of drying in dehydrator WSP the solar radiation was 836.5 (W/m^2), the solar radiation out on tilt angle was 1062.08 (W/m^2) and temperature was 47.09°CWhile drying garlic was $R^2 = 0.8415$ and this was proven by this equation $y = 0.3124x^2 - 6.8468x + 71.704$ while the whitening index (WI) decreased from 63.29 to 31.15.

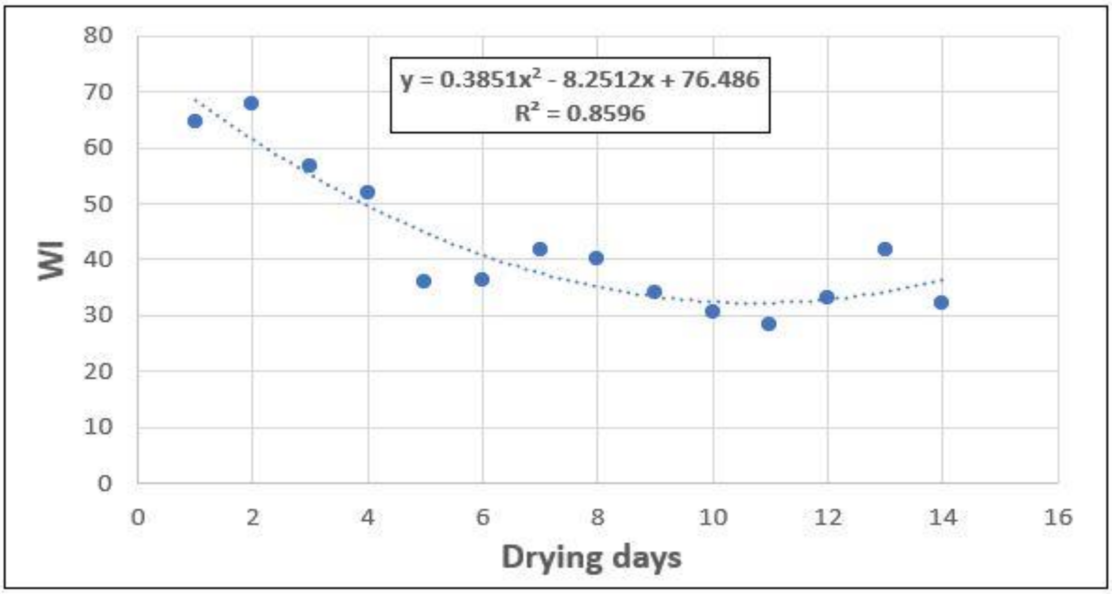

Fig. (5): Change in whitening index (WI) and drying days in dehydrator WSA

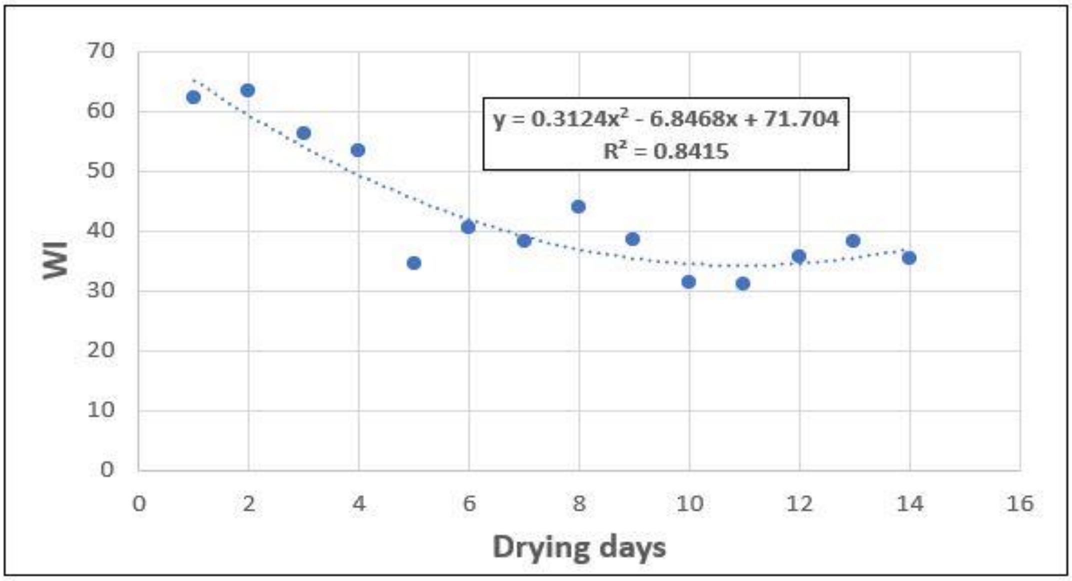

Fig. (6): Change in whitening index (WI) through drying days in dehydrator WSP

The highest value of R^2 was illustrated in Fig. (7) that there is the relationship between the browning index (BI) during 14 days of drying in dehydrator OFP the solar radiation was 769.2 (W/m^2), the solar radiation out on horizontal was 915.87 (W/m^2) and temperature was 49.18°C while drying garlic was $R^2 = 0.8977$ and this was proven by this equation $y = 0.9867x^2 + 4.3858x + 42.86$ and while the browning index (BI) increased from 31.51 to 322.77 during drying **Skrede (1985)** mentioned that it is not ever thinkable to distribute the zero and early ordination models to draw the kinetics of colorize changes, since these changes are not ever due to the Maillard activity, but also necessitate the temperature destruction of pigments acquaint in the sample.

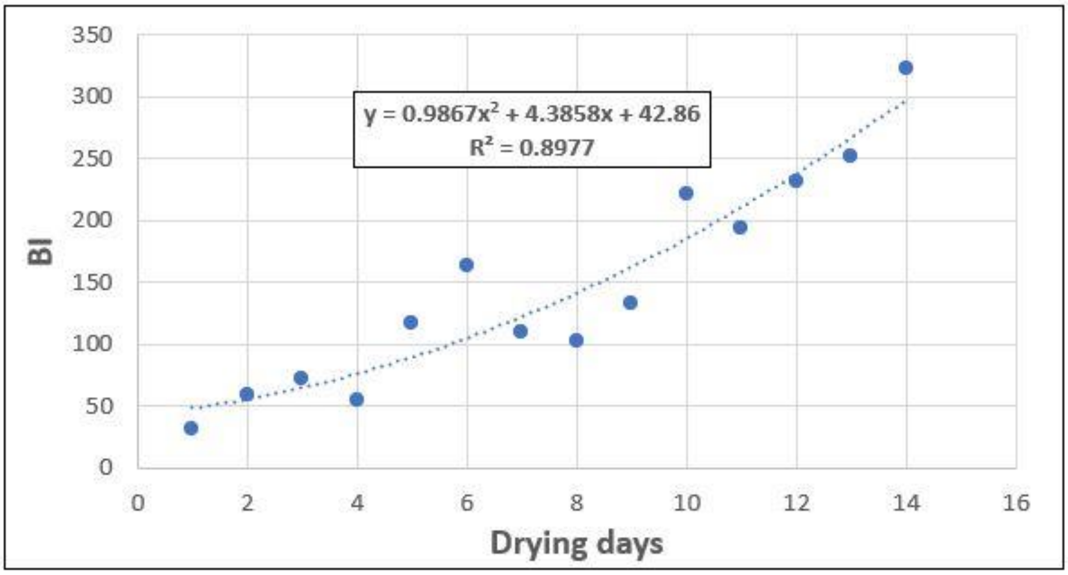

Fig. (7): Change in browning index (BI) through drying in dehydrator OFP

The highest value of R^2 was illustrated in Fig. (8) that there is the relationship between the color change (ΔE) during 14 days of drying in dehydrator WSA while drying garlic was $R^2 = 0.8122$ and this was proven by this equation $y = -0.3343x^2 + 7.3168x + 14.125$

while the color change (ΔE) increased from 26.33 to 54.79 during drying days, The data showed in Fig. (9) that there is the relationship between the color change (ΔE) during 14 days of drying in dehydrator BFA the lowest solar radiation was 232.6 (W/m^2), the solar radiation out on horizontal was 915.87 (w/m^2) and temperature was 47.28° while drying garlic was R^2 = 0.8333 and this was proven by this equation $y = -0.3151x^2 + 6.944x + 17.414$ and while the color change (ΔE) increased from 17.76 to 56.85 during drying. **Sacilik and Elicin (2006).** The color change (ΔE) values were also discovered. Desirable flag is those closest to the newfangled colouring of apple slices. The minimal regard for ΔE was constitute for untreated apple slices dried at a drying air temperature of 50 °C. It is hyaloid that raw sample and decrease temperature serviced originative beautify of impudent apple slices surpass.

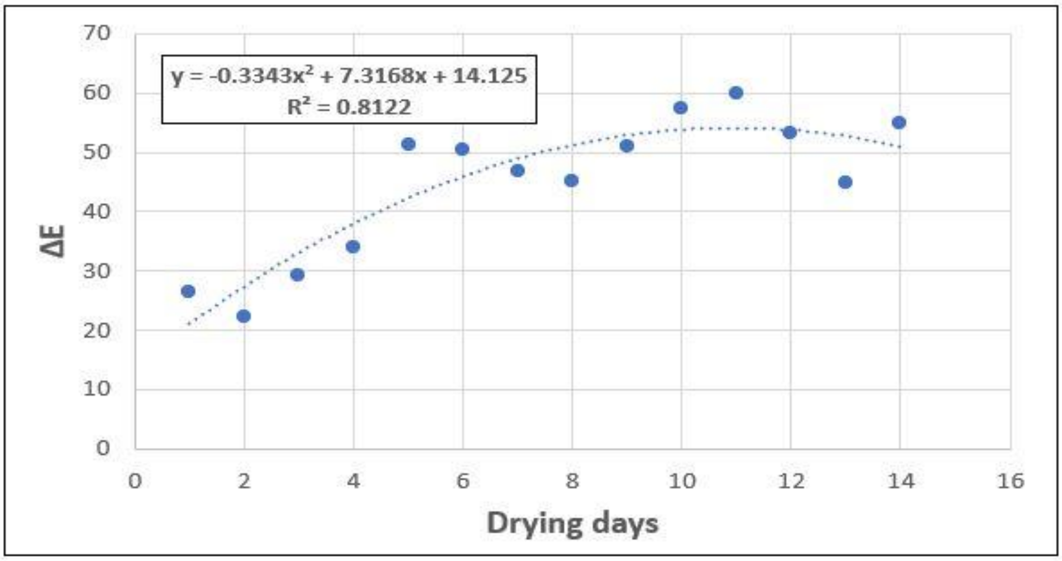

Fig. (8): color change (ΔE) through drying days in dehydrator WSA

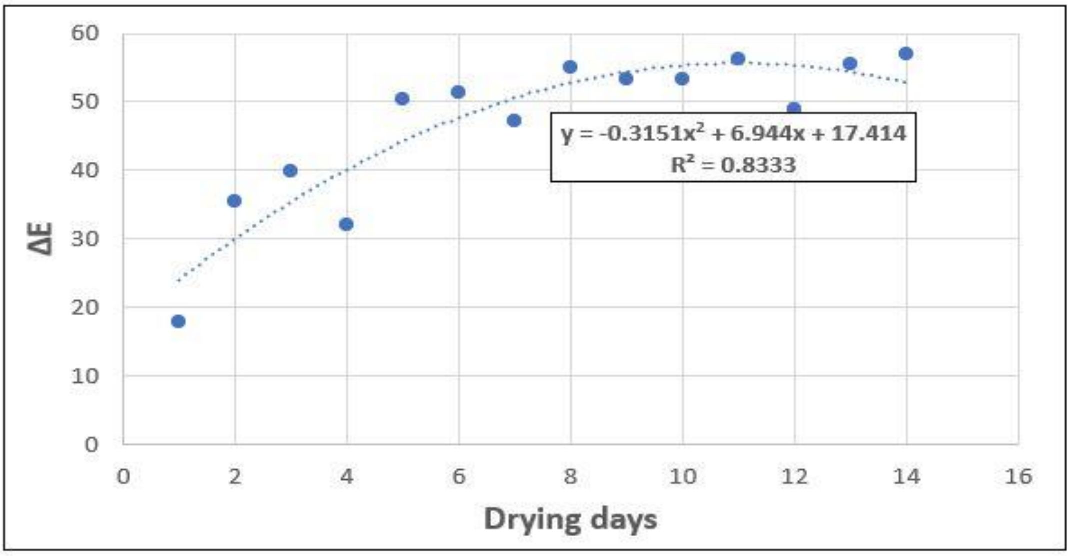

Fig. (9): color change (ΔE) through drying days in dehydrator BFA

In Fig. (10) The highest value of antioxidant (%) was in dehydrator GFP the solar radiation was 680.25 (W/m^2), the solar radiation out on horizontal was 915.87 (W/m^2) and temperature was 49.47°C and dehydrator PFA 88.21 and 88.15, respectively. **Chen et al. (2020)** stated that all the dried samples compared with the freshwater samples, indicating that drying remittent the light and inflated the yellowness of the flavoring slices. The optical fact worth for dehydrated flavored by freeze-drying (FD 20) at a shelf temperature of 20°C emptiness of 0.21 mm Hg direct pressing was 18.94±0.91 and by using vacuum-drying at a drying temperature of 50°C (VD50) was 22.32±1.47 and there are a strongly noteworthy statistics between b* duration and antioxidant activity and enzyme restrictive expression of seasoning was observed **(Wongsa et al., 2014)**.

On black garlic in early studies, it has been reported that this growth in its antioxidant content could be due to the increase in polyphenols and S-allyl-cysteine, a ternate derived from alliin **(Lee et al., 2009)**.

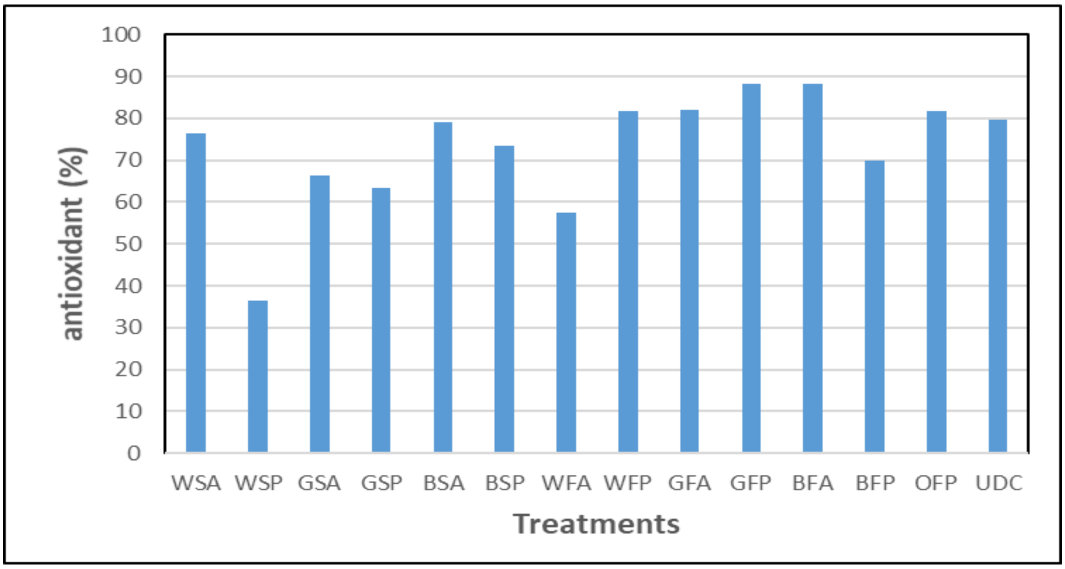

Fig. (10): Content of antioxidant (%) in different dehydrator's types and undried cloves

In Fig. (11) the highest value of optical index was in dehydrator GSP 23.61, and the solar radiation was 786.65 (W/m^2), the solar radiation out on tilt angle was 1062.08 (W/m^2) and temperature was 47. 80°C.Alter changes occur during drying walk can be influenced by additional factors, such as wetness release, oxidation, and nonenzymatic browning **(Nahimana and Zhang, 2010)**.

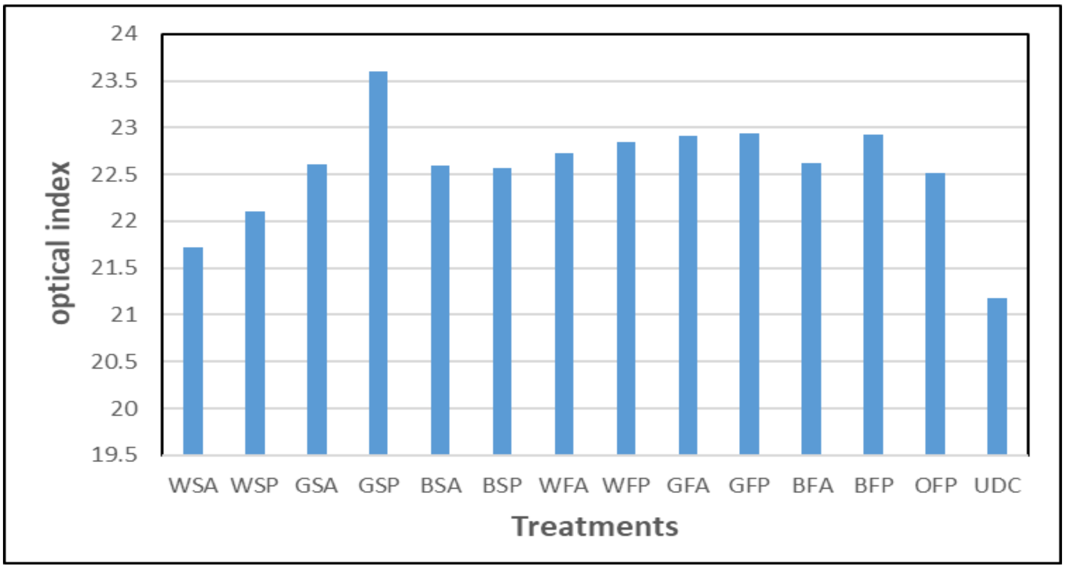

Fig. (11): Optical index for different dehydrator's types and undried cloves

4. CONCLUSION

The experimental work was carried out to evaluate the effect of using direct solar drying systems for dried garlic. Because of drying process caused some changes in color and chemical compounds of dried garlic. Consequently, the decision of customer can be affected on marketable process resulting in the dried garlic product from drying process. Therefore, colorimetric analysis and some chemical tests were employed in this present study to determine the changes levels as a result in operated different direct solar dehydrators. Moreover, the drying conditions such as solar radiation, air temperature and air relative humidity can be studied and associated with colorimetric analysis to know the source of these changes in color of dried garlic. So, the important research results that mentioned above could be concluded in the following points:

- In fresh garlic before drying the whitening index (WI) value was 83.59 and browning index (BI) was 16.43 and after drying process the whitening index (WI) values were decreased, while the values of browning index (BI) were increased in all treatments inside dehydrators when compared it with values before drying.
- The minimum value of optical index was 21.18 in fresh sample and after drying increased because the appearance of brown color.
- After storage in dehydrator (WSA) the highest value of whitening index (WI) was 49.71 and the lowest value of browning index (BI) was 76.87, while in dehydrator 11 (PFA) the lowest value of whitening index (WI) was 24.51 and the highest value of browning index (BI) was 173.27
- The limited changes in color and chemical compounds for garlic dried were observed in the dehydrators that active operated, inclined roof and white covering. Therefore, the study recommended using its.

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استخدام التحليل اللوني لتحديد كفاءة بعض أنظمة التجفيف الشمسي للثوم

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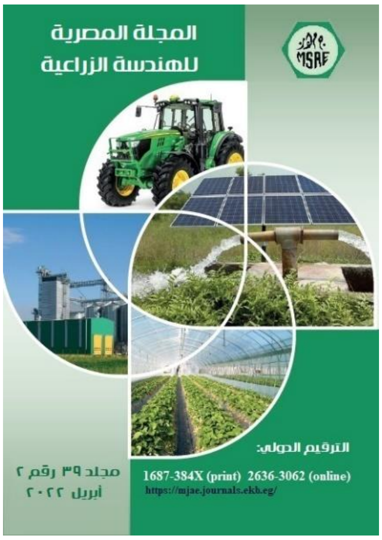

الملخص العربي

أجريت هذه الدراسة بهدف تقييم جودة الثوم المجفف (.Allium sativum L) من خلال فحص التغيرات اللونية الناتجة عن معاملات التجفيف الشمسي ، بالإضافة إلى اختبار بعض المركبات الكيميائية و ،شملت المقارنة بين بعض أنظمة التجفيف الشمسي المتغيرات التالية: نمطين من طرق التهوية هما نوع الحمل الحراري للهواء الطبيعي سلبي(P) والحمل بالدفع ايجابي(A)، وكذلك شكلين لأسقف المجفف الأول السقف مفرد القبة (S) والثاني سقف أفقي (F) إلى جانب ثلاثة أنواع لغطاء المجفف تشمل غطاء رقيق من ألواح البولي إيثيلين الأزرق(B)، غطاء أبيض رقيق من البولي إيثيلين (W)، والأخير غطاء زجاجي (G) .

أظهرت النتائج أن قيم الإشعاع الشمسي الساقط على السطح الأفقي أقل من تلك التي تسقط على السقف المائل نتيجة عدم وجود تيارات هوائية في المجففات ذات الأسقف الأفقية، ظهرت اختلافات في درجة الحرارة وحركة الهواء ودرجة الحرارة بين النوعين مما تسبب في زيادة اللون البني للثوم المجفف ومؤشر اللون البني (BI) وانخفاض مؤشر التبييض (WI) خلال فترة التجفيف للمجففات ذات السقف المسطح.

وكانت أعلى قيمة لمؤشر التبييض (WI) كانت ٤٢,٥٢ و٤٩,٧١ قبل التخزين وبعده وأقل قيمة لمؤشر اللون البني (BI) كانت ٩٤,٤٩ و٧٦,٨٧ قبل وبعد التخزين في مجفف مغطى بغطاء أبيض وسقف جملوني مع نوع الحمل الحراري للهواء المدفوع .بالإضافة إلى ذلك ، تم اكتشاف الحد الأقصى لتغير اللون (ΔE) في المجفف المغطى ببولي إيثيلين أزرق وتم تشييده كغطاء سقف أفقي بنوع الحمل للهواء المدفوع (BFA) بينما كان الحد الأدنى ٣٥,٢١ في المجفف (WSA). أوصت الدراسة باستخدام المجفف بطريقة التجفيف (WSA) للحصول على أفضل جودة للثوم المجفف.

الكلمات المفتاحية:
الثوم؛ التجفيف الشمسي؛ التحليل اللوني؛ التلون البنى.